



# HOUSE OF LORDS

## SCIENCE AND TECHNOLOGY SELECT COMMITTEE Connected and Autonomous Vehicles: The future? Oral and written evidence

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## **Ageas (UK) Limited – Written evidence (AUV0042)**

### **About Ageas**

Ageas (UK) is a leading provider of award-winning insurance solutions in the United Kingdom and the third largest motor insurer. It distributes Personal and Commercial products underwritten by Ageas Insurance Limited through brokers, intermediaries, affinity partners, the internet and through its own wholly or part-owned companies trading as Ageas Retail. Ageas Retail's brands include Castle Cover, Kwik Fit Insurance Services and RIAS. Ageas UK also holds a 50.1% share in Tesco Underwriting, providing home and motor insurance to Tesco Bank customers.

Insuring around seven million customers and working with a range of partners, Ageas UK is recognised for delivering consistent and high-quality customer experiences. It employs around 5,000 people with offices based across the UK.

Ageas (UK) is part of a listed international insurance Group. It operates successful insurance businesses in Belgium, the UK, Luxembourg, France, Italy, Portugal, Turkey, China, Malaysia, India, Thailand, Vietnam and the Philippines through a combination of wholly owned subsidiaries and long term partnerships with strong financial institutions and key distributors. Ageas ranks among the market leaders in the countries in which it operates. It represents a staff force of over 40,000 people and reported annual inflows close to EUR 30 billion in 2015 (all figures at 100%).

### **IMPACTS AND BENEFITS**

#### **1. What are the potential applications for autonomous vehicles?**

1.1 Autonomous vehicles have a range of potential applications which will be driven in part by the vehicles being developed. There are two key types of vehicles currently being designed:

- a) Vehicles that still have manual controls but are capable of driving on motorways and other roads with separate carriageways and grade-separated junctions autonomously with no requirement for input or monitoring by the driver. They will need to be able to take themselves to a place where it is safe for them to stop if the driver is unable or unwilling to take back control when asked to do so.
- b) Vehicles that have no manual controls (other than to set a destination and start the journey). These will be capable of driving autonomously at relatively low speeds on defined roads or within a specific (usually urban) geographical area.

1.2 The first of these vehicle types will still fit into the current individual ownership or leasing model, although a number of different variants of vehicle sharing may evolve over time.

1.3 The second type of vehicle however is very likely to be owned and operated by a Mobility-as-a-Service (MaaS) operator (which could be public or private sector) and used to provide ride-hailing or ride-sharing services.

1.4 We expect the capabilities of both types of vehicles and the roads and conditions in which they can operate will increase over a lengthy period of time to the point that we have autonomous vehicles capable of operating almost anywhere. This could lead to a long-term shift away from private ownership to vehicles towards a general MaaS system of transport.

## **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

2.1 Improved road safety – human error is a factor in between 90% and 95% of road traffic accidents. Reducing these errors is of paramount importance to Ageas as an insurer. The introduction of autonomous vehicles is likely to reduce the number of accidents over time, as the adoption rate and capabilities of these vehicles increases. Human error is only going to be removed altogether once all vehicles on the roads are autonomous, which may take many decades. Vehicles that are capable of both manual and autonomous driving will have enhanced driver assistance systems that will use some of the autonomous driving technology to support the driver and help to reduce accidents during manual driving.

2.2 Reduced congestion – Autonomous vehicles are likely to bring about a reduction in overall numbers on the road if new models of ownership develop. They will also reduce congestion by a more efficient use of road, reducing the number of accidents, and the use of connected communication to moderate traffic flow.

2.3 Reduced vehicle emissions – Increasingly autonomous vehicles will have electric or at least hybrid power leading to lower emissions. Reducing congestion will also cut emissions for conventionally powered vehicles.

2.4 Convenience – A vehicle that will undertake the entire driving task for some or all of the journey will free up the driver (or user) to undertake other tasks that would not currently be possible (or legal) such as using a mobile phone, tablet or laptop for work or leisure or watching a film on a screen in the car. With autonomous ride-hailing services, the ability to summon a vehicle quickly and cheaply is likely to prove more convenient than other options, particularly within urban areas.

2.5 Extending personal mobility – There are currently several sections of the population unable to hold a driving licence, or who have given up driving through infirmity, disability or similar. Autonomous cars without manual controls could restore personal mobility to these people.

2.6 Infrastructure – Autonomous vehicles could detect issues with road surfaces helping road authorities to carry out repairs earlier and reducing costs. Additionally, reducing the number of vehicles on our roads and using spaces such as car parks and on-street parking more effectively could lead to lower infrastructure costs.

2.7 Decreasing cost of mobility – A number of studies have been carried out into the per mile cost of vehicle ownership versus cost of usage of Mobility as a Service provided by fully autonomous vehicles. There are a number of variables (particularly around cost of technology) but these studies have tended to show a significantly lower figure per mile for MaaS, especially in urban areas.

2.8. The main disadvantage will probably be the deterioration of manual driving skills. This is particularly problematic when there is a mixed fleet of vehicles on our roads and more people have to occasionally take over the driving of a manual or semi-autonomous vehicle but do not practice driving regularly. This is more likely to see them involved in an accident.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

3.1 We anticipate that autonomous vehicles will have a major impact on the insurance industry. In the long term autonomous vehicles could dramatically reduce the number and severity of accidents on our roads. This would reduce costs for insurers and, in turn, reduce the amount consumers would have to pay, leading to a reduced income.

3.2 It is likely that we will have a mixed fleet on our roads for some decades to come. We will see conventional vehicles, vehicles with Advances Driver Assistance Technology (ADAS), vehicles that are capable of autonomous travel in certain circumstances, and vehicles that are wholly autonomous all on our roads at the same time.

3.3 This will have an impact on the frequency, type and liability of claims. It is vital that the insurance industry is involved in development of autonomous vehicles and the legislation and regulation of both their testing and eventual adoption on our roads so that our claims experience is used appropriately.

### **4. How much is known about public attitudes to autonomous vehicles?**

4.1 Research into consumer and public attitudes has been carried out by a number of organisations with distinctly variable results. The public need to be educated on the different types of autonomous vehicles and the benefits of using them. Large scale trials, such as Volvo's Drive Me London scheme, are likely to prove critical in explaining to the man in the street what autonomous cars are likely be capable of, where they will operate, and what the individual and societal benefits are. We envisage that increasing understanding will lead to more favourable attitudes towards autonomous vehicles and drive up their adoption.

### **5. What is the scale of the market opportunity for autonomous vehicles?**

5.1 A report produced by KPMG for the SMMT in March 2015 estimated that the connected and autonomous vehicles market could be worth as much as £51 billion to the British economy by 2030 and could create some 30,000 new jobs over the same period. However, there are also likely to be significant changes in many other markets and across society as a whole. Fewer repairs would see less demand for garages, for example, and trades such as taxi drivers, hauliers, and buses could all be put under pressure. If autonomous vehicles are

to receive wide-spread acceptance it is important that these changes are managed appropriately by the Government.

## **CREATING AN ENABLING ENVIRONMENT**

### ***Research and development***

#### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

6.1 We believe that demonstrations of different types of autonomous vehicles and their capabilities will be absolutely critical in the run up to their wide-spread deployment.

Demonstrations will inform and educate the public about what they can expect and what the key benefits will be. A number of trials are being undertaken currently and over the next two years, a series of significant, reasonably large-scale, high-profile demonstrations are also going to be needed. Volvo has already made the commitment to its Drive Me London programme but we need to ensure there are others.

6.2 As part of this introduction of autonomous vehicles to the public, it will be critical to remove any ambiguity with clear consumer friendly definitions of what an autonomous vehicle is. We want to see the terms Automated Driving and Automated Vehicle used:

- a) Automated Driving - the vehicle is capable of driving with no input from, or monitoring by, the driver; and
- b) An Automated Vehicle is capable of Automated Driving for either the entire journey or clearly defined segment. It carries out planned and controlled handovers from automated to manual operation and vice versa.

6.3 It may well be the case that different types of Automated Vehicles are available, capable of Automated Driving at different times and in different circumstances. There will almost certainly need to be detailed, technical definitions of these vehicles. We believe a system of testing and certification of Automated Vehicles would be desirable and that it should be possible to store this information in the DVLA vehicle database and on the vehicle's registration documents. Insurers could then use this both for rating the vehicle at point of quotation/sale and when defining our claims processes where such vehicles are involved in an accident.

6.4 This approach will mean that consumers are fully informed when choosing to buy or lease an Automated Vehicle about when they will be in control of the vehicle and when the vehicle is in control.

#### **7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

7.1 The UK Government has provided considerable funding in this area (with the promise of more to come) which we support. However, we are currently at the critical point in the

development of autonomous technology and if we are to benefit from a £51 billion boost to the economy over the next 15 years we want to see significant investment now, particularly in world-leading testing facilities.

## **8. How effective are Innovate UK and the CCAV in this area?**

8.1 C-CAV has been effective in driving the connected and autonomous vehicles agenda forward, in promoting the interests of UK plc in this area and in the provision of a number of funding opportunities for the sector.

8.2 Innovate UK has managed a number of the funding competitions successfully, but we would suggest the following as areas for improvement:

- a) The Intelligent Mobility Fund needs to be increased in overall size and also should be ‘front loaded’, so that more funding is available now while the opportunities are at the greatest.
- b) The process to bid for funding needs to be greatly simplified. While there has been some improvement in this area it is still taking far too long from submitting a bid to actually launching a programme.
- c) We need to be using our advanced regulatory regime, strong knowledge base and expertise in key areas of the automotive supply chain to actively encourage non-UK vehicle manufacturers to undertake, at the very least, research and development, if not manufacturing in the UK.

## **9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

9.1 As we are not an SME we are not in a position to comment.

### ***Real world operation***

## **10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

10.1 Many of the changes to the physical infrastructure that are needed may be fairly mundane, for example more frequent painting of road markings that can be read by autonomous vehicles. These would have the advantage of leading to a higher level of road safety across the board as we know from our work the Road Safety Foundation and other road safety groups that better road markings can make roads safer. Wholesale physical changes should not be needed in the initial stages of deployment but there may come a point at which autonomous-vehicle-only lanes could be considered and other infrastructure such as car parks for autonomous vehicles.

10.2 The digital environment will be critical to a future of autonomous vehicles. Nearly all types of autonomous vehicles will require a high speed internet or cloud connection to deliver real time high definition 3D mapping, traffic information and other services. This will typically be provided via a 4G LTE mobile network although we would anticipate a migration

to 5G as this becomes available. Mobile network coverage can however be patchy on the UK road network and this is an area that is likely to require significant investment to improve matters.

10.3 There is also the question of V2V (vehicle to vehicle) and V2I (vehicle to infrastructure) communication – usually collectively known as V2X (vehicle to everything). While not strictly essential for the operation of autonomous vehicles, these can provide additional information to the vehicle's systems and are on the point of being mandated in the US. Current V2X technology uses 802.11p DSRC (digital short range protocol) – known as ITS-G5 in Europe – on a dedicated band in the frequency spectrum but the arrival of 5G mobile communications may provide a better and potentially more unified solution.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

11.1 Current vehicles are not yet at the point of being highly automated but many have a range of ADAS (advanced driver assistance systems). These are now becoming more sophisticated, to the point where the vehicle can take care of both longitudinal (accelerating and braking) and lateral (steering) controls for periods of time.

11.2 We are now starting to see this in so-called ‘traffic jam pilot’, ‘highway pilot’ and ‘pilot assist’ systems from a number of manufacturers. However, these systems still require the driver to monitor the vehicle and the road and be ready to take over control of the vehicle at a moment’s notice. We know that humans are not particularly good at this and should not be encouraged to take their hands off the wheel, take their eyes off the road or be lulled into a false understanding of the vehicle’s capabilities.

11.3 Within the next three to five years vehicles will become available that will have systems that meet the necessary technical requirements to be certified as Automated Vehicles that are capable of Automated Driving according to the definitions put forward in Question 6. It is essential that UNECE international vehicle regulations and domestic Construction and Use Regulations are updated to ensure that Automated Driving and Automated Vehicles are permissible on the roads before they are introduced on to them.

11.4 Within a similar timescale we would also expect to see Automated Vehicles capable of Automated Driving for an entire journey within a restricted area being developed. These are likely to be truly driverless ride-hailing or ride-sharing vehicles with no manual controls, other than for selection of destination, a ‘start’ button and possibly an ‘emergency stop’ button. Initially these may only be on one or two designated routes but this would gradually expand to cover wider areas.

11.5 Ultimately Automated Vehicles will be produced that will be capable of Automated Driving in all environments but this is likely to take some years.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

12.1 Cyber-security has become a key priority for motor manufacturers and their suppliers developing autonomous vehicle technology and the Government, via C-CAV and DfT, has taken a keen interest in this area. As insurers, we feel it is vital that connected and autonomous vehicles and networks and other infrastructure giving access to vehicle systems are tested and certified for cyber-security.

12.2 Data protection and privacy are likely to carry significant weight in the mind of the consumer and this would partially be addressed via cyber-security certification.

12.3 There will also be a need to ensure that key data from the vehicles can be shared, particularly with insurers, in the event of a crash involving autonomous vehicles. This will enable the cause and potential liability for the accident to be established. It is important that consumers understand the reasons for this.

12.4 Vehicle connectivity also opens up the possibility of a whole range of other optional services being offered to the consumer that use vehicle data. Consumers opting in to such services will need to be fully informed of how that data is to be used and agree to it.

### **13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

13.1 For the recent C-CAV consultation into ADAS and Automated Driving Technology, Ageas provided both input to the ABI response and a detailed response in its right. There are a number of key changes required which can be summarised as follows:

13.2 Changes to UNECE Vehicle Regulations – Current regulations do not adequately cater for Automated Driving Systems. Although some progress is being made in the development of UNECE Regulation 79 to cater for Automatically Commanded Steering Systems, we do not believe this is to be the most appropriate approach. There needs to be a separate regulation for Automated Driving and Autonomous Vehicles (using the definitions set out in our response to Question 6). This regulation can then provide all the technical requirements that would sit behind those two consumer-friendly definitions.

13.3 Changes to UK Construction and Use Regulations – Generally our Construction and Use Regulations will follow what is agreed within UNECE. Should we find that progress at UNECE in Geneva is unacceptably slow, we might consider developing our own regulation in parallel.

13.4 Amendments to the UK Road Traffic Act and changes to the prevailing insurance liability regime – Our major recommendation in response to the recent C-CAV ADAS and Automated Driving Technology Consultation was that compulsory insurance provisions are amended so that tort of negligence regime is universally replaced by a form of ‘strict liability’. This would mean that:

- a) The vehicle insurer would pick up the claim(s) in relation to its vehicle in the first instance
- b) Data would be made available from an Automated Vehicle (and vehicles capable of certain higher level categories of Assisted Driving) under the Data Storage Solution

for Automated vehicles (DSSA) provisions proposed within forthcoming changes to UNECE Regulation 79 (or similar) which will indicate whether that vehicle was under manual or automated control

- c) Those involved in accidents are always covered, whether the fault lies with driver, the driving systems, or where no fault or negligence can be determined
- d) An injured but innocent (i.e. not-at-fault) first party could claim against the motor insurance policy on the vehicle in the first instance
- e) The vehicle insurer would retain recovery and/or contribution rights against any third party or manufacturer and/or supplier(s) determined to be ‘at-fault’
- f) An at-fault third party insurer would be able to take over and settle any personal injury claim, once their liability has been established

13.5 We accept that making such a regime change on a universal basis may be a step too far for the Government to make currently but we believe that, at the very least, Automated Vehicles should have cover that will operate on such a ‘strict liability’ basis. This change would mean that those using Automated Vehicles are covered for any accidents in a way that ensures they receive financial support quickly and simply. It avoids a person in need being stuck between large, multinational insurers, car manufacturers, software designers etc who are in disagreement about who is responsible for a crash.

13.6 Amendments to the Highway Code – Once we have Automated Vehicles deployed on the road then the Highway Code and associated legislation should be amended to permit drivers to undertake other tasks (e.g. using a mobile phone or laptop or reading) while the vehicle is operating in Automated mode.

#### **14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

14.1 Vehicles should be programmed to avoid getting into situations in which a choice of this nature needs to be made. One simple example of this may be that autonomous vehicles would not drive faster than a speed that enables them to stop for or avoid an obstacle that might present itself in the road – in other words autonomous vehicles should practice ‘defensive driving’.

14.2 If, for some external reason an impact becomes inevitable, then an autonomous vehicle should always strive to minimise that impact via maximum braking and/or evasive steering.

#### ***Wider governance***

#### **15. What does the proposed Modern Transport Bill need to deliver?**

15.1 The Modern Transport Bill must deliver an environment in which autonomous vehicles can be deployed as soon as the technology is ready and sufficiently safe for this to happen. It must remove obstacles as far as possible, relying on the appropriate bodies to fully define Automated Driving and Automated Vehicle, and allowing deployment onto the roads of any vehicle that has been type approved and properly certified as an Automated Vehicle. It should clarify the steps to be taken on motor insurance including the provisions for a form of

'strict liability' regime to be introduced. It should also set out what drivers will and will not be permitted to do in both Automated Vehicles and vehicles that fall short of the Automated Vehicle definition but have a variety of Advanced Driver Assistance Systems fitted.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

16.1 We are not in a position to answer this question.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

17.1 As a motor insurer we are primarily concerned with autonomous vehicles operating on public roads. Other organisations are better placed to discuss the possibilities of autonomous vehicles in other areas.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

18.2 Anecdotally, the prospect of the UK leaving the European Union has had an impact on European funding for collaborative research and development. If this materialises into a long-term problem the UK Government is clearly going to need to make up this growing shortfall in funding for research and development and this will require a different approach from that currently used by Innovate UK. Horizon 2020 allows for funding to be granted up to in effect 125% of cost, in order to allow for incidental expenses to be recovered and something similar could be beneficial in a purely UK-based replacement.

*26 October 2016*

## **Association of British Insurers (ABI) and Thatcham Research – Written evidence (AUV0051)**

### **INTRODUCTION**

#### About the ABI

The Association of British Insurers is the leading trade association for insurers and providers of long term savings. Our 250 members include most household names and specialist providers who contribute £12bn in taxes and manage investments of £1.8trillion.

#### About Thatcham Research

Thatcham Research is the motor insurers' automotive research centre. Established by the motor insurance industry in 1969, the centre's mission is to contain or reduce the cost of motor insurance claims whilst increasing safety standards. Today, Thatcham Research still occupies its unique position as the UK's only 'not for profit' insurer funded research centre. Whilst the original aims remain intact, the centre now enjoys a much wider remit at the forefront of the latest vehicle technology research, spanning safety, security and repair.

### **EXECUTIVE SUMMARY**

Insurers wholeheartedly support the development of automated vehicles, which have the potential to revolutionise road safety. In its response to the recent C-CAV consultation, 'Pathway to Driverless Cars', the industry made proposals for insuring the first wave of automated cars. We would welcome the adoption of these proposals in the Modern Transport Bill. The industry's proposals can be summarised as follows:

- Drivers should continue to buy a single motor insurance policy to cover both manual and automated driving.
- Insurers should have a new legal right to recovery, allowing them to get costs back from motor manufacturers, software companies or other parties in cases where the vehicle or technology was found to have been at fault.
- Strict rules on what people can and cannot do behind the wheel need to be maintained and drivers will need absolute certainty about when they can safely allow the car to drive autonomously.

The insurance industry recognises that this will be an interim solution, designed to give confidence to manufacturers, investors and consumers for when this technology is first available on the market, and to ensure the UK meets its ambition of becoming a world leader in this technology. As the technology develops, we recognise further consideration will need to be given to the question of liability.

The insurance industry intends to be closely engaged in those further debates and for further reforms to underpin this system, it will be important that the UK Government is closely engaged in the international process of setting regulatory standards for safe use of

automated driving technology. A critical issue will be *appropriate access to data, to ensure that where there are accidents, claims can be settled quickly and there are not protracted disputes* between manufacturers and insurers over who was, or should have been, in control of the vehicle. We believe it is in the interests of all stakeholders to resolve these questions, but it is likely the Government will need to provide clarity over how the relationships between different stakeholders will operate when automated driving becomes a reality.

## IMPACTS AND BENEFITS

### 1 What are the potential applications for autonomous vehicles?

- 1.1. The insurance industry is an enabler that can manage the risks associated with automated driving and give consumers the confidence they will need to make full use of this technology.
- 1.2. Automated driving clearly has wide potential to transform the road network. Other stakeholders will want to comment on the various benefits in more detail. However, specific to insurers, two applications in particular will be significant –
  - Safety mechanisms to address the 94%<sup>1</sup> of accidents currently estimated to have occurred as a result of human error.
  - Connected car infrastructure and associated data that has the potential to be used to assess risk and manage claims more efficiently.
- 1.3. To understand how this technology is likely to be applied, especially in the short-to-medium term, it is worth noting that several different levels of automation could be introduced. A commonly used definition of the potential stages of vehicle automation has been created by [SAE International](#). This definition sets out increasing levels of automation, ranging from Level 0 ('No Automation') up to Level 5 ('Full Automation')<sup>2</sup>.
- 1.4. However, while these SAE International definitions have helped to facilitate discussion between different sectors and stakeholders, the insurance industry does not believe that these definitions will prove sufficient to manage the roll-out of this technology onto the roads. There are two reasons why these definitions will have limited use –
  - Firstly, the rollout of this technology is unlikely to simply involve a progressive step from one level of automation to the next (as these definitions imply). Instead, it is likely that some manufacturers will produce vehicles that allow 'automated' driving on certain road conditions (where the driver can

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<sup>1</sup> This estimate of the number of accidents estimated to involve human error is used in the Department for Transport's 2015 Road Safety Statement (<https://www.gov.uk/government/publications/road-safety-statement-working-together-to-build-a-safer-road-system>, p.27) – we are aware of a number of other estimates, but all range between 90-95%.

<sup>2</sup> More information on SAE International's Five Levels of Automation is available here: [http://www.sae.org/misc/pdfs/automated\\_driving.pdf](http://www.sae.org/misc/pdfs/automated_driving.pdf)

disengage entirely) but on other roads, the driver will be expected to be fully in control (albeit supported by assistance systems affecting braking, lane detection and potentially even overtaking and speed). The SAE definitions do not appear to adequately explain such a scenario, which is dependent less on the technical capability of the vehicle and more on the surrounding road infrastructure. The crucial issue will not be the level of automation the car is capable of, but how the transition between different levels of automation at different stages of the journey is managed.

- Secondly, while technical experts will understand these definitions, these definitions do not provide enough clarity for consumers. It will be vital that road users fully understand the distinction between ‘driver assistance’ and ‘fully automated driving’, especially if automated driving will only be safe in certain road conditions. While the technology may develop in gradual stages towards ‘full automation’, for the driver the step between when they need to maintain overall control and when they can safely disengage is clearly the most significant and must be managed accordingly.

- 1.5. Therefore, a priority for the insurance industry is ensuring that policymakers and consumers understand the clear distinction between advanced driver assistance systems (ADAS) and fully automated driving technology (ADT). Consumers must not be misled about the capability of ADAS (which is already appearing in commercially available cars and is likely to become more advanced) and ADT (which we do not expect to be commercially available until approximately 2021, at the earliest).
- 1.6. One further significant point to note is that, even if the technology that supports fully automated driving can only be fully deployed in certain road conditions (such as motorways), the underlying sensors/radars will also be available to assist ‘manual’ driving. This means that automated driving technology offers considerable potential benefits to driver safety (and convenience) in all driving conditions, not just while fully automated driving is enabled.

## 2 What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

- 1.7. One of the main potential benefits expected from this technology is improved road safety outcomes. Already, this potential is being realised with the fitment of autonomous emergency braking (AEB). For example, in 2015, research published by Thatcham Research found that a VW Golf VII fitted with AEB technology was involved in 45% fewer insurance claims for third-party injury than equivalent vehicle models that did not have this technology.<sup>3</sup> The insurance industry is currently actively investing in further research and analysis to understand the benefits of this technology for safety. Furthermore, the insurance industry has

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<sup>3</sup> Thatcham Research, ‘Golf drives down personal injury’, May 2015 - <http://www.thatcham.org/news-and-events/news-and-press-releases-reader/items/golf-drives-down-personal-injury>

actively encouraged the take up of the technology by putting vehicles that come with AEB as standard into a cheaper insurance category.

- 1.8. However, alongside these potential safety benefits, there is an associated risk that will need to be managed. As outlined above (paragraph 1.5), it is vital that consumers are not misled about the potential of the technology. To address this, there must be absolute clarity around vehicle owners/operators' roles in the driving task, including their responsibility to monitor the road and driving conditions and their responsibility to ensure systems are only deployed when it is safe to do so.
- 1.9. There is a risk that the significant media interest in 'driverless cars' encourages manufacturers to use misleading language in their marketing and advertising. Some adverts already appear to give the impression that a car with sophisticated ADAS is a 'driverless car', when it is not. In fact, the technology relies on the driver to remain in overall control of the vehicle. Any technology offering 'driver assistance', however advanced, by definition is reliant on a driver. Eventually, fully automated driving is expected to be possible, supported by redundancy systems that will not require a 'driver' to intervene in an emergency. Until then, the practical reality is that if drivers feel encouraged to remove their hands from the wheel, it is likely they will also remove their eyes from the road ahead and turn their concentration away too. These risks will need, therefore, to be carefully managed and it will be essential that these are adequately addressed by the vehicle 'Type Approval' process and also within the relevant UK regulations (such as the Highway Code).
- 1.10. More broadly, there are three issues of particular significance that will also need to be addressed before fully automated vehicles are approved for use on the road –
  - **Accident Data** – It will be essential for the insurance industry to have access to relevant vehicle data, in a usable format, for use in the instance of a claim, where it will be essential to know whether the automated technology was being operated at the time of an incident and, if so, if it was being operated in line with manufacturer instructions and regulations. Failure to ensure this data is available in an accessible format could lead to unnecessarily protracted disputes.
  - **Accurate Information on Vehicle Specifications** – The Government has proposed that the Modern Transport Bill will create a requirement for cars enabled for automated driving to be covered by an appropriate level of insurance. It will therefore be essential for insurers to be able to verify what technology is available for use in the car, in order to meet this requirement. More broadly, insurers will need to understand what technology is used in cars to ensure they are able to accurately assess the risk and set a competitive premium.

- **Vehicle Parts and Repair Costs** – Increased sophistication of vehicle technology has inevitable consequences for the cost of repair, both in relation to the cost of parts and the skills required to perform repairs (both for ongoing maintenance and in the event of an incident). It will be vital to maintain the capability for competition within the repair network and vehicle aftermarket, both in order to ensure consumers are not disadvantaged and to allow insurers to manage the costs of any claims.
- **Arrangements for driver assistance technologies** – Consideration should also be given by Government to these issues when they apply to the increasingly sophisticated assistance technology likely to be fitted to cars before full automation is possible. In circumstances where faulty assistance technology may have contributed to the accident, a proportionate degree of data sharing would make disputes between drivers (and their insurers) and manufacturers easier to resolve. It would also be in the wider interests of ensuring a clear pathway to full automation for all parties to begin developing closer relations in advance.

1.11. We see no reason why these issues should prevent the successful uptake of automated driving technology, as we believe it will be in the interests of all stakeholders to address them. However, it will be important that policymakers address these issues as they develop the regulatory framework that will underpin the use of this technology.

### **3 How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

- 1.12. The ABI is only in a position to comment on what the likely impact of this technology on the insurance industry would be. It is too early to answer this question with absolute certainty. Ultimately, this will depend on the real-life claims experience. However, the initial assumption of the insurance industry is that, provided the safety performance of automated driving technology is as predicted, this will reduce the overall frequency of road accidents, and as such will reduce costs overall, including for those vehicles not equipped with the technology.
- 1.13. Furthermore, the likely increase over time in market penetration of vehicles with Advanced Driver Assistance Technology (ADAS) suggests that, by the time vehicles equipped with fully automated driving technology are on our roads in significant numbers, the “conventional vehicles” of today will be fewer in number and fully automated vehicles may be interacting largely with sophisticated ADAS equipped vehicles (the next generation of conventional vehicles) more than with “fully manual” ones.
- 1.14. That said, a number of factors could ultimately determine whether there are any additional costs related to insurance for automated driving, including:

- Frequency of incidents where the driver of a ‘manual’ car is the at-fault party in an incident involving an automated car.
- The mix of drivers – were those drivers who continue to use ‘manual’ driving technology to be those with less safe driving behaviour and/or worse claims histories, there could be an associated impact on premiums.
- The speed of penetration of ADT technology and the ease with which other drivers adapt to how this technology works.
- Any change in the cost/availability of parts for ‘manual’ vehicles.
- As ADT penetration within the market increases, there may be a reduction in the number of engineers who specialise in the skills needed to repair and maintain manual cars.

#### **4 How much is known about public attitudes to autonomous vehicles?**

- 1.15. The ABI is aware of a number of surveys that have been conducted to assess consumer attitudes to this technology. However, the view of the insurance industry is that – while the technology is still in development and trial phase – such consumer surveys may have limited value. Several ABI members are active partners in the ongoing UK Government funded trials of automated driving technology.<sup>4</sup> We believe the results of these and other trials should be used to guide how consumer and public attitudes are addressed as the technology develops.
- 1.16. Insurance is an enabling sector. Clarity on how these vehicles will be insured and certainty that consumers will not be disadvantaged as a result of accidents for which they were not responsible can be expected to have a significant positive impact on public attitudes to this technology.
- 1.17. One potential area of concern is a common perception that the public do not prioritise safety systems when purchasing new cars (put crudely, anecdotal experience suggests that if consumers have a limited budget for optional features to be added to their car, they would select a top of the range in-car entertainment system over an optional fitment AEB system). Consideration should therefore be given by all stakeholders to how take-up of technology with a clear safety benefit can be incentivised. It is also worth noting that, while an individual driver may not see a viable cost/benefit incentive to purchasing an expensive optional added safety feature, the aggregated effect of reduced accidents on the efficiency of the road network is potentially very significant, and would more than justify the investment in this technology.
- 1.18. As previously mentioned (paragraph 2.1), the insurance industry has already demonstrated its willingness to play its part in incentivising the take-up of safer driving technology with its approach to Autonomous Emergency Braking. Any vehicle where AEB is fitted as standard will receive a lower insurance ‘Group

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<sup>4</sup> Full details of the ongoing Innovate UK funded trials are available here:

<https://www.gov.uk/government/collections/driverless-vehicles-connected-and-autonomous-technologies>

Rating<sup>5</sup>, which can lead to significant reductions in the premium charged to customers. The insurance industry opted to introduce this incentive before it had collected claims data reflecting the safety benefits, a demonstration both of the insurance industry's confidence in this technology and its willingness to embrace developments that will improve road safety outcomes.

## 5 What is the scale of the market opportunity for autonomous vehicles?

- 1.19. Insurers are strongly supportive of the development of this technology, which has the potential to have an even greater impact on road safety as the invention of the seatbelt. There are also significant benefits to society and the economy from extending mobility to those currently unable to drive and to making the road network more efficient.
- 1.20. The significant interest from the insurance industry in this technology is demonstrated by the creation of the ABI and Thatcham's joint 'Automated Driving Insurance Group'.<sup>6</sup> This group includes representatives from leading motor insurers and leading industry stakeholders. It has met regularly during 2015/16 to facilitate the development of the insurance industry's position on these issues and to enable engagement with key stakeholders, including from Government, regulators, vehicle manufacturers and other stakeholders. The creation of this group demonstrates the insurance industry's commitment to adopting a pro-active and collaborative approach to automated driving technology as it develops.

## CREATING AN ENABLING ENVIRONMENT

### Research and development

## 6 Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?

- 1.21. The facilities available for demonstrating low speed autonomous pod-type vehicles are now well developed with a range of trials underway (and potentially more to come with further rounds of Innovate UK funding). While this form of automated driving may well become prevalent in dense urban areas, other forms of automated driving are also likely to be developed that will allow the technology to be used for semi-rural and inter-urban travel. This is likely to involve vehicles that look much like ordinary cars that are capable of driving in both manual and automated mode. Although, in some respects, these semi-rural

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<sup>5</sup> Group Rating is an advisory system, administered by Thatcham Research on behalf of the ABI, which provides an assessment of the relative risk of new vehicle models, with factors considered including safety, security and ease of repair. More information on group rating is available here: <http://www.thatcham.org/what-we-do/group-rating>

<sup>6</sup> Members of the group are: Admiral, Ageas, Allianz, Aviva, AXA, Co-operative Insurance, Covea, Direct Line Group, esure, LV, Markerstudy, RSA, Zurich, the Lloyd's Market Association (LMA) and the Motor Insurers' Bureau (MIB).

and inter-urban driving environments are less complex, they are also typically much higher speed. Few, if any, demonstration facilities exist that allow safe, controlled experimentation at high speed on a road with geometric, visual, radar/lidar and communication properties of Motorways, dual carriageways and other high speed elements of the primary route network.

- 1.22. The ability to test and evaluate this form of automated vehicle would be greatly enhanced by a dedicated section of off-road track capable of accurately simulating high speed roads up to and including motorways.

**7 Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

- 1.23. There appears to be a strong and healthy group of innovative businesses operating in this field (including several spin-outs from academia). The work of C-CAV and Innovate UK should also increase public awareness and acceptance of vehicle automation. One clear benefit of the Innovate UK-funded trials is that, through the involvement of several ABI members in consortia, attention is being given to how these vehicles are insured.

- 1.24. However, it appears that the focus of the Government's attention appears to be the driverless 'pod' style vehicles, which will seemingly be most suitable for inner-city and urban driving. However, of equal importance will be the automated driving technology that could be used for inter-urban and semi-rural driving (i.e. on motorways). This is likely to be rolled out, initially, by established vehicle manufacturers. The insurance industry would recommend that more attention should be given to research and development focused on the technical standards that will underpin the 'Type Approval' process for new vehicle models.

- 1.25. We understand that there are already ongoing discussions, primarily within the global UNECE framework for vehicle Type Approval<sup>7</sup>, about what changes will be needed to how specific vehicle models with automated functionality are authorised for use. We are concerned that some of the proposed regulatory requirements appear to be being developed without a substantial quantity of scientific evidence and research – perhaps because of the desire to ensure the regulatory framework is in place before manufacturers begin seeking to bring automated vehicle technology to market.

- 1.26. In order to address this concern, the Government could potentially fund applied research to help define the appropriate technical standards that would underpin the global regulatory framework for Type Approval of new vehicle models. If

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<sup>7</sup> It is our understanding that such systems are under active consideration as part of an ongoing review at UNECE level of steering system regulations (Regulation 79), and that this means it is likely they will be able to receive type approval within the 2-4 year timeframe.

such research could be completed to high standards, but with a fast turnaround, this would allow the global regulatory framework to be updated in good time.

Were the Government to provide funding for such a project, it would therefore quickly and safely remove the barriers to taking the innovative technology research already being funded by Innovate UK and making it a commercial proposition available to motorists.

**8 How effective are Innovate UK and the CCAV in this area?**

- 1.27. As outlined above (paragraph 7.1-7.4), Innovate UK and CCAV are working very effectively at generating a strong ecosystem of small innovative companies producing hardware and software elements required for automated vehicles. However, this work needs to be more proactively coordinated with work on technical standards and Type Approval of vehicles (where key decisions will be taken at a global level through the UNECE process.)

**9 Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

N/A

**Real world operation**

**10 Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

- 1.28. For the insurance industry (as already indicated in the answer to Question 2 above) access to data and information on vehicle specification/capability will be crucial. Consideration will therefore need to be given to how data related to the use of automated driving technology is stored and accessed. These issues are already actively being explored by the insurance industry as part of the Automated Driving Insurance Group (ADIG)'s ongoing agenda. The operation of an 'event data recorder' is also being explored in the context of the MOVE-UK consortium<sup>8</sup> (one of the projects being funded by Innovate UK).

- 1.29. More generally, given the expectation that the Modern Transport Bill will include a clause requiring consumers to ensure they have adequate insurance in place to cover the use of automated driving technology, consideration will need to be given to how insurers verify what technology has been enabled on a vehicle. This will also need to be considered in the context of maintaining a competitive and efficient network for vehicle repair and maintenance. It will be important to have

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<sup>8</sup> Partners to the MOVE-UK consortium include: Bosch, Jaguar Land Rover Limited, TRL Limited, The Floow Limited, Direct Line Insurance and the Royal Borough of Greenwich. Funding for this project was confirmed in February 2016, with more details available here: <https://www.gov.uk/government/news/driverless-cars-technology-receives-20-million-boost>

ready access to information about what parts need to be replaced and/or re-calibrated to ensure the vehicle can be driven safely following a repair.

1.30. Many of the automated driving systems will require ongoing upgrades and maintenance (including, potentially, via over the air software updates). The insurance industry would expect there to be regulatory oversight ensuring that safety-critical upgrades are performed and clarifying where the responsibilities of manufacturers and registered keepers lie in relation to ongoing maintenance of the vehicle. It is likely that this will need to be supported by digital infrastructure that will be capable of verifying that necessary upgrades have been performed. In addition, the insurance industry would welcome clarity from Government on the extent to which it envisages highway infrastructure and vehicle-to-infrastructure (V2I) technology underpinning the use of this technology.

**11 How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

1.31. The insurance industry supports the proposal contained within the recent C-CAV ‘Pathway to Driverless Cars’ consultation that a “rolling programme” of regulatory reviews should be implemented. Automated driving technology has worldwide applications and the underlying technology will continue to evolve. Changes will require continuous review and the regulatory framework needs to deliver certainty of principle while maintaining sufficient flexibility to be adaptable to changes. A rolling programme will allow regulatory change based on experience and due reflection, particularly bearing in mind the considerable amount of interdependent national and international regulation that has built up.

1.32. In that respect, it is vital that, in addition to the issues being considered in the context of the Modern Transport Bill, the UK Government actively works with its worldwide counterparts to establish:

- Universally agreed, easily understood, consumer-friendly definitions of advanced driver assistance systems and automated driving systems; and
- Universally agreed minimum and maximum technical requirements for different levels of ADAS and for ADT, binding upon all involved parties.

1.33. In addition, as the technology becomes commercially available, it will be important (as emphasized in paragraph 2.3) that the marketing and sales process for these vehicles pays due regard to informing drivers about the safe use and capability of these vehicles, and does not market something as ‘driverless’ irresponsibly. We would also envisage the driving test being amended in due course and also note the proposals in C-CAV’s ‘Pathway to Driverless Cars’ consultation to amend the Highway Code.

**14 Does the Government have an effective approach on data and cybersecurity in this sector?**

- 1.34. The insurance industry recognises that, with the technology itself still at a comparatively early stage of development, further consideration will need to be given to these two issues and it would not be realistic to expect such issues to be settled at this stage. We have already set out our views on the importance of data in Question 2.
- 1.35. With regards to cybersecurity, a crucial distinction will be between potential cyber breaches affecting individual vehicles and ‘systemic’ attacks across an entire vehicle fleet or cohort. In the event of a systemic attack, it is clearly inappropriate that this be seen as a responsibility for motor insurers<sup>9</sup>, and if adequate alternative measures are not established, this could make providing insurance for automated vehicles unattractive or even entirely unviable.

**13 Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

- 1.36. Yes. The ABI and Thatcham have already provided a detailed response to the recent C-CAV consultation as part of its ‘Pathway to Driverless Cars’ work.<sup>10</sup> If required, we are happy to answer further questions from the committee on the detailed policy proposals contained in this response, which were developed following extensive consultation with ABI members and legal experts.
- 1.37. In this response, the insurance industry proposed that, for the first wave of vehicles that are capable of fully automated driving (likely to initially be used on motorways and for parking manoeuvres) the Government should require an extension of the existing motor insurance policy, and associated terms and conditions – maintaining a ‘single policy’ approach – and the Government should also create an associated right of recovery (allowing insurers to claim costs from manufacturers, developers or other stakeholders where they are ultimately responsible for a road accident). Our response to the C-CAV consultation makes detailed proposals for how such a right of recovery could work. This would ensure that automated driving is covered and provide cover for the ‘not at fault’ driver as well as passengers and (external) third parties.
- 1.38. However, the insurance industry does not believe that the appropriate mechanism to achieve this is through extending the application of ‘product liability’ insurance (as was proposed in the original C-CAV consultation

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<sup>9</sup> A more detailed explanation of this issue and the need for separate arrangements for a systemic cyber-attack on automated vehicle systems is contained in the ABI/Thatcham response to C-CAV’s recent ‘Pathway to Driverless Cars’ consultation, available here:

[https://www.abi.org.uk/~media/Files/Documents/Consultation%20papers/2016/09/090916\\_ABI\\_Thatcham\\_response\\_CCAV\\_Automated\\_Driving\\_Consultation.pdf \(p.18\)](https://www.abi.org.uk/~media/Files/Documents/Consultation%20papers/2016/09/090916_ABI_Thatcham_response_CCAV_Automated_Driving_Consultation.pdf (p.18))

<sup>10</sup> Our response to the consultation has been published in full here:

[https://www.abi.org.uk/~media/Files/Documents/Consultation%20papers/2016/09/090916\\_ABI\\_Thatcham\\_response\\_CCAV\\_Automated\\_Driving\\_Consultation.pdf](https://www.abi.org.uk/~media/Files/Documents/Consultation%20papers/2016/09/090916_ABI_Thatcham_response_CCAV_Automated_Driving_Consultation.pdf)

document). While existing product liability terms and conditions are appropriate in their current settings, we believe existing practices would need to be significantly altered if this system were to be extended to deal routinely with road traffic accidents. We believe this would be disproportionate and unnecessary. Instead, the insurance industry's proposal that existing motor insurance is expanded to cover automated driving would meet the Government's intended policy outcomes without disrupting established insurance covers for other technologies.

- 1.39. It is clear that there will need to be a consistent approach to this from manufacturers. In their public statements, some manufacturers (notably Volvo) have stated that they would accept that they are liable for incidents where the automated driving technology failed and caused an accident. Other manufacturers have appeared to suggest that they would see the driver as ultimately responsible for any accidents, and as a result would not necessarily accept liability. It is unclear how much engagement there has been between vehicle manufacturers to establish an 'industry wide' position on these issues or to agree common definitions. It is our impression that the different views in individual manufacturer's public statements do not necessarily reflect different approaches to the fundamental legal/regulatory questions under discussion. Instead, they appear to reflect different approaches to the technology itself, with some manufacturers committed to 'fully automated' driving, with the 'driver' fully disengaged (in which circumstances, it would be entirely unreasonable to hold someone liable for an accident they could do nothing to prevent) and other manufacturers developing technology that will depend on interaction with an active and alert driver (in which case, it may seem more reasonable to continue to hold that driver ultimately responsible for preventing an accident). We expect that the UK Government's work on the Modern Transport Bill will prompt vehicle manufacturers to engage constructively on these questions on an industry wide basis. It is clear that regulation cannot be 'brand specific', and that all vehicles on the road will ultimately need to be bound to the same safety standards and regulatory framework.
- 1.40. We await the Government's official response to this consultation and the proposals that will be published in the Modern Transport Bill. In future years, as technology develops further, we recognise that achieving the right insurance objectives will require further attention from regulators and Government. However, we believe decisions on this should be taken in light of the experience with the first wave of this technology.

**14     What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

- 1.41. The insurance industry recognises that this is a matter worthy of attention as safety standards for automated driving are set. We do not have any detailed evidence on this issue, beyond cautioning against a disproportionate response to

these issues. Although the UK has seen significant improvements in road safety outcomes in recent years, there are still far too many people killed and seriously injured on UK roads.<sup>11</sup> As such, automated driving technology should be measured in relation to its potential to reduce the number of deaths and serious injuries that would otherwise have occurred, and regulatory decisions taken accordingly, rather than holding this technology to a potentially unrealistic standard.

## **Wider governance**

### **15 What does the proposed Modern Transport Bill need to deliver?**

- 1.42. The insurance industry regards the proposed legislative change to deal with insurance arrangements for the first wave of automated vehicles as essential to give industry and consumers clarity. We see the Government's commitment to setting a clear direction in advance of the technology being commercially available as very welcome.
- 1.43. Beyond this, the insurance industry hopes that the Modern Transport Bill will be an opportunity to set out how the process of ensuring all stakeholders are able to work together to manage the needs and expectations of drivers and consumers as this technology develops. We recognise that it will not be able to resolve every question, given that the Bill will become law several years before the technology itself is commercially available, but the Bill should set out a framework through which all stakeholders can collaborate to resolve these questions.

### **16 How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

- 1.44. Autonomous vehicles will require highly complex and sophisticated sensors and technology. Most forecasters anticipate that autonomous vehicles will be more heavily utilized than traditional vehicles (i.e. each individual vehicle will be on the road for a greater proportion of the day) and that, despite the safety benefits, they will still suffer occasional accidental damage, not just from road traffic accidents but also from falling objects, road debris, windscreen damage and vandalism.
- 1.45. The UK currently enjoys a vibrant independent repair sector that helps to maintain competition and control the costs of both service and repair. It is vital that the technical education sector is supported in developing a wide range of technicians capable of repairing autonomous vehicles. As such, the insurance industry is concerned that the current funding model from the skills funding

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<sup>11</sup> IN 2015, there were 1730 reported road deaths, 22,144 reported serious accidents and 186,189 reported casualties of all severities on UK roads. Source:

[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/556385/rrcgb2015-00.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/556385/rrcgb2015-00.pdf)

agency (SFA) discourages skilled candidates from training for a career in the independent repair sector. If this skills gap is not filled, then it will leave vehicle manufacturers as the only organisations capable of providing the training and skills. The independent repair sector is a vital part of maintaining a competitive environment for vehicle repairs, and ensures insurers are able to manage and control the cost of repair work.

- 17 Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

N/A

- 18 What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

- 1.46. The UK has significant potential to become a world leader in this technology, and the forward-looking approach adopted by the Government to automated driving is therefore welcomed by the insurance industry. We are not aware of any reason why the terms of Brexit should directly affect the ongoing research and development into how automated vehicles will be used.
- 1.47. It will be vital, however, that the UK recognises that there is a significant international dimension to this debate, and that the broader interests of the UK insurance industry<sup>12</sup> are acknowledged and protected, in order that the potential for insurance to act as an enabler for this technology is realised.
- 1.48. As discussed above, the technical regulations used as part of the Type Approval system that currently governs vehicle design across Europe are formulated by the United Nations Economic Commission for Europe (UNECE). This acts as a forum for the global harmonization for automotive regulations. The UK has been a member of the UNECE agreements since considerably before its membership of the EU began. The insurance industry is not aware of any plans for the UK to withdraw from the UNECE.
- 1.49. The environment for research, development and the wider supply chain for the design and construction of automated vehicles will inevitably depend on general health of the automotive industry in the UK. The facilities required for research and development around automated vehicles are expensive, and are often financially supported by the demand for ongoing and routine test work after the

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<sup>12</sup> The ABI has recently set out the strategic objectives of the UK insurance industry within the context of the UK's EU Exit here: <https://www.abi.org.uk/News/News-releases/2016/09/ABI-sets-out-five-priorities-to-make-the-best-of-Brexit>

initial research is done. Thatcham Research has relied on this business model to fund its development of cutting edge testing that has demonstrated the safety benefits of a range of ADAS technologies and the insurance industry plans to continue with this approach to research and test the capability of new innovations in vehicle automation.

- 1.50. However, if fewer vehicles were to be developed in this country, there would be a reduced volume of routine test work for Thatcham and other research institutions, test houses and proving grounds. This would undermine the UK's ability to fund the investment in cutting edge technology to test the most innovative developments in automated driving. Therefore, in order to meet the ambition of making the UK a world leader in automated driving, the Government must ensure it retains a competitive vehicle manufacturing industry and associated repair and testing network.

*26 October 2016*

## **Association of Personal Injury Lawyers (APIL) – Written evidence (AUV0023)**

*Letter from Sam Ellis, Parliamentary Officer, Association of Personal Injury Lawyers*

### **Autonomous Vehicles**

1. The Association of Personal Injury Lawyers (APIL) is a not-for-profit organisation which is dedicated to campaigning for improvements in the law to enable injured people to gain the full access to justice they deserve. Our members comprise principally practitioners who specialise in personal injury and whose interests are predominantly on behalf of injured claimants, including those involved in road traffic accidents.
2. APIL welcomes the opportunity to respond to the committee's inquiry into autonomous vehicles. Due to the nature of our work and the work of our members, we have limited our comments to the question of insurance.
3. It is vital that there is insurance in place which can provide financial compensation to those involved in an accident caused by an automated or partially automated vehicle. Section 145(3)(a) of the Road Traffic Act 1988 states that a motor insurance policy "must insure such person...in respect of any liability which may be incurred by him or them in respect of the death of or bodily injury to any person or damage to property caused by, or arising out of, the use of the vehicle on a road in Great Britain". Section 185 of the Act defines a "motor vehicle" as a "mechanically propelled vehicle intended or adapted for use on roads".
4. The existing insurance framework should, therefore, already provide that automated and driverless vehicles are covered by compulsory motor insurance. For the avoidance of doubt, however, there should be a specific reference in legislation to the need for compulsory motor insurance for these vehicles.
5. The proposed Modern Transport Bill provides an opportunity to clarify the law on insurance for automated and driverless cars. Part VI of the Road Traffic Act could either be amended by the Modern Transport Bill, or the Government could repeal Part VI, and include the provisions within the Modern Transport Bill with a specific reference to automated and driverless cars.
6. The recent consultation by the Centre for Connected and Autonomous Vehicles (CCAV) proposed amending the Road Traffic Act 1988 to "extend the compulsory insurance requirements for automated vehicles so that the owner must also ensure that there is an insurance policy in place that covers the manufacturers' and other entities' product liability"<sup>13</sup>. We do not believe that this is necessary, as the driver of an automated vehicle should already have cover under his existing motor insurance policy if, for example, the car crashes of its own accord and injures the driver after he has handed full control over to the vehicle.

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<sup>13</sup> Centre for Connected & Autonomous Vehicles, Pathway to Driverless Cars: Proposals to support advanced driver assistance systems and automated vehicle technologies, July 2016, page 18.

*25 October 2016*

## Atkins – Written evidence (AUV0047)

### **Q1**

The range of potential applications for autonomous vehicles is significant, we are already seeing solutions in farming, mining and ports and from there, over time, we can see opportunities to further unlock economic value, increase efficiencies and improve safety.

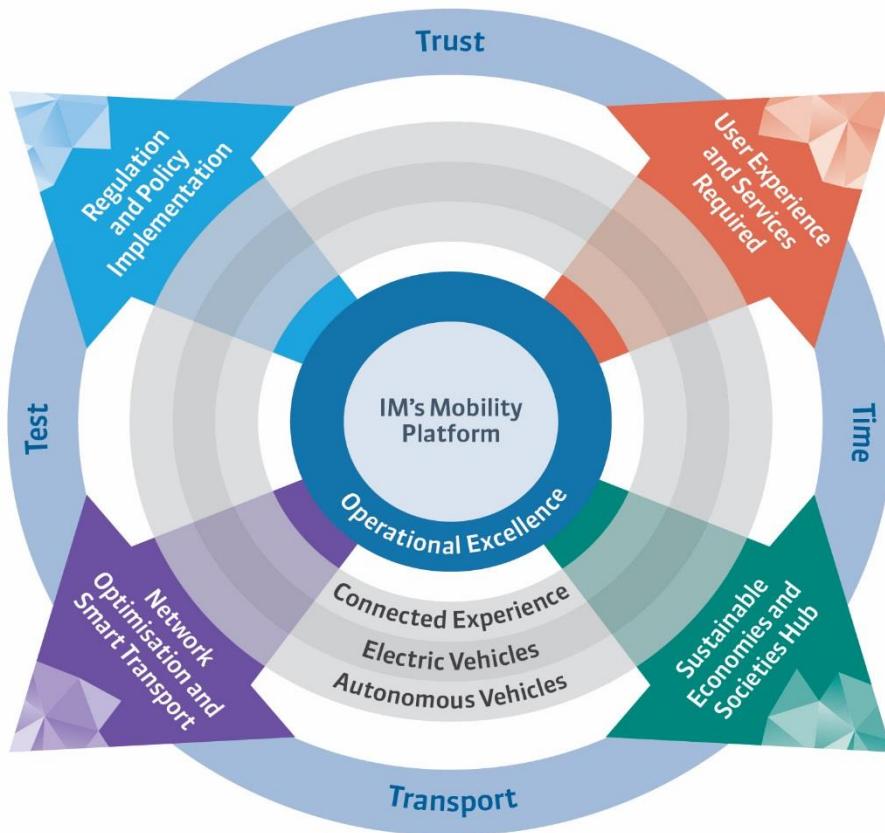
In the roads sector, examples potential applications include road maintenance, asset management, platooning vehicles, passenger movement through private vehicles, small pods and buses. The airport sector has some near term opportunities that leverage existing technologies and are arguably less problematic to implement than in the roads sector.

Examples include air side solutions around plane movement, baggage movement and landing bridges. Clearly air craft already have autonomous capability and we think it will be sometime before full autonomous flights for mass transit are a reality that said for personal travel research and deployment of solutions for personal travel and cargo are nearing completion. Moving landside, we see opportunities around concourse passenger movement, baggage movement, flight connections and onward connections to other modes of transport, examples of driverless shuttles already exist.

We see in rail and mass transit a mix of capabilities, the rail sector in the UK as it progresses on its digital journey that opportunities will arise in the long term (2030+) but in other forms of mass transit that solutions already exist, for example, London Underground and Docklands Light Rail.

### **Q6. To Q9**

Atkins believes that Connected and Autonomous Vehicles are part of a connected ecosystem, and as such, for penetration to be achieved that in turn offers a positive change, the exploitation of an Intelligent Mobility platform that links the various data sets together to provide trusted, reliable, and optimised transport must be at the heart of the UK's focus.



Atkins believes that more can be done to sustain growth in the Intelligent Mobility market which in turn, will directly influence the use and deployment of Connected and Autonomous Vehicles.

The UK transport network is under increasing pressure to better identify, plan and deliver solutions that address the multiple challenges currently crippling the sector. On-going demands and expectations for a more efficient, accessible network that improves safety and capacity and reduces congestion, is at a pivotal point where innovative provisions are necessary to avoid a race to the bottom.

Expanding and ageing population numbers and urbanisation are a couple of the socio-economic factors impacting on the transport network. In response, the industry has called for the implementation of Intelligent Mobility to successfully support the network in boosting productivity and generating long-term sustainable growth across the nation. This new initiative will harness the potential of emerging technologies to create an integrated network capable of transforming the sector - from future infrastructure design through to service delivery. It brings a new focus to optimising 'the way we approach mobility'. That is, specifically looking at how to use technology and data to connect people, places and goods across all transport modes in a smarter way. Intelligent Mobility is rapidly gaining momentum and is considered a game changer.

The UK needs a strong Intelligent Mobility market. Although progress has been made in terms of the government's ongoing support for research and development projects in the field of Connected and Autonomous vehicles, there is still no clear, well defined vision for the market. Much more needs to be done in order to make Intelligent Mobility a tangible offering. Moving forward, this will mean a pronounced shift in thinking in addition to the realignment of investment and delivery.

There are four core principles necessary to support the implementation of Intelligent Mobility:

- Government and industry must implement a roadmap from conceptualisation to completion with clear parameters suitable to drive efficient collaboration, optimise growth and navigate potential risks;
- An independent authority, like the National Infrastructure Commission, should take on the role of the 'guiding mind' - to remove fragmented decision making, create opportunities for growth, make regular assessments on the feasibility of projects and encourage a cross-sectoral approach to delivery; and importantly
- In addition to the current Research and Development awards being made, direct provision must be provided in order to drive the adoption of Intelligent Mobility as a Business as Usual activity.
- The UK needs to establish a policy and regulatory framework that facilitates an eco-system of innovation.

Atkins understands that a 'one size fits all' approach is not possible to achieving an intelligent and fully integrated network and therefore calls on government to set out a cross-party industrial strategy that turns ideas into commercial success while stimulating better outcomes across our transport network.

Technology is increasingly central to our lives both within the public and private realm. However, the pace of change along with the vast array of choices entering the market, is often confusing and challenging for public bodies to understand and to make the best use of new developments in this area. Questions around risk management, safety and security must be balanced against increased capability, new intelligence and skills creation.

In recent years, the concept of Intelligent Mobility (IM) has gathered momentum. Identified by the UK government as a £900bn market, IM is expected to revolutionise the way we travel. The application of new and disruptive technologies is set to impact on the role of transport, customer behaviours and expectations.

The Transport Systems Catapult has identified the primary goals of Intelligent Mobility as follows:

- Make travelling an end-to-end user-centric experience;
- Make our transport system more sustainable and reduce its environmental impact;
- Save many lives;
- Generate billions when moving people and goods;
- Make our transport systems more resilient;
- Make our transport assets more productive;
- Improve accessibility for all segments of society;

- Make transportation of people and goods quicker.

Technology is converging and as new products and systems enter the market, be it Connected or Autonomous vehicles, mobile phone applications or the Internet of Things; they are all interconnected, sharing information about their users and surroundings. This raises several questions around the management, accountability, governance and commercialisation of data. More specifically:

1. Who is sharing what information and with whom?
2. Who is responsible for the information being shared?
3. How is the process regulated i.e. who is making the decisions based on this new data?
4. How is it being commercialised and how can skills be created in line with market demand?

Technology is an enabler; and as we move from experimental to everyday it will reshape the design and delivery of transportation. If the UK is to compete in the global race and shape the IM market in the coming five to ten years, then government must be proactive in building a robust link between current funding and establishing a credible long-term vision that encompasses all elements of Intelligent Mobility beyond Connected and Autonomous vehicles.

As steps in R&D investment continue to move in the right direction, the challenge rests with government's ability to facilitate an environment where both public and private sectors are able to capitalise on the opportunities presented by Intelligent Mobility.

The points listed below outline the steps government must take in order for IM to become an exemplar for innovation and These actions will position UK plc as a leader in this market, driving jobs, growth, more efficient and safer journeys for citizens and better connectivity for businesses with customers and supply chains.

- 1. Develop a nationwide co-ordinated approach to IM and its subsequent implementation.**

If it is worth £900bn, how do we make sure we are creating opportunities for the UK? Establishing an industrial strategy that seeks to support Intelligent Mobility in order to encourage economic growth and add value to the current infrastructure pipeline will allow government and industry to capitalise on this new market.

Innovation is part of the UK's DNA. However, converting this to sustainable and long term growth and job creation must be a central focus of IM in the UK. A national strategy must reflect a global understanding of the diverse market. There are a number of advisory groups operating in the IM sector, such as IM-PACT and the Technology Forum performing UK focused activities in this area. To build on this activity, it is necessary to develop a cogent capability framework in the short term that allows for internal investment to be focused as well as identifying international gaps where UK businesses can play a key role. This will help to deliver a capabilities review for Intelligent Mobility in the UK, which can be benchmarked against global competitors and identify investment opportunities.

**2. Create tangible demonstrators linked to everyday performance that highlights the value of IM and prove their worth to the UK plc.**

Showcase demonstrators are a key part of the IM value creation. It is important to demonstrate novel capability and expertise that readily highlights the UK's role in the IM space. It is proposed that this must be taken one step further and linked to an active 'business as usual' deployment programme, in order to differentiate from our global competitors, where demonstrator projects are becoming much more prevalent. To ensure sustainable success, this programme must include consideration of the commercial implications as well as the short to medium term roll out requirements. Demonstrators must be inclusive, highlighting how technology and people are working together to provide a range of socio-economic benefits which includes providing transport solutions for an ageing population.<sup>14</sup>

**3. Make the distinction between Connected and Autonomous and develop a detailed value proposition for their deployment through a robust business case.**

It is clear that Autonomous (Driverless) Vehicles offer an exciting and challenging future to our approach to Transportation, both in the UK and Globally. Unfortunately, it is also very clear that Connected Vehicles (with a driver) are either being ignored or under-appreciated in terms of what they can offer today. Connected capability is linked but separate to Autonomous vehicles. Connected Vehicles must be approached as a distinct offering in the market place, with strong overlaps to the world of Autonomy, but recognising the world where a driver is always in control, but more and more dependent and expecting of services provided through digital connectivity.

Job creation, inward investment and the exportation of capabilities such as intellectual property, products and systems, underpin the UK's focus on CAVs. Significant expertise exists within the UK automotive industry to drive this forward but only if this is leveraged and maximised. However, CAVs (as one aspect of Intelligent Mobility) reflect a changing world and as a result, an evolving supply chain, from semi-conductor companies to wireless and discrete sensor providers. The business case across the value chain must be fully understood, articulated and supported by on-going validation in line with changes in the technology and OEM focus.

The role of the Centre for Connected and Autonomous vehicles (C-CAV) should be expanded to assume a wider narrative by helping to create the infrastructure (both physical and regulatory) to drive long term investment and enable CAVs to succeed in the UK.

**4. Understand the impact on current and future infrastructure.**

The existing road network is based on principles of design that must be reviewed with the advent of CAVs. For example, the use of crash barriers, lane width and capacity optimisation should be understood from an infrastructure perspective including opportunities for significant financial savings and better land use. Understanding the changes needed now and in the future and how these will be undertaken is key. Risk assessments for network operators and Local Authorities, a defined methodology along with the modelling of new

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<sup>14</sup> It is estimated that between 2015 and 2020, the general population is expected to grow by 3 per cent with the number of those aged over 65 increasing by 12 per cent during the same period.

vehicle behaviours must be undertaken to ensure that safe but network optimised designs are created. Existing communications networks must be mapped against future needs and a complete review of legacy equipment and their capabilities must be undertaken in order to understand what can be exploited or needs to be replaced.

**5. Challenge the industry to establish sustainable Mobility as a Service (MaaS) deployments linked to central funds and invest in establishing public and private partnerships for the exploitation of new customer-centric services.**

Local government and associated cities look to central government to form a unified approach to the implementation of MaaS. Without a strategic and policy-led approach, there is a distinct risk that various regions and cities will develop solutions that are then delivered in silos and the overall value to the UK plc is significantly reduced. It is imperative that strong leadership is shown in developing a national perspective on MaaS and that government leads on this. This is significant in light of the devolution agenda and transfer of powers to local authorities. The National Infrastructure Commission may have a role to play in providing recommendations that best support the roll out of Intelligent Mobility across the UK to ensure consistency and establish a delivery timeframe that facilitates regional and national growth.

**6. Establish the testing and benchmark conditions for deployment and license of CAVs.**

Testing and validation of the technology, as well as the user requirements, is central to the success of CAVs. Private test tracks and virtual environments are important, in line with traditional approaches, but a system approach is needed for CAVs. This means that the city, the roads and users for example, must be considered as key elements and the UK must provide a mechanism for testing to take place in a real world environment that is safe and secure by design. Benchmarking, which can establish the UK as a global reference point, must be created in the areas of performance, safety, and risk at a technical, behavioural and local level. The government has outlined its ambition to ‘make the UK a centre for driverless vehicles’ and our forecast indicates that with direct investment and service creation, the development of a world class test facility is feasible. In the case of the Atkins led VENTURER ‘driverless car’ research and development programme, research has indicated that further direct investment in a dedicated test facility will enable the creation of over 10,000 jobs across the South West region in the field of CAV development and testing by 2025.

**7. With the convergence in multiple technologies, there must be a co-ordinated business operating model across multiple themes (that links various data sets such as Block Chain, the Internet of Things, Big Data, and CAVs together).**

There must be an ecosystem, or multi-stakeholder engagement platform, that supports the successful deployment of technologies. For this to be achieved it cannot be done in isolation and the government must define at a national level what is required for a sustainable solution to take shape; one that links a number of companies with competing offers together. The UK can establish itself as market leader by developing a targeted operating model for engagement that protects and optimises the various market offerings. The government should assume the role of an enabler. This operating model must define the

engagement across parties as well as the technical requirements, such as data flow and security, necessary for implementation.

**8. Define the UK's role in sharing and exploiting data and its approach to cyber security.**

Intelligent Mobility is a data rich world. Traditional vehicle manufacturers and new market entrants will generate, as well as consume, huge volumes of data in order to drive their new market offerings. Highways England, Department for Transport and cities have access to a huge amount of existing data. However, to capitalise on this, it must be made clear what the roles of the institutions are going to be and how the organisation, the technology, and the data can be linked together in the most innovative and robust way possible. The UK can be a world leader in establishing a market focused independent data exchange role that allows for data from all providers to be handled in an anonymous way that drives value creation as well as network optimisation.

Transportation plays a critical role in society and as such should be safe by design across the planning and execution of new roads and railways. The design envelope has to consider the digital world we live in today. The National Cyber security centre is a start. However, a cyber secure framework that puts transportation at its centre must be created and an organisational culture change that creates defined cyber security elements within its operations.

**9. Establish the technology, policy and regulatory requirements for CAV for the next 5 years.**

As the UK looks to become world leaders in the deployment of Connected and Autonomous vehicles, it is vital that a regulatory framework exists which allows for such deployment to take place. It is important to create an environment where car manufacturers are attracted to invest in testing their services in the UK rather than abroad. As other countries vie for the lead position, regulation and policy on its own will not be enough. In parallel, a defined insurance strategy must be in place as well understanding the business model linked to use of data across the CAV and wider IM market.

**10. Drive a national agenda, fully integrating all aspects of transport, ensuring the rural economy is not forgotten.**

Around 18% of England's population live in rural areas and it is estimated that the rural economy will make a substantial contribution of £35 billion to the national fund in the next decade. IM, with its focus on technology driven solutions and user take up, will be dominated by urban opportunities. However, there are significant benefits to be attained in rural environments and it is necessary to make sure that rural applications are not neglected, leading to a two-tier transportation and customer service provision. Businesses must demonstrate, through a focused rural programme, a number of IM based services and offerings that can add value, both economically and socially, through a new approach to transport. This can help position UK businesses as leaders, not just from an urban perspective but a rural one as well. We recommend that the government works to drive the national agenda, full integrating all aspects of transport to boost the development of this sector.

Building a national capability will require a pooling of efforts across industry, academia and government. The identified recommendations, if implemented, will not only allow the UK to establish a strategic advantage with transformative importance to the economy, but will facilitate social benefits for all segments of the population.

It is increasingly important that the UK leads the charge in demonstrating its capabilities in a growing and nationally important market that will facilitate productivity and maintain the attractiveness and competitiveness of Britain's economy.

The National Infrastructure Commission is in a unique position to make targeted recommendations that will maximise the growth potential of transport infrastructure. Therefore, it is necessary for the Commission to consider the wider implications of Intelligent Mobility; and to adequately assess how to successfully balance the future of infrastructure delivery with the radical shift of technological applications in the transport industry. This must include a clear roadmap that helps to align industry challenges with research and development to propel a modern and fit for purpose network.

#### **Q10. Changes to digital or physical infrastructure**

Atkins believes that there will be significant changes to both the existing physical and digital infrastructure. Changes will need to be considered at a minimum in the following areas:

- Provision of information to the travelling public
- The use of on-street monitoring systems
- The use of the central reserve and barrier
- Road speed limitations and road widths
- The ownership and sharing of information between vehicle to vehicle and vehicle to infrastructure
- Maintenance requirements and monitoring facilities
- Road user charging
- Big Data Storage and Management
- Vehicle Flows and Traffic capacity management

It is Atkins considered opinion that the rate of change in technology requires immediate consideration of the above. Atkins is also firmly convinced of road authorities to understand the 'Connected' element of Connected and Autonomous vehicles as it is now available through a number of vehicle manufacturers.

Changes to the digital infrastructure will require an adoption of an end-to-end journey capability brought about through connected and autonomous vehicles and as such, the establishment of enterprise level data management and provision across a number of different sources of data at different timing.

The UK must prepare now for the coming technologies that will fundamentally change how people move and interact with the space around. The actions that cities can take to prepare for CAVs include providing the digital infrastructure required for connected vehicles, considering systems for data capture and exploitation, preparing existing infrastructure for

CAVs, considering cyber security requirements and taking on a governance and regulatory role.

Since the publication of Atkins' White Paper on Connected and Autonomous Vehicles (CAVs) in September 2015, a huge amount of relevant innovation has occurred across the world.

From vehicle manufacturers, to start-ups and government funded projects, many organisations are getting excited by the opportunities that **CAVs** present. In addition, **Electric Vehicles** are becoming more mainstream as people look for a more affordable and environmentally friendly solution to their transport choices. New technology such as Internet of Things (**IoT**) and **Blockchain** are gathering momentum with vast volumes of data being created at a staggering rate.

With so much going on, what must be done next?

The development of a **Mobility Platform** that creates the environment for these new technologies to dynamically engage is the key.

Operational excellence, both at a city level and wider, depends on the use of a Mobility Platform to understand how the 4 Ts of *Trust, Time, Test, and Transport*, are linked across a number of areas and how the various technologies in the connected physical world will merge over time.

### **Implications for Infrastructure**

The existing road network is based on principles of design that must be reviewed with the advent of CAVs. For examples, how will the use of crash barriers, lane width, and capacity optimisation change as CAVs become prevalent on the road network? There is therefore a need to understand the impact of CAVs from an infrastructure perspective. Are changes needed now or in the future and how is that undertaken?

Risk assessments and methodology must be reviewed, whilst modelling of new vehicle behaviours must be undertaken to ensure that safe and operationally efficient infrastructure is designed. Existing communications networks must be mapped against future needs and a complete review of legacy equipment and their capabilities must be undertaken in order to understand what can be exploited or needs to be replaced

### **User Experiences and Services Required**

CAVs must be about empowerment. It is an imperative that CAVs do not create a two tier society. As such, the needs and requirements of the wider community must be matched against the capabilities and opportunities that CAVs can introduce. Cities and authorities must assess the implications of private and public CAV fleets and how these can be made to work for the benefit of all, rather than the few. In particular, we need to understand how CAVs can offer new opportunities for independence to a wide user group, such as the older population and those with mobility issues, and the impact this may have on demand.

## **Network Optimisation and Secure Transport**

CAVs offer the potential of a safer, more reliable transport infrastructure. A reduction in the number of accidents and related injuries can directly improve journey time reliability and customer experience.

However, it is vital that network operators understand the value that data transmitted to and from CAVs can bring, and as such, understand the requirements this brings for their utilisation. Vehicles that can ‘talk’ to each other about their journey, the congestion they experience, and other known data points such as weather, offer a valuable resource to the network operator.

The operator must understand how these new systems can link to legacy ones and the data analytics required to make sense of it all. In addition, there is a need for authorities to accept that this digital world carries with it a new type of operational risk and as such it must be understood how the security of the data transmitted is monitored and continuously assessed in real time. It is no longer enough to sit and wait for the inevitable to take place. Actions must be taken now to protect the travelling public and the services they rely upon.

## **Modelling and the Rules Engine**

It is clear that the implication of CAVs on the wider transport network must be fully understood. There is no clear understanding of what impact such vehicles will have on network capacity. Will CAVs lead to reduced headways? And will the benefits of this be outweighed by an increased use of vehicles?

Modelling of changes in behaviour and driving patterns must be undertaken and benchmarked against real time deployments in order to create reliable and quantifiable models that underpin future designs and investments.

Development of a Rules Engine, complementary to both in-vehicle and network operators' management strategies must be created and embedded within the deployment of connected transportation. A Rules Engine will help to not only define the benchmarked behaviour of the individual vehicles themselves but also create an optimum starting point for network strategies focused on improved customer experience.

### **Q11. How might a move to extensive deployment be managed?**

Atkins believes that the move to extensive deployment depends on three areas of consideration:

1. The market USP (unique selling points) that the auto industry is looking to establish and a race to be a first deployment, at both a local and global level
2. The consumer market defining their needs across the different user groups
3. Pragmatic insurance conditions linked to clear legislative direction
4. The testing and validation of the ‘connected system’ to allow trusted and secure autonomous and connected vehicles to take place

Testing leading to Trust is a key area of focus for Atkins.

The testing, certification and validation of connected and autonomous vehicles plays a fundamental role in the adoption and usability of CAV based technology. At the heart of any deployment will be validation, ensuring elements of CAV are fit for purpose and provide both the improved user experience, and that the services developed will operate as expected under all conditions. Both within the UK and globally a number of test tracks are or will be in operation but according to a report from the Institute of Engineering and Technology (2014):

*Traditional off-road testing facilities may not be appropriate for the testing of some aspects of highly automated systems. The UK's dedicated test-track facilities do not have facilities that are configured in an urban layout with blocked sight-lines that may be important in testing how automated vehicles behave at busy junctions where it is not possible to have a direct preview of approaching traffic.*

Issues such as safety, hand over mechanism, cyber protection and usability will all have to be rigorously validated and understood, from both a manufacturer's, country and user perspective. Validation is not just technology driven. Companies will have to ensure that people, the end users, engage with CAV as expected and understand the benefits and usability of solutions on offer.

Testing and the facilities needed to perform the validation and verification needed, is very much seen as a global opportunity. It opens up avenues for job growth and IP creation. In the UK, the DfT have drafted a 'Code of Practice' that outlines a practical approach to the testing of autonomous vehicles allowing real-world testing of automated technologies to take place in the UK today, providing a test driver is present and takes responsibility for the safe operation of the vehicle; and that the vehicle can be used compatibly with road traffic law. **From a testing perspective both options must be considered and not in isolation. The physical should help optimize the virtual which in turn will be fed back to optimise the sensors and algorithms deployed on-street.**

With roads becoming increasingly 'smarter' and new types of vehicles with more and more autonomy joining daily traffic, advanced testing is recommended. Behaviour of such vehicles cannot always be predicted and the risk of testing in a real world environment is high - significantly higher than for manual vehicles. The use of simulators is crucial - not dissimilar to in-lab testing of medication before actual consumption by humans.

An automotive simulator provides an opportunity to reproduce the attributes of an actual vehicle, but in a virtual environment. External factors and conditions are replicated to such extent that the passenger – or, in the case of autonomous vehicles, the computer – has the impression the vehicle is operating in a real world environment. Simulator software can replicate real life events and situations with extreme accuracy to create a fully immersive experience. This has multitude of advantages, such as driver safety, reduced risk (no real damage to the car in case of a collision), cost reduction (e.g. fuel savings, reduced maintenance costs), and environmental advantages (reduced emissions) to name a few. The ability to safely replicate dangerous or rare situations gives simulators a unique ability in training or assessing drivers or users of (semi-)autonomous vehicles. This is equally

important when assessing how the roads of the future will deal with emergency services such as police and fire - where vehicle navigate chaotic environments at high speed. If some of the surrounding vehicles are autonomous, they will not behave in the same way a human would.

In the case of an autonomous vehicle, a virtual vehicle model is required that will dynamically behave in the simulation exactly as the robot vehicle does in reality; replicating parameters like acceleration, braking distances, cornering speed limits and suspension behaviour.'

### **Reflection**

We are on the cusp of the 4<sup>th</sup> Industrial Revolution, where the introduction of the digital age will allow people, places and goods to be continuously connected morning noon and night. . The rate of change and development with technology is truly staggering. A new 'gizmo' and mobile app is launched nearly every minute, with announcements on Connected and Autonomous vehicles made nearly every day. With this in mind, it is important to understand the short term implications and opportunities that exist with disruptive technologies. Equally important is understanding the changes that must be made today to make the transport solutions of tomorrow relevant to our operations. Our roads are beset with congestion, lack of customer engagement, and increasing levels of pollution and risks to users. The aspiration is to reduce these to Zero, to create a 'Road to Zero' where we have truly capitalised on the technology and information that his new digital age brings us.

Intelligent assets linked to the revolution taking place in Internet of Things, are becoming increasingly mainstream. The improvement in sensor technologies as well as consolidation of testing in the digital environment across this new connected world, makes it ever more important that we fully understand our role and relationships across the 'capture/process/understand/action' trail.

Connected Vehicles as well as infrastructure will play an increasingly important role in network monitoring, allowing operators to begin to implement proactive rather than reactive strategies – imagine if a car can tell you in real time that an accident is occurred, or that air temperatures suddenly dipped and salting is needed, or that weather is deteriorating and new timing strategies must be implemented. Platooning, where one truck leads and makes the decisions for those behind that connect as a road-train can allow for improved safety, fuel usage. These scenarios aren't as far-fetched as they might seem, with co-operative Intelligent Transport Systems being deployed as you read this. There is an impact across a wide supply chain that can be clustered together in four main areas:

**Infrastructure, Services, Data Management and Customer Experience.**

### **Short Term**

Technology and what it can do for us is changing before our eyes. Lots of new sensors are becoming available, both fixed and virtual, with a challenge to organisations as to how best to exploit them. Examples of this include Mobile phone data and how it can now be a source of new and vital strategy and planning information, providing origin and destination details

at a granular level. Internet of Things is a burgeoning technology and market space, and it seems particularly applicable to helping traditional assets become smart and interactive. In tandem with this, with an ever growing importance of connectivity, it is important to understand and trial a number of new communications networks in order to understand at a simple level how they work and the value of them, but more fundamentally, how we can fully exploit them across the whole digital environment. This includes WAVE, or G5, networks, LiDar on street, in-vehicle congestion management and automation etc. Technology provides the capability, but people and their tailored needs and requirements must be placed at the heart of everything we do. Scenarios where freight management schedules are linked to traffic light adaptions, dynamic priority combined with electric vehicles, automated congestion relief linked to incentives to turn off at service stations, automatically responsive junctions to dynamic loading, including cycle and pedestrian priority, are all either possible or in the early stages of implementation.

It goes without saying almost, but we cannot dare to ignore the implications around CAVs. Testing and Validation are absolute necessities in order to ensure the safety of these new systems.

### **Medium Term**

The key question here really is what is the Medium Term? With Ford and others announcing the deployment of Autonomous vehicles on the road by 2021, the horizons for change are becoming increasingly closer. It's not just about CAVs, though they will play a central part. It is also about the services that will be opened up to people and the provision of frictionless travel and information. Journey Management as a “system of systems” approach to creating an ambient and responsive capability, will not only capture but fully engage with customers.

It is at this stage that intelligent sensors/analysis will become increasingly the norm and with customers becoming more aware of the digital world in which they travel and the improved and interactive services that come on stream. A number of technology proof of concepts will now begin to morph into limited business as usual with an increased focus on delivering a ‘single source of truth’. This means that all the data sources, all the information existing both internally and externally will begin to come together in a way that the travelling public really begin to trust and relate to the information they are being exposed to. Interoperability, long used as a term for technical discussion is just as important now but from a different perspective. Services delivered for people, places and goods will need to be truly interoperable.

### **Long Term**

This is the ideal state, a future world where there are no accidents due to driver error, where there is no harmful emissions thanks to electric and alternative fuel types, and where congestion is a thing of the past. This is the **ROAD to ZERO**. Road to Zero can become a reality, with technology enabling a fundamental change in the delivery and experience of transportation services. Fully deployed intelligent assets and vehicles ensuring a comprehensive and user centric experience through dynamic real time information and choices across the network. This will be achieved through a dedicated connected and

automated intelligent motorway coupled to cutting edge communications network. Data will flow seamlessly across the various ‘actors’ and a Strategic Commander capability will be on offer to the network operator and authorities, balancing the needs of all modal types in real time. Fully automated vehicles will flow across the network and people will demand Mobility as a Service transport solutions for their end to end journey requirements.

What is our appetite for change and our fear of failure? Can we make Road to Zero happen in our lifetime and can we be brave and bold and challenge the ‘norm’ in order to achieve the ‘brilliant’?

## Q12. Cyber Security

### Cyber Maturity Framework

Cyber security is a key component of any connected and digital ecosystem. Data and information must be protected from external and internal attacks that will occur. Large global companies must both ensure and protect the flow of data across their organisation. It is vital that organisations maintain a real time understanding of the security of their network, and the threats, mitigations and weaknesses that exist 24/7. In order to achieve this the UK Government and private bodies must:

1. Understand the importance of cyber security and how their organisation addresses it
2. Define the ‘ideals’ behind their day to day security, such as ‘always protected/always monitored’ etc
3. Create the capability to deliver a ‘snap shot’ assessment of all parts of their digital chain, from devices, to communication, to information feeds etc and the impact factor associated with a breach
4. Deliver a range of counter strategies that factor in the operational and brand impact for the organisation and their customers
5. Operate a secure and resilient monitoring system for real time integration of all steps outlined as well as a reporting mechanism and chain of command structure for decision making.

A cyber framework model will help deliver this. It is a tool that will quantify the cyber effectiveness of the digital ecosystem within an organisation, focusing on the overall system as well as identifying the strengths and weaknesses relating to cyber for each sector within the organisation itself. It can be used to drill down into the deployed systems, assets and architectures etc. in place for effective measurement of safety and vulnerability.

Additional Question:

### **Q. How can UK Government exploit the immediate market opportunities of Connected Capability?**

New technologies have changed the way people live their lives. In particular, real-time information technology has played an important role in improving transport users’ journeys and their expectations of the network performance. As a result, there is a need for road network authorities to be agile and customer focused in the adoption of new technologies.

It is clear that Autonomous (Driverless) Vehicles offer an exciting and challenging future to our approach to Transportation, both in the UK and Globally. Unfortunately, it is also very clear that Connected Vehicles (with a driver) are either being wilfully ignored or under-appreciated in terms of what they can offer today. Connected capability is linked but separate to Autonomous vehicles. The technology is already being deployed in vehicles, with a number of trials already taking place that looks to understand the technical requirements and hazards around sharing information between vehicles, and between vehicle and Infrastructure. Connected Vehicles must be approached as a distinct offering in the market place, with strong overlaps to the world of Autonomy, but recognising the world where a driver is always in control, but more and more dependent and expecting of services provided through digital connectivity.

### **System of System Approach**

Technology, whether it is Internet of Things, Block Chain, Connected or Autonomous vehicles etc etc, are converging around the central point of ‘Services’. A Service is a digital consumable that users, either individuals or Network operators, will provide or pay for that enhances their experience. A number of Services have already existed for a number of years, such as traditional Gantry based Variable message signs, or In Car Sat Nav devices. However, technology, and customer expectations have moved on considerably with users requiring the right information at the right time in the right format. We have moved into a Digital Age which is synonymous with personalised real time Information and Choices being provided. The services that can be on offer depend on the appetite for moving with the digital world and understanding the value and relationships that exist across a number of traditionally disparate systems. As such, a System of Systems approach is fundamental to its success. What this means is understanding the impact across a number of areas to fully exploit the potential of connected capability. This includes, but not limited to, leadership and exploitation in a number of areas such as:

- Communications Network
- Hardware requirements on street
- Hardware Requirements in Vehicles
- Emergency Services
- Incident Detection and Management
- Data Management
- Revenue Generation

The challenge facing the industry is very much akin to the one faced by the media organisations, such as BBC, when faced with rival offerings exploiting the availability of internet based services to create personalised and novel services for their customers. It changed its delivery model to include BBC iPlayer as an equal to the traditional methods of operation.

### **The impact on the road network**

Vehicles will have the ability to communicate with each other, or with infrastructure, or with a central/distributed cloud based system. What this means is that the road network must

consider both a physical and digital infrastructure, such as the best use of Variable Message Signs, the migration towards Mobile App based information exchange, we well as understanding the backbone provision required for communications to take place. The automotive sector are looking at both traditional infrastructure requirements, such as 5G or WAVE, or alternatives that include using mobile or cloud based connectivity. The performance and safety case is not well understood with activity underway via Innovate UK funding to understand the alternatives for autonomous vehicles in more detail.

However, what is clear is that in the very short term, reliable and robust communications must be available for the connected vehicle. For this to take place, a number of points must be considered such as:

1. Developing the business case for investing in a communications backbone that facilitates interoperable communications across all manufacturers, promotes sustainable and long term development, future proof for alternative technologies, and links to brand development and customer experience
2. Understand the technical implications of Connected vehicles, particularly safety and safety related messages
3. Address and model the implication of connected vehicles across the network linked to various levels of penetration and various levels of available connectivity
4. Understand the implications of sharing information, or being part of the information exchange, when accidents or unwelcome behaviour results
5. Quantify the liability to the network operator in the instance of failure and the associated performance of the connected vehicle (ie did not break as the comms network did not get the message across in time)
6. Understand the integration requirements across various systems and timelines for maintenance of key operational requirements

### **The impact on the provision of data**

For both Connected and Autonomous vehicles, the availability of data underpins both the operation as well as the services and business models that will be borne out. The data is a fundamental driver to its success, and as such, the network operator can play a key role in both:

1. The delivery of data that enable revenue generating services
2. The delivery and receipt of data that is core to the operation of the network

To facilitate the provision and use of data, it is equally important that a robust non silo'ed data governance and management system is in place. This requires an understanding of the existing data sets, their relevant timeliness, the coverage provided by them, as well as developing the links between the various data sets linked to network operation (ie cause and effect – does a failure of a certain asset at a certain time cause the perturbation of the network in an unusual way and what are the strategies to refine this). As such, a complete data trail must take place that enables the operator to:

1. Understand in terms of what it says and doesn't say
2. Assess the reliability and reassurance associated with the data
3. Map the internal and external value that data is perceived to hold
4. Link to the Key Performance Indicators

5. Identify services and revenue generation that can be enabled from its sharing with public and private enterprises
6. Identify ownership, performance agreements in place, and collective resilience against failure

### **Cyber Security**

The movement of people places and goods through tunnels is dependent on a complicated digital system, with various levels of maturity, and multivendor system solution that in turn engages with other elements of a digital ecosystem across a city. While some elements in themselves may be robust, it is the link to other elements that offer potential areas of weakness and vulnerability to threat and cyber-attack. Should an attack occur, the impact is huge. As such, it is necessary to develop a tool that looks at cyber security from an Intelligent Mobility (IM) perspective, understanding that safe, reliable, and non-compromised movement of people places and goods across all modes of transport, is an absolute necessity. Approaching cyber from an IM perspective, and its links to behaviours and the influence it brings to operational capability, the model will look to establish a portable framework for assessing and quantifying cyber safety and robustness that can then be used in other areas of critical importance.

The Cyber Management Maturity Model must be used in a number of ways including:

- Developing a framework to establish the cyber capability within the organisation against a defined benchmark/criteria for assessment
- Outline the risk level and maturity index associated with current and future systems linked to operational implementation
- Creating a gap analysis based on a review of baseline capability and recommended security levels
- Define a detailed and defined investment plan linked to improved security

Example - Using the model, it will be possible to examine the risk profile of a Network Operator's traffic infrastructure, including lights, detectors, sensors etc, and outline the impact factor of a breach in security. The model will also outline the coverage levels in place and the mitigating factors needed at both a detailed architectural level as well as a system level.

### **Decision Support Tool for Modal Shift**

Real Time Travel Information (RTTI) has the potential to change completely the use and expectations of network performance through modal shift, i.e. the use of smart phone journey planners to modify travel behaviour that encourages bike sharing or use of autonomous vehicles based on up to date information on capacity, congestion, journey times, road works etc. However, it is particularly difficult for road authorities, with long term business cases and infrastructure investment programmes, to keep up to date, not only with the changes to technology but also to the expectations of the travelling public.

A robust and scalable Decision Support Tool (DST) allowing national road authorities to fully understand the impact of RTTI is key, along with a definition and design of the building blocks that support its operation.

*26 October 2016*

## AutoNaut Ltd – Written evidence (AUV0079)

### *1. What are the potential applications for autonomous vehicles?*

AutoNaut® is a unique, storm-proven UK technology using the pitching and rolling of a vessel's hull to propel it in all directions relative to the wind and waves. With just four moving parts it is reliable, silent, zero carbon, and capable of very long endurance at sea in all weathers. Small vessels, 2m – 10m, are equipped with the electronics and communications to make them fully autonomous, and able to accommodate a wide range of scientific sensor payloads.

AutoNaut Ltd started trading in 2013 and now has 7 employees. In 2016 UK company Seiche Ltd, world leaders in Passive Acoustic Monitoring (PAM), invested in the company. The growing global market for USVs is being tackled with vigour.

### *2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?*

AutoNaut is a disruptive autonomous technology with the capacity to replace manned ships in a number of roles such as hydrographic survey, monitoring marine mammals around seismic survey and pile driving activities, and pipeline and cable survey. In station keeping mode it can operate as unmoored metbuoys gathering forecasting data, thereby improving safety by taking people out of dangerous situations, and significantly reducing costs and carbon emissions. A surveillance equipped AutoNaut is drawing interest for uses in combatting illegal unreported and unregulated (IUU) fishing in British marine protected areas, as well as border force and coast guard activities around the world. Military applications such as anti-submarine warfare (ASW) are also being tested, and lend themselves to automation.

Benefits include zero carbon operation, reduced costs, improved data and safety. There are few disadvantages except disruption to existing ways of doing things.

### *3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?*

### *4. How much is known about public attitudes to autonomous vehicles?*

For unmanned surface vessels (USVs) like AutoNaut, very little is known about public attitudes, but they do attract media attention. There is public concern about weaponised aerial drones, and we prefer to avoid the word.

### *5. What is the scale of the market opportunity for autonomous vehicles?*

Globally the market for USVs is growing rapidly but is new and difficult to evaluate. We regard this as a great export opportunity. Market growth is limited today by the oil price curbing commercial O&G activity, by wavering Government support for renewables, by navies still trying to work out how to use autonomy, and by academic/scientific institutions being required to bid for funds several years in advance of being able to use such devices. All these factors will fluctuate.

*Creating an enabling environment*

*Research and development*

*6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?*

*7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?*

*8. How effective are Innovate UK and the CCAV in this area?*

IUK has been supportive and helpful. We have not encountered CCAV.

*9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?*

No. We developed AutoNaut from TRL 2 to TRL 8 by two retired gents working for two years and putting in their own money – with some input from IUK, SBRI, NERC, CDE, and dstl. No young person with mortgage and children to support could take this risk to develop a new autonomous technology.

*Real world operation*

*10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?*

The volume of data acquired at sea will require expanded satellite communications capability, and lower transmission costs.

*11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?*

*12. Does the Government have an effective approach on data and cybersecurity in this sector?*

*13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?*

We have played a full part in supporting the MAS Regulatory Working Group and its development of a code of conduct for Marine Autonomous Systems. We will continue to be closely involved in this ongoing task.

*14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?*

The direction of travel is for marine autonomous systems to work with and launch and recover aerial and underwater vehicles, and to ‘swarm’. As well as ‘safe navigation’ issues there will inevitably be future ethical issues around weaponisation and ‘illegitimate’ use.

*Wider governance*

*15. What does the proposed Modern Transport Bill need to deliver?*

*16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?*

*17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?*

The seas and oceans are important too.

*18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?*

26 October 2016

## Aviva Insurance Ltd – Written evidence (AUV0026)

*Submission from: Mr Simon Warsop, Chief Underwriting Officer - Personal Lines Insurance, Aviva Insurance Ltd*

### Foreword by Simon Warsop

I am pleased to respond to this call for written submission on Autonomous Vehicles on behalf of Aviva. We have limited our answers to questions relevant to our specific insurer's knowledge and expertise.

Aviva fully supports the House of Lords Science and Technology Select Committee in their inquiry to examine whether the actions taken by the Government are appropriate. Aviva responded in full to the Government's recent consultation on the Pathway to Driverless cars.

It is worth repeating our message to the Government that we believe that the UK should be at the forefront of autonomous vehicle technology and that this technology can in many ways improve road safety, driving efficiency, and create new opportunities for UK businesses.

As an insurance company this is an important issue to Aviva and we currently participate in the Association of British Insurers Automated Driving Insurance Group with Government and vehicle manufacturers.

### Summary

- In order to have an effective approach to data and cybersecurity the Government need to create a regulatory framework for advance vehicle technology.
- The critical point on the timeline for insurance is when technology crosses from level 3 to level 4 (full autonomy). We believe that prior to level 4 automation, the driver will remain in complete control of the vehicle so no changes to current legal insurance framework are needed until then; however there are other risks that Level 3 automation poses from a risk perspective.
- A rolling programme of regulation is essential with overarching principles established as soon as possible with the future liability framework set out for insurers and what this means for customers.
- It is our view that the Road Traffic Act should be extended to cover not only the negligent acts of the user of the vehicle but also the negligent acts of the vehicle when in autonomous mode. We think this is a simpler and more elegant solution which customers will better understand.
- Any solution however must be founded upon a balance between insurers and vehicle manufacturers which makes data fully available such that recovery of cost when the vehicle is 'at fault' and causes injury or damage.
- Regulation will be needed to govern failure to up date software and the potential hacking of vehicle technology.

- While we have suggested changes to the Road Traffic Act above to facilitate autonomy we make the case for a more radical change in the form of a first party model which Aviva has always supported and which we think has a number of advantages to the consumer.

### **About Aviva**

Aviva provides peace of mind for more than 33 million people across the world, protecting their families and possessions by providing insurance, savings and investment products. More than 16 million customers rely on us in the UK. In 2015 Aviva dealt with approximately 815,000 claims paying out £2.2billion.

### **Q12. Does the Government have an effective approach on data and cybersecurity in this sector?**

Data and cyber security is an increasingly important influence for many elements of daily life, though historically there has been little if no risk in terms of motor vehicles. With increased reliance of technology and especially connected technology that situation is quickly changing and the Government is right to identify that risk.

As with Financial Services generally, the protection of data (of all types) and cyber security needs a heightened profile in the vehicle manufacturing sector. This is because the risks are increasing, especially as we move towards semi and ultimately autonomous vehicles which are effectively “driven” by data.

Cyber and data security are global issues and there is no single solution. We would implore the Government to engage fully with other jurisdictions and investigate their thinking and opinions. There are a number of different moving parts which need to be coordinated if an effective “all round” solution is to be achieved.

In this, we see the role of the UK Government as essential. Their role should be to facilitate the various parties to produce an effective approach backed where appropriate with legislative changes. As a model we would point to the National Highway Traffic Safety Administration in the USA.

From an insurance perspective, access to data will become a critical component of pricing the insurance premium for vehicles as well as for understanding claims. The Government needs to be doing more to ensure that there is clear transparent access to vehicle data following a claim which would allow insurers and the market to understand the circumstances of an accident, for example if the vehicle or driver was in control. This is a critical issue that was raised in the response to Pathway to Driverless cars.

### **Q13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

It is our view that the best (and most straight forward) solution for Government is that the Road Traffic Act should be extended to cover not only the negligent acts of the user of the vehicle, normally the ‘driver’, but also any accidents caused by the vehicle itself when it is in effect the driver in fully autonomous mode.

The current law of tort and the Road Traffic Act will need to be adapted and altered to create clear laws and liabilities which have the legal effect of making the vehicle itself the ‘driver’ when in full autonomous mode.

When in full autonomous mode the owner or driver who was driving before the vehicle was placed in Autonomous Vehicle Technology mode will become a ‘passenger’ and therefore have the ability to pursue a claim against the vehicle insurer.

The legal problem currently is that the vehicle has no legal personality or status and cannot be negligent when judged against the actions of a reasonable road user. In effect we are suggesting the law will have to change so that there is either strict liability for all vehicles in Autonomous Vehicle Technology mode, or compulsory cover is extended to include the vehicle itself by creating some form of legal persona or standard for the vehicle to be judged against when it is in full autonomous mode.

It is our view that this is not an easy legal change to make and any legal action would in reality have to be pursued against the motor insurer. As a result the Government should recognise that the real benefit would be to create a first party insurance model with insurers then having to pay third party claims and potential first party claims with a clear right of subrogation for the insurer against the vehicle manufacturer.

We believe this solution, rather than trying to adapt existing Product Liability insurance is a simpler and more effective solution which consumers will understand better. It will also provide a ‘one stop shop’ solution for the general public.

However, this solution has to be accompanied by clear laws and regulations to give the insurer full access to all of the vehicle’s data so that where there is any element of fault with the vehicle itself or the software in the vehicle, the cost of any claims is passed on to the vehicle manufacturer.

By way of example Aviva considers that where a vehicle is in autonomous mode the Government should place a reverse burden of proof against the vehicle manufacturer and in effect create a strict liability upon the vehicle manufacturer for having sold the vehicle with the software and Autonomous Vehicle Technology capability in place. The result of this will be that insurers, who have had to pay a claim following an accident to all of the innocent victims, will not have to prove fault or carelessness against the vehicle manufacturer if the car can be shown to have been in autonomous mode when the accident and losses occurred.

**Q18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

We agree that the UK has the potential to become a world leader in this field however we cannot ignore the global reach of the motor market. If the UK creates its own specifications in isolation, the UK consumer risks being isolated in terms of choice of vehicle (as foreign

manufacturers may choose not to follow this specification) and UK manufacturers face being disadvantaged on world markets having to produce different specifications.

Vehicle design and manufacture has become a truly global industry (the UK exports over 85% of cars manufactured here) and the Government need to ensure Brexit implications enhance (and not damage) UK Research and Development or vehicle manufacturing capability.

With Europe likely to continue to be a large trading partner for vehicles (both import and export markets), continuing to work particularly with the EU and adopting or mirroring Regulations in respect of design safety, data access and vehicle / type approval will in our view continue to be desirable for the UK.

Equally from an insurance perspective, consistency with other countries will enable us to more effectively support the needs of customers. Vehicles and customers travelling to and from the UK must be confident that they can cross boarders with the relevant insurance and meeting each area's legislation.

*25 October 2016*

## **AXA UK – Written evidence (AUV0017)**

### **AXA UK:**

1. AXA UK (AXA) is part of the AXA Group, a worldwide leader in financial services. AXA Group operates in 64 countries with over 165,000 employees and 103 million customers.
2. AXA has around 11 million customers in the UK and operates through specific operating companies – AXA Insurance, AXA PPP healthcare and AXA Wealth.
3. AXA is a partner in three part-government funded trials of driverless and connected and autonomous vehicles – VENTURER, UK Autodrive and FLOURISH.

### **Executive summary:**

4. In 2014, the Government launched a ‘competition’ to fund three trials designed to help bring driverless cars to UK roads. Since then, further funding has been made available to develop what are called connected and autonomous vehicles (CAVs). In that sense, the conversation around driverless has moved on significantly in the last two years alone – not only will vehicles be able to drive autonomously but the entire eco-system of the road transport network will also change to allow them to communicate with each other and with infrastructure.
5. AXA recognised that such technology would fundamentally disrupt the existing insurance model but also have a potential positive impact on road safety, the environment and those people currently unable to drive. Therefore, the decision was taken to proactively join consortia that were bidding for Government funding. Of the three initial projects funded, AXA was successful in being part of two (VENTURER and UK Autodrive) and one in the second phase (FLOURISH).
6. Through our involvement in these projects, we hope to gain an understanding of the risk modelling that will be necessary to underwrite insurance policies for cars with higher levels of automation by, for example, exploring the issues of where liability will fall during the use of such vehicles. It will also give us advanced notice of safety and assistance features making their way on to the existing car market, enabling us to reflect these aspects in reduced pricing for our customers at an earlier stage.
7. Whilst AXA sees autonomous vehicles as a massive step forward in terms of road safety, motor vehicle accidents will still happen and insurers will need to be able to determine the cause - the driver or the car.
8. Motor insurance has been compulsory in the UK for almost 90 years and it exists to protect road users and pedestrians. That protection is incredibly important when

consideration is given to the fact that over 90 per cent of all motor accidents are caused by human error.

9. Driverless technology has the potential to significantly reduce the number of accidents on the roads and the injuries and deaths caused by those accidents. It is thought that the reduction could be as much as 50 per cent and that can only be good news for road safety.

**The projects:**

**VENTURER:**

10. VENTURER launched in July 2015 and focuses on the people as well as the technology side of the trials and seeks to understand the blockers and drivers to wide scale adoption of autonomous vehicle (AV) capability.
11. As part of the project AXA has provided input into the trial scenarios as well as producing a comprehensive [report](#) (attached) that focuses on the changing nature of liability. One objective of the trials currently being undertaken by the VENTURER consortium is to generate a better understanding of how drivers manage the handover process. Addressing the behavioural and physiological constraints around handover is vital to developing a proposition which meets user expectations and maximises the potential safety benefits of autonomous vehicles.

**UK Autodrive:**

12. UK Autodrive began in November 2015 and will carry out on-road trials in Milton Keynes and Coventry, using cars provided by project partners Ford, Jaguar Land Rover and Tata Motors European Technical Centre. The programme will also trial a fleet of lightweight, self-driving ‘pods’ for use on pavements and other pedestrianised areas.

**FLOURISH:**

13. FLOURISH began in June 2016 and will focus on the user needs of CAVs and the connectivity network, both vehicle to vehicle and vehicle to infrastructure.
14. AXA will examine the legal and insurance raised by increased levels of connectivity. This will include data management and protection as well as the integrity of the system i.e. hacking.

**Other related evidence:**

15. In September 2015, AXA released a [report](#) entitled *The Future of Driverless Haulage*.

16. Automated technology has the potential to transform the haulage industry, with very significant implications for the UK's roads, in terms of safety and congestion, for its environment, businesses and the UK economy as a whole.
17. In commissioning this economic modelling, AXA wanted to discover the financial impacts of introducing driverless haulage fleets. The results confirmed that automated freight will not only be much more efficient and make the roads safer for other users, particularly for those travelling at night, it will also reduce the prices of the end products that we all buy. If logistics can be made cheaper and more efficient, the cost of goods can potentially come down accordingly.

### **Conclusion**

18. AXA welcomes the Committee's inquiry into autonomous vehicles and is more than happy to provide oral evidence or further information should that be of use to the Committee.

*20 October 2016*

**Nicholas Bevan, Professor Robert Merkin QC and Dr Kyriaki Noussia, University of Exeter – Written evidence (AUV0044)**

**Driverless vehicles – where are we going wrong?**

**Introduction**

1. This paper responds to the Committee's call for evidence of 15th September 2016 on autonomous vehicles.
2. Its remit is confined to offering an opinion on the adequacy of the Government's proposals from July 2016 relating to compulsory third party motor insurance and product liability for autonomous vehicles<sup>15</sup>. These issues are pertinent to the following questions listed in the Committee's call for evidence:

*'Real world operation'*

13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?

...

*'Wider governance'*

15. What does the proposed Modern Transport Bill need to deliver?'

3. This paper will open by commenting on the Government's specific proposals set out in Chapter 2 of its July 2016 paper: Pathway to Driverless Cars. It will then offer some observations on the need for wider reform, on the possible implications of a Brexit and on other related concerns about the Department for Transport's approach to regulating compulsory motor insurance.

**The Government's proposals**

4. In Chapter 2 (Insurance: enabling the evolution) the Government's consultation paper sets out certain proposals for consideration. These are summarised as follows:
  - a. That the scope of compulsory third party motor insurance should be extended to include product liability cover<sup>16</sup> and this should be achieved by amending Part VI of the Road Traffic Act 1988<sup>17</sup>;
  - b. That this extended cover should only apply vehicles equipped with automated vehicle technology<sup>18</sup>;
  - c. That the scope of this new provision for product liability cover (as distinct from the existing cover restricted to driver or user liability) should also embrace 'not at fault' drivers whose vehicle is responsible for causing an accident<sup>19</sup>;

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<sup>15</sup> Set out in Chapter 2 of Pathway to Driverless Cars: proposals to support advanced driver assistance systems and automated vehicle technologies, Centre for Connected & Autonomous Vehicles, July 2016.

<sup>16</sup> Pathway to Driverless Vehicles, para 1.3

<sup>17</sup> Ibid, para 2.17

<sup>18</sup> Ibid, para 1.3 and 2.9

<sup>19</sup> Ibid, para 2.7 and 2.9

- d. That vehicles should be classified to allow manufacturers, insurers and consumers to differentiate between vehicles that require this extended cover and those that don't<sup>20</sup>;
  - e. That the minister's current private law agreements with the Motor Insurers' Bureau (MIB) be amended to extend the MIB's liability to compensate victims of uninsured and untraced drivers<sup>21</sup>;
  - f. There are no plans to regulate the precise terms of cover provided by insurers<sup>22</sup>.
  - g. There are no plans to amend the existing legislation on product liability. The existing fault based approach is preferred over a strict liability regime.<sup>23</sup> However, the Government has specifically canvassed views from respondents both for and against such a proposition<sup>24</sup>;
  - h. However, consideration needs to be given to creating a new direct right of action against an insurer<sup>25</sup>, even where the accident may have been caused or contributed to by a manufacturing defect, where its software has been hacked by a third party or where the defect is due to the vehicle owner or user failing to properly maintain and update the system or attempts to circumvent the systems in breach of a policy term<sup>26</sup>;
  - i. Insurers are to be given a reciprocal right to recover their outlay from any other parties responsible for causing injury or loss (that is to say from third parties other than the driver of the insured vehicle<sup>27</sup>), including the vehicle owner<sup>28</sup>;
  - j. That where a driver has attempted to circumvent the system or has failed to maintain or update its systems then the insurer should be able to exclude liability to that driver but not third parties;<sup>29</sup>
  - k. Insurers are to be left to 'make arrangements' with manufacturers and to develop insurance products that share the economic risk to support the sales of their automated vehicles<sup>30</sup>;
  - l. The Government is not minded to opt for a 'first party insurance model' but has canvassed views on this<sup>31</sup>.
  - m. The Government favours a staged approach to regulatory reform
5. Whilst the broad thrust of the Government's proposals is welcomed, to the extent that they are intended to protect consumers and innocent third parties from the financial hazard posed by the introduction of autonomous vehicles and systems, we have a number of comments on the substance of the proposals.

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<sup>20</sup> Ibid, para 2.9

<sup>21</sup> Ibid, para 2.12

<sup>22</sup> Ibid, para 2.14

<sup>23</sup> Ibid, para 2.20

<sup>24</sup> Ibid, para 2.30, see Questions 2J and 2K.

<sup>25</sup> Ibid, para 2.24

<sup>26</sup> Ibid, para 2.25

<sup>27</sup> Ibid, para 2.22

<sup>28</sup> Ibid, para 2.27

<sup>29</sup> Question 2H

<sup>30</sup> Ibid, para 2.14

<sup>31</sup> Ibid, paras 2.34 to 2.39

## Comments on the proposals

6. Dealing with the aforementioned proposals in order of mention:
  - a. ***That the scope of compulsory third party motor insurance should be extended to include product liability cover and this should be achieved by amending Part VI of the Road Traffic Act 1988.***
7. The Government's proposals fail to acknowledge that it is at least arguable that European law already requires that product liability is to be covered by mandatory third party motor insurance. There is nothing that limits insurance to the user. If that is right, then the requirement has not been met in this jurisdiction and the UK is at risk of an infringement action. That said, the point appears not to have occurred to other member states or to insurers, and as far as we are aware domestic motor insurance laws in the EU refer only to the user.
8. The minimum standard of civil liability motor insurance and the minimum standard or consumer protection for defective products are set by two European directives.
9. Articles 3 and 10 of European Directive 2009/103/EC on motor insurance (MI Directive) prescribe the minimum level of protection to be derived from civil liability insurance<sup>32</sup> and in default of insurance, the compensatory guarantee<sup>33</sup> required of the authorised Compensating Body<sup>34</sup> to any third party injured by motor vehicle use.
10. The European Directive 85/374/EEC on product liability (PL Directive) sets the minimum standard of civil liability for defective products. This appears to have been fully implemented by the Consumer Protection Act 1987.
11. The first two paragraphs of Article 3 MI Directive are worth reciting in full:

‘Each Member State shall, subject to Article 5<sup>35</sup>, take all appropriate measures to ensure that civil liability in respect of the use of vehicles normally based in its territory is covered by insurance.

The extent of the liability covered and the terms and conditions of the cover shall be determined on the basis of the measures referred to in the first paragraph.’
12. It is arguable from the above extract that the MI Directive can be regarded as contemplating that any civil liability resulting from the use of the vehicle (regardless of whether it is attributable to the owner, driver or manufacturer) must be covered by this insurance.

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<sup>32</sup> Article 3, MI Directive

<sup>33</sup> Article 10, MI Directive

<sup>34</sup> In the UK this role is discharged by the Motor Insurers' Bureau

<sup>35</sup> Article 5 MI Directive permits in certain circumstances member states to derogate certain vehicle owners and certain types of vehicle to be derogated from the Article 3 insurance requirement

13. Given the elevated importance given to the MI Directive's protective purpose by the Court of Justice ruling in its judgment in *Damijan Vnuk v Zavarovalnica Triglav d. d.* [2014] (Case C-162/13) and the observation made in the European Commission's Road Map communiqué of 8 June<sup>36</sup> it is also strongly arguable that this is an absolute requirement and that member states do not have any legislative discretion to restrict the scope of the protection required by Article 3 to driver negligence.
14. The authors are not aware of any decision on this point. However, given the European law context, it is likely that Section 145 Road Traffic Act 1988 (if properly construed in the light of this European law) would be adjudged to already effectively require such cover. Indeed, in *Bernhard Pfeiffer et al v Deutsches Rotes Kreuz, Kreisverband Walshut eV*<sup>37</sup> the Court of Justice has this to say on this point:

‘When a national court has to apply the domestic provisions which have been specifically enacted for the purpose of transposing an EU Directive intended to confer rights on individuals, the national court must presume that the Member State, following its exercise of the discretion afforded it under that Article, intended entirely to fulfil the obligations arising from the Directive concerned’.
15. Accordingly, although the ostensible and literal meaning of the words in Section 145(3)(a) of the Road Traffic Act 1988 appear to restrict the third party insurance requirement to ‘any liability which may be incurred by him or them’ as distinct from the potential liability of a manufacturer or supplier for a hidden defect, adherence to the strict or literal meaning of these words is likely to result in the UK transposition being held to be inconsistent with Article 3.
16. Whereas the well-established European law principle of consistent construction obligates national courts to apply a purposive construction of any national law intended to implement European law so that it gives full effect to that European law requirement, in so far as is possible<sup>38</sup>.
17. If we are right, then urgent steps need to be taken to bring the UK transposition of the MI Directive into full compliance with this European law and to a standard that satisfies the European law principle of legal certainty<sup>39</sup>. This will involve extensive

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<sup>36</sup> ‘It is not envisaged to change the definition of motor vehicle, because the existing definition is technology-neutral and will in the future capture all types of vehicle with a driver intended for travel on land and propelled by mechanical power (including e.g. automated vehicles).’ European Commission, Inception Impact Assessment, Adaptation the scope of Directive 2009/103/EC on motor insurance, 8 June 2016.

<sup>37</sup> *Bernhard Pfeiffer et al v Deutsches Rotes Kreuz, Kreisverband Walshut eV*: [2004] CJEU (Case C-397/01 to C-403/01)

<sup>38</sup> See *Bernhard Pfeiffer et al v Deutsches Rotes Kreuz, Kreisverband Walshut eV*: [2004] CJEU (Case C-397/01 to C-403/01), paras 113 to 119, see also Lord Aikens' approach to consistent construction in a motor insurance context in *Churchill v Wilkinson* [2012] EWCA Civ 1166 where additional notional wording was added to Section 151(8) to bring the UK provision into conformity with the MI Directive

<sup>39</sup> See *Commission v Greece* [1996] ECR I-4459, Case C-236/95 at paragraph 13, where the CJEU ruled: ‘.... the Court has consistently held that it is particularly important, in order to satisfy the requirement for legal certainty, that individuals should have the benefit of a clear and precise legal situation enabling them to

reforms not just to the relevant primary<sup>40</sup> and secondary legislation<sup>41</sup> but also extensive revisions to the Government's extra-statutory provision for victims of uninsured and untraced drivers<sup>42</sup> as well as initiating measures to ensure that the policy terms provided by authorised motor insurers actually comply with the minimum standards of consumer and third party cover required by European law<sup>43</sup>.

***b. That this extended cover should only apply vehicles equipped with automated vehicle technology***

18. As argued above, this is potentially inconsistent with Article 3 of the MI Directive. The UK has no legislative discretion here.

***c. That the scope of this new provision for product liability cover (as distinct from the existing cover restricted to driver or user liability) should also embrace 'not at fault' drivers whose vehicle is responsible for causing an accident***

19. It would appear that this is also required by Article 3 MI Directive.

***d. That vehicles should be classified to allow manufacturers, insurers and consumers to differentiate between vehicles that require this extended cover and those that don't;***

20. The European law mandatory requirement for civil liability motor cover allows for no such distinction. The civil liability cover should include any mechanical or technical defect in the vehicle, regardless of whether it consists of a fault in an automated system or a simple mechanical defect in a brake or accelerator pedal.

***e. That the minister's current private law agreements with the Motor Insurers' Bureau (MIB) be amended to extend the MIB's liability to compensate victims of uninsured and untraced drivers;***

21. It would appear that under European law the MIB is already obliged to compensate for mechanical and technical defects in vehicles that are caught by the Article 3 insurance requirement.

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ascertain the full extent of their rights and, where appropriate, to rely on them before the national courts (see to this effect Case 29/84 *Commission v Germany* [1985] ECR 1661, paragraph 23, Case 363/85 *Commission v Italy* [1987] ECR 1733, paragraph 7, and C-59/89 *Commission v Germany* [1991] ECR I-2607, paragraph 18).'

<sup>40</sup> Part VI of the Road Traffic Act 1988, as well as abrogating the codification of the third party rule to be found in the Contracts (Rights Against Third Parties) Act 1999 and the Third Parties (Rights Against Insurers) Act 2010 where they apply to third party victims who are supposed to be protected by compulsory motor insurance

<sup>41</sup> Such as Regulation 3 EC Rights Against Insurers Regulations 2002

<sup>42</sup> Namely the MIB agreements: the Uninsured Drivers Agreements 1999 and 2015 and the Untraced Drivers Agreement 2003

<sup>43</sup> In *UK Insurance Ltd v Holden and another* [2016] EWHC 264 (QB) Judge Waksmann QC noted that the policy wording was not wide enough to satisfy even a literal interpretation of the scope of cover required by Section 145 Road Traffic Act 1988

22. This is because Article 10 MI Directive requires the UK to ensure that its authorised compensating body is charged ‘with the task of providing compensation, at least up to the limits of the insurance obligation for damage to property or personal injuries caused by an unidentified vehicle or a vehicle for which the insurance obligation provided for in Article 3 has not been satisfied’.
23. Unfortunately, all the current MIB agreements inherit the same restrictions in scope that apply to Part VI Road Traffic Act 1988. However, it seems likely that a properly informed court, applying a European law consistent construction of any of the current MIB agreements (as required by *Pfeiffer*<sup>44</sup>) would interpret them as extending to cover liability for product liability as well as driver liability. Failing this, there is a strong case to argue that notwithstanding the defective implementation of Article 10 within the MIB agreements, the MI Directive has direct effect against the MIB<sup>45</sup>.
- f. *There are no plans to regulate the precise terms of cover provided by insurers.***
24. The Article 3 insurance requirement is set in absolute terms. It obliges member states to *ensure* that liability arising out of the use of vehicles is covered by civil liability insurance. Accordingly, the Government’s current laissez faire approach to regulating motor insurers’ policy terms is incompatible with the mandatory requirement of the MI Directive.
25. Whilst it is entirely understandable that motor insurers should seek to restrict their third party cover to the minimum extent required by the literal meaning of the words employed by Section 145 Road Traffic Act 1988 (even when this falls below the proper level and scope of cover required by Article 3 MI Directive) the Government appears to have failed to enforce even this inadequate level of cover, see for example HHJ Waksman’s judgment in *UK Insurance Ltd v Holden & Pilling* [2016] EWHC 264 (QB)<sup>46</sup>.
26. Arguably what is called for is the codification of standard policy terms of cover for compulsory motor insurance.
- g. *There are no plans to amend the existing legislation on product liability. The existing fault based approach is preferred over a strict liability regime. However, the Government has specifically canvassed views from respondents both for and against such a proposition.***

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<sup>44</sup> Supra

<sup>45</sup> The only decision on this point is by Flaux J in *Byrne v MIB & Secretary of State for Transport* [2007] EWHC 1268 (QB) where he ruled that Article 10 does not have direct effect against the MIB. However, the case for direct effect of Article 10 is argued extensively by Nicholas Bevan in *Bridging the Gap*, British Insurance Law Association Journal, March 2016 and again less extensively in *Putting Wrongs To Rights, Parts 1 and 2*, 27 May 2016 and 3 June 2016 respectively

<sup>46</sup> See paras 22 to 24

27. After ensuring in so far as is possible public safety, the compensatory entitlement of third party victims should be the paramount concern of the Government in this area. In our view, the current product liability regime does not provide the necessary level of compensatory guarantee necessary to ensure prompt settlement of third party claims arising out of autonomous vehicle systems. This is because these claims are likely to be exposed to potentially competing causalional issues, that third parties have no first-hand knowledge of, as well as the prospect of a producer raising a state of the art defence under Section 4(e) of the Consumer Protection Act 1987.
28. There is also something anomalous in the notion of imposing a law that requires law abiding road-using members of the public to cover, through private insurance, the risk of defective products that they have purchased or hired as consumers in good faith that the products are fit for purpose and safe on or roads. This would effectively require consumers and motorists to subsidise part of the development and deployment costs of manufacturers and suppliers of autonomous vehicles by indemnifying them against the risk posed by launching their new technologies into the UK market. This could have the undesired effect of providing a disincentive to proper safety testing and regulatory compliance.
29. One possible solution might be to impose an absolute liability on producers, suppliers, distributors and retailers of these new technologies, extending possibly to maintenance and service operators of such systems, for loss or injury caused or contributed by them<sup>47</sup>. However, the Government might face some practical difficulties in effecting such a measure as Article 15.2 of Council Directive 85/374/EEC on defective products seems to require the European Commission's prior approval before the state of the art defence<sup>48</sup> can be abrogated.
30. It is important that motor insurance premiums are not exposed to extensive product liability that is unlikely to recoverable from the responsible parties, whether by virtue of the effect of Section 4 of the Consumer Protection Act 1987 or otherwise.
31. However, to guard against the risk of a foreign manufacturer being under-insured and/or insolvent , and given the likelihood of lengthy and costly litigation delaying the third party's compensatory redress, the government would be wise to consider introducing a statutory provision that imposes an absolute duty of indemnity on all motor insurers to satisfy any third party or driver claim (whether caused or contributed to by a product defect associated with the vehicle's use) in terms analogous to but distinct from the strict liability that applies to an employer under the Employers' Liability (Defective Equipment) Act 1969. The insurer will not be deemed to be negligent and the existing law on product liability might not require alteration. This should apply to conventionally controlled and ADAS<sup>49</sup> and AVT<sup>50</sup>

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<sup>47</sup> To apply to non-consumer scenarios and to be excluded from the section 4 state of the art defence

<sup>48</sup> See Article 7 (e) of Directive 85/374/EEC for the state of the art defence and Article 15.2 ibid for the power to derogate

<sup>49</sup> Advanced Driver Assist Systems

<sup>50</sup> Automated vehicle technology

controlled vehicles alike<sup>51</sup>. Further statutory provision should be made to allow the insurer to recoup its outlay as a subrogated claim from a producer, supplier or other third party, wholly or partly responsible for the defect that caused or contributed to the accident<sup>52</sup>. This would ensure that innocent victims recover their compensation relatively promptly from the insurer involved, or in default, from the Motor Insurers Bureau (MIB).

32. Motor insurers are better placed than private individuals to take informed decisions on whether to pursue subrogated product liability claims, whether individually or as class actions.

33. Another option might be to introduce a no-fault state compensation scheme as in New Zealand under the Accident Compensation Act 2001 (ACC). However, this is unlikely to be welcomed by claimant representatives or insurers for various reasons, not the least being concerns over the lower levels of award under the ACC scheme. ACC does have a number of controversial features, including that it compensates victims who are in full or in part to blame for their own injuries. It also gives rise to a good deal of litigation on the extent of injuries and potential fraudulent claims: insurers themselves face such issues today, but ACC switches those costs to the State.

*h. However, consideration needs to be given to creating a new direct right of action against an insurer<sup>53</sup>, even where the accident may have been caused or contributed to by a manufacturing defect, where its software has been hacked by a third party or where the defect is due to the vehicle owner or user failing to properly maintain and update the system or attempts to circumvent the systems in breach of a policy term.*

34. Article 18 MI Directive already requires member states to provide a direct right of action against the insurer of a party responsible for an Article 3 liability.

35. The UK transposition of this direct right is found in the EC (Rights Against Insurers) Regulations 2002. However, this is defective in several respects. First, by qualifying the third party's entitlement to compensation, by subjecting the claimant to any defence that the insurer could raise against its policyholder<sup>54</sup>. Whereas under European law the third party's entitlement is free standing in nature, a victim should not be subject to any contractual restrictions or exclusions of liability<sup>55</sup>, save to the

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<sup>51</sup> See above under Question 2J for an explanation of the European law requirement in this respect

<sup>52</sup> Where there are concurrent findings of causative user fault and a product defect, the third party should be paid in full by the motor insurer but the insurer's right to recover its outlay from the producer / supplier should be proportionate to its causative potency and perhaps determined along the lines of the Law Reform (Miscellaneous Provisions) Act 1945

<sup>53</sup> Ibid, para 2.24

<sup>54</sup> See Regulation 3 (2) of the 2002 Regulations

<sup>55</sup> Recital 15 states: 'It is in the interest of victims that the effects of certain exclusion clauses be limited to the relationship between the insurer and the person responsible for the accident.' See also Ruiz Bernáldez [1996] CJEU Case C-129/94, paragraph 20; Candolin and Others [205] CJEU Case C-537/03, paragraphs 27 to 35. See

extent expressly permitted by Article 13 MI Directive<sup>56</sup> and the claim can only be reduced in exceptional circumstances and to a proportionate extent to reflect the claimant's own responsibility for his or her own loss or injury. Second, due to its geographic restriction in scope. It is also unclear whether the way Regulation 3(1) confines the application of the direct right to persons entitled to a cause of action against an insured person in tort, excludes product liability<sup>57</sup>.

**j. *Insurers are to be given a reciprocal right to recover their outlay from any other parties responsible for causing injury or loss (that is to say from third parties other than the driver of the insured vehicle), including the vehicle owner.***

36. This is a sensible suggestion. Statutory provision should be made to allow a motor insurer to recoup its outlay as a subrogated claim from a producer, supplier or other third party, wholly or partly responsible for the defect that caused or contributed to the accident<sup>58</sup>. This would ensure that innocent victims recover their compensation relatively promptly from the insurer involved, or in default, from the MIB.
37. Where the claimant is also the driver / owner of the vehicle wholly or partly responsible for his or her loss or injury and it is established that that same individual is also partially responsible for a defect that caused or contributed to the accident, then the insurers right of recovery against that person must not extinguish the claim disproportionately. The provisions of the Law Reform (Contributory Negligence) Act 1945 should cover this scenario in the vast majority of cases but there may be difficulties where the same claimant is also the policyholder<sup>59</sup>.
38. Motor insurers can ensure greater control of claims and costs if they are also responsible for indemnifying both the liability of the user and the producer / distributor of the product. They are better placed to take informed decisions on whether to pursue subrogated product liability claims.
39. The MIB could assume a valuable role as a centre of expertise in investigating, assessing and handling such claims on its members' behalf. In which case it may be

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also *Churchill Insurance Company Limited v Benjamin Wilkinson and Tracy Evans v Equity Claims Limited* 2011 ECJ Case C-442/10

<sup>56</sup> Even where this applies, as a derogation from the MI Directive's protective purpose, it is to be applied restrictively, see *Candolin and Others*, *Supra*, paragraph 21

<sup>57</sup> Arguably it doesn't as third party product liability can exist under common law tort principles as well as under the Consumer Protection Act 1987 but in the former case the evidential burden rests on the claimant and it is one that will be difficult to overcome where there the mechanical or technical fault that causes the accident features a defect that is a 'state of the art' component of an autonomous vehicle

<sup>58</sup> Where there are concurrent findings of causative user fault and a product defect, the third party should be paid in full by the motor insurer but the insurer's right to recover its outlay from the producer / supplier should be proportionate to its causative potency and perhaps determined along the lines of the Law Reform (Miscellaneous Provisions) Act 1945

<sup>59</sup> Under European law, the amount of compensation a victim of a motor accident is entitled to may only be limited in exceptional circumstances and on the basis of an assessment of that particular case *Candolin and Others* [2005] CJEU Case C 537/03, paragraphs 29, 30 and 35

necessary to confer the MIB with a statutory subrogated power to recover either its own outlay or that of one of its members in this regard.

***k. Insurers are to be left to ‘make arrangements’ with manufacturers and to develop insurance products that share the economic risk to support the sales of their automated vehicles.***

40. This proposal assumes that motor insurers will be in a position to negotiate fair and reasonable terms with manufacturers and suppliers. Further measures may be needed, such as bolstering the strict liability of producers and suppliers for defective products, if motor insurers (and the affordability of premiums) are to be protected from extensive exposure to risk from the introduction of advanced autonomous vehicles on our roads.
41. If motor insurers are not able to recover a significant proportion of their outlay in settling claims caused by defective products, insurance premiums are likely to rise yet again.

***I. The government is not minded to opt for a ‘first party insurance model’ but has canvassed views on this<sup>60</sup>.***

42. It is agreed that a first party insurance model is inappropriate.
43. Whilst motor insurance often includes first party cover (as with the comprehensive motor cover or with legal expenses insurance) first party cover policies are primarily contractual arrangements that result in an agreed sum or an anticipated loss being paid direct to the policyholder. They are not subject to the third party protection that applies to third party policies: they usually confer no rights on third parties so they are neither caught by the Contracts (Rights of Third Parties) Act 1999, s151 Road Traffic Act 1988, nor the insolvency protection within the Third Parties (Rights Against Insurers) Act 2010.

***m. The Government favours a staged approach to regulatory reform***

44. We agree.
45. Our understanding of the advanced driver assistance systems likely to be introduced in the short and medium term is that they are designed to temporarily substitute direct human control of motor vehicles - subject to an overriding power of intervention by the human driver - in certain highly prescriptive scenarios: such as maintaining a course in motorway traffic, remote control parking and, for convoys of heavy goods vehicles run in close formation and controlled by a single lead driver. Presumably there will be further innovations along these lines. These systems will still require constant vigilance by vehicle users who must at all times be ready and able to resume control, either at the completion of the semi-automated process or in

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<sup>60</sup> Ibid, paras 2.34 to 2.39

response to an exigency that requires human intervention. Because human control is retained, some responsibility for safe driving will continue to rest on the user. However, this will require new skills and training, allowing the user to recognise exactly when intervention is necessary by reason of an apparent failure of technology or by the occurrence of an event which automation cannot predict or counter, eg, someone throwing a concrete block onto a road from a bridge. It will also be necessary to train users to override the technology when it detects a phantom problem, eg, a newspaper on the road. While it is possible to retain the basic common law rules relating to duty, breach and damage, some thought needs to be given to how those standards are to be applied to a failure to intervene. The existing common law rules do not necessarily impose a duty on a person to carry out a positive act to prevent a loss triggered from circumstances beyond that person's control (so that there is no duty to pull a drowning child out of a river).

46. However, once fully automated vehicle technology is introduced then, provided the owner or user has not tampered with the technology, failed to maintain it or otherwise misused it or attempted to resume or assert control - then it is difficult to envision how the user could be held liable under existing tort rules for a resulting accident. Under common law principles such a user would be no more responsible for an accident than a bus passenger for the negligence of the bus operator or driver. Even on the most conservative estimate, 90% of road accidents currently are caused or contributed to by human fault, but if that is removed then there is no obvious basis for the imposition of liability.
47. Accordingly, if the compensatory entitlement of innocent third parties is to be adequately protected, provision needs to be made to ensure that there is either or both: (i) strict liability for any product defect (which the mandatory insurance cover must incorporate), although it remains to be determined whether liability should attach to the user or owner of the vehicle, the manufacturer of the product or the supplier of any part of the technology; and/or (ii) the insurer (and in its absence the a fall-back Compensation Body) should be subject to an absolute and free standing duty to indemnify liability for such use, subject of course to the conferral of a subrogated right to pursue any third parties for an indemnity or contribution, including producers, suppliers and garages etc. Either option would require legislation.
48. The key point here is that where there is full automation it may no longer be appropriate to fix liability and thus the incidence of insurance on the user or owner, and it might be better to require the suppliers of vehicles or technology to face strict product/service liability backed by insurance.

## **Additional observations**

### ***The pressing need for reform***

49. The Government needs to give serious and urgent consideration to repealing of Part VI Road Traffic Act 1988 along and all associated regulatory provision [such as the

European Community Rights Against Insurers Regulations 2003 and the Motor Vehicles (Compulsory Insurance) (Information Centre and Compensation Body) Regulations 2003] and the private law agreements between the Secretary of State for Transport and the MIB relating to victims of uninsured and unidentified vehicles with a view to codifying it within a Modern Transport Act in terms that satisfy legal certainty and which also comply with the MI Directive.

50. The entire corpus of our national law provision for protecting the compensatory entitlement of third party victims of both culpable drivers and of defective products needs to be reviewed. This should include a re-evaluation of the suitability of the continued application of the common law third party rule in this context, whereby strangers to a contract are subject not just to the benefits of a contract but also its burdens. This rule applies save to the extent abrogated by Sections (1) and (2) 148 and 151(2)(b) and (3) Road Traffic Act 1988.
51. The inference that under UK law certain policy exclusions are valid against a third party can be drawn from the fact that Section 148 of the 1988 Act only prevents an insurer from relying on a limited number of exclusions that are listed in s 148(2) (such as the invalidation of any restrictions on the age or physical or mental condition of the driver)<sup>61</sup>. A similar conclusion is to be drawn from Section 151(2)(b) (the unauthorised use exception) and Section s151(3) which nullifies against a third party any restriction of cover to persons holding a driving licence. Whilst some limitations of liability are specifically expressed to be void; the correlative implication is that all other limitations are valid<sup>62</sup>.
52. According to Ward LJ's meticulous analysis Part VI Road Traffic Act 1988<sup>63</sup>, the fact that a compulsory third party motor insurance policy has been issued and delivered under Sections 145 and 147 does not guarantee that a third party victim's claim is covered.<sup>64</sup>
53. According to this analysis Sections 143 and s145 of the 1988 Act impose a duty on the user of a motor vehicle, as opposed to the insurer, to ensure that he has in place adequate insurance to cover any use actually made of that vehicle. It is the responsibility of the user to ensure that his use conforms to whatever restrictions in cover apply to the policy; if he fails in this, he is driving uninsured. There is no concomitant requirement on an authorised motor insurer to provide cover in respect of any and every use to which the user puts the vehicle.<sup>65</sup> The qualified nature of the statutory third party cover provided under Ward LJ's interpretation may make sense from a commercial perspective but it seems to undermine the effectiveness of social

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<sup>61</sup> Ward LJ in *EUI Limited v Bristol Alliance Limited Partnership* [2012] EWCA Civ 1267, para 42; this judgment was analysed and criticised by Nicholas Bevan in *Marking The Boundary* in the Journal of Personal Injury, issue 3 of 2013

<sup>62</sup> Ibid, para 51

<sup>63</sup> Ibid, paras 34 to 53

<sup>64</sup> Furthermore, it should also be noted that some events cannot be insured against as a matter of public policy: such as an intentionally criminal act, *Hardy v Motor Insurers' Bureau* [1964] 2 All ER 742

<sup>65</sup> Ward LJ in *EUI Limited v Bristol Alliance Limited Partnership* [2012] EWCA Civ 1267, para 38

policy imperative of protecting the legitimate compensatory entitlement of innocent third party victims that appears to be the legislative intention underpinning Part VI of the 1988 Act. It also conflicts with Article 3 of the MI Directive and a long and consistent line of Court of Justice judgments<sup>66</sup>.

54. A complete overhaul of these provisions is necessary because the protection they afford is patchy, inconsistent, tediously long and unnecessarily complicated<sup>67</sup>. This is in large measure the cumulative effect of decades of empirical development. All too often new provisions have been added without any obvious appreciation as the effect this has on the underlying Parliamentary objective<sup>68</sup>.
55. The technical complexities caused by this approach are now so extensive that it can often take years to negotiate modest changes, as is evident with the six years of delay that has attended the government's negotiations with the Motor Insurance Bureau concerning the long overdue replacement of the Untraced Drivers Agreement 2003<sup>69</sup>. This gives the impression that the Government not only allowed its policy to be dictated by the motor insurance sector but that the industry is able to block reforms it does not like. Over the past eight decades no attempt has been made to rationalise this important area of our national law provision in a holistic fashion. There appears to be a strong case to put both of the schemes for uninsured and untraced drivers on a proper footing by codifying them within a statutory instrument.
56. The lack of legal certainty and systemic inconsistencies with European law is self-evident. It has also been exposed in by a number of recent cases, such as *Churchill Insurance v Wilkinson; Evans v Equity & Secretary of State for Transport* [2012] EWCA Civ 1166; *Delaney v Pickett* [2011] EWCA Civ 1532; *Delaney v Secretary of State for Transport* [2015] EWCA Civ 172; *UK Insurance Ltd v Holden and another* [2016] EWHC

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<sup>66</sup> From *Ruiz Bernaldez* [1996] CJEU (C-129/94) E.C.R. I-1829 to *Damijan Vnuk v Zavarovalnica Triglav d. d.* [2014] CJEU (Case C-162/13)

<sup>67</sup> The UK's extensive infringements are analysed in some detail in Nicholas Bevan's article, *Mind The Gap: Ongoing developments in the United Kingdom resulting from the Governments' failure to fully implement the sixth European directive on motor insurance* (2009/103/EC), published in the British Insurance Law Association Journal issue no 129 of October 2016; winner of the BILA Best Article Prize for 2016

<sup>68</sup> A point well made by Lord Hailsham LC in *Gardner v Moore and others* [1984] 1 All ER 1100: 'This leads me to point to the light shed on the policy of the 1972 Act by ss 148 and 149. It is true, of course, that these sections were grafted onto ss 143 and 145 (which, to the extent cited above, were copied from the 1930 Act) but without any apparent belief in the mind of the legislature that the scion was incompatible with the stock.'

<sup>69</sup> In July 2013 the DfT published a communique, *Statement of intent on the Consultation on the Review of the Uninsured and Untraced Drivers' Agreements* which indicated that the proposals set out in its February 2013 consultation paper were the product of three years' negotiation with the MIB. These included improvements to the UtDA. It planned to publish a new UtDA that autumn. Whilst some minor changes were introduced in a sixth supplemental agreement, such as the misleading semantical changes to the guilt knowledge requirement that in our view fail to address the illegality exposed following the Court of Appeal's decision in *Delaney v SoSfT* [2015] to uphold the Francovich award against the UK (see our comment below under 'Legal challenges and delayed reform'), the DfT has failed to deliver even on its own plans (e.g. to provide safeguards for children and mentally incapacitated victims). We are now over three and a half years on from the February 2013 consultation. Accordingly, it would appear that the DfT and the MIB are in deadlock. In our view this indicates that the form in which the UK have chosen to implement Article 10 MI Directive is inappropriate, a more dirigiste approach (imposed by statutory instrument) may be required to drive through the necessary reforms.

264 (QB) in the raft of decisions culminating in the Supreme Court's decision in *Moreno v Motor Insurers' Bureau* [2016] UKSC 52 and in the ongoing judicial review *RoadPeace v Secretary of State for Transport* Case no. CO/4618/2015.

57. This imprecision and inconsistency with the minimum standards of protection required under European law are counter-productive. It makes it difficult for insurers to set accurate reserves and to price their premiums competitively. It encourages fraud and expensive legal challenges. The lack of clarity is also unfair to consumers who purchase policies in good faith that they are fit for purpose, when all too often their cover is hedged by qualifications and restrictions. It can also prove to be inaccessible for those victims who discover their compensatory entitlement is negated or reduced for technical reasons they are unable to influence or control. Much of this complexity is unnecessary.
58. When the MI Directive is read in the light of the underlying principles that feature in the consistent line of Court of Justice judgments from *Ruiz Bernaldez* Case C-129/94 [1996] to in *Damijan Vnuk v Zavarovalnica Triglav d.d.* Case C-162/13 [2014], the insurance requirement prescribed by Article 3 is capable of being distilled into the following propositions:
  - i. Third party cover must be good for:
    - Any motor vehicle conforming with the article 1 definition<sup>70</sup>
    - Any civil liability arising out of any use consistent with the normal function of the vehicle<sup>71</sup>
    - Anywhere on land<sup>72</sup>
  - ii. The duty to insure and the scope of cover are coextensive<sup>73</sup>
  - iii. Member states have no discretion to introduce new restrictions, exclusions or limitations<sup>74</sup>,
  - iv. Only one exclusion of cover is permitted: this applies to passenger who voluntarily enters the vehicle knowing that it has been stolen<sup>75</sup>.

59. According to the European Commission's legal office the MI Directive is undergoing an extensive regulatory review following a wide-ranging infringement complaint

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<sup>70</sup> The Article 1 definition of "Vehicle" means any motor vehicle intended for travel on land and propelled by mechanical power, but not running on rails, and any trailer, whether or not coupled"

<sup>71</sup> *Vnuk*, paras 56 and 59

<sup>72</sup> *Vnuk*, para 59

<sup>73</sup> This is the inescapable implication of *Bernaldez (supra)*, *Katja Candolin and Others. v Vahinkovakutusosakeyhtiö Pohjola and Others* [2005] ECJ (Case C-537/03), and *Farrell v Whitty* [2007] Case C-356/05 and it is subject only to the single exception permitted by Article 13.1 of the MI Directive

<sup>74</sup> See Mr Justice Jay's analysis in *Delaney v Secretary of State for Transport* 2014 EWHC 1785 para 108 in the context of the MIB Uninsured Drivers' Agreement. The same principles apply to primary or secondary legislation implementing the MI Directive. This issue of legislative discretion is also important in the context of state liability under *Francovich* principles

<sup>75</sup> See *Bernaldez* paras 18 to 21 (the opinion of Advocate General Lenz of 25 January 1996, paras 25 to 30, provides a helpful analysis of the rationale) and *Candolin* paras 17 to 23

against the UK<sup>76</sup>. This exercise will include a review of the way in which different member states have implemented the MI Directive. It is likely that a seventh MI Directive will be approved within approximately two or three years' time. The Commission have indicated that it is contemplating confining the Article 3 insurance requirement to traffic use on publicly accessible land and to specifically exclude certain non-traffic uses of vehicles<sup>77</sup>. Meanwhile it is clear that the current MI Directive is intended to confer a holistic and free standing entitlement to compensation<sup>78</sup> up to the minimum levels set by Article 9 and subject only to the single permitted exclusion set out in Article 13<sup>79</sup>.

60. Unfortunately, as is evident from Ward LJ's analysis<sup>80</sup> our domestic implementation fails to meet this standard. The learned judge's reasoning, by which he attempted to reconcile the qualified and restricted nature of the third party cover provided for under Part VI of the Road Traffic Act 1988 with the holistic scope of the European law requirement is clearly inconsistent with the Court of Justice's reasoning in *Vnuk*. Consequently, whole tracts of the wording in Part VI of the 1988 Act are either inconsistent with or directly contradict the European law it is supposed to implement.
61. If a similarly literal approach to interpretation, as employed by the Court of Appeal in *EUI*, were to be applied to our national law provision in the context of a road accident caused wholly or partly by a mechanical or technological defect, it is conceivable that a court would uphold any contractual restrictions in scope in cover against a third party victim. This would undermine the effectiveness of the protection required under the MI Directive<sup>81</sup>.
62. Accordingly, rather than adding to the present confusion by introducing in a piece meal fashion new legislation restricted to regulating compulsory insurance for autonomous vehicles and driver systems, we urge a root and branch review of our entire national law provision for ensuring that victims of motor vehicle use are guaranteed their fully compensatory entitlement. In our view there is good reason to believe that this holistic approach should result in concise, clear and fair law that is capable of being understood by layman and professionals alike.

#### **Brexit**

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<sup>76</sup> The complaint was brought by Nicholas Bevan following the Department for Transport's refusal to enter into a dialogue with representative bodies on the need for reform following its own February 2013 consultation on the MIB Agreements. It is registered under CHAP(2013)02537 and its reference under the EU Pilot scheme for handling complaints is 5805/13/MARK

<sup>77</sup> This would bring the Article 3 into closer alignment with Section 145 Road Traffic Act 1988.

<sup>78</sup> Recital 15 states: 'It is in the interest of victims that the effects of certain exclusion clauses be limited to the relationship between the insurer and the person responsible for the accident.'

<sup>79</sup> *Katja Candolin and Others. v Vahinkovakuutusosakeyhtiö Pohjola and Others* [2005] ECJ (Case C-537/03), paragraphs 17 to 21

<sup>80</sup> In *EUI v Bristol Alliance Partnership* [2012] EWCA Civ 1267

<sup>81</sup> *Candolin (supra)* see paragraph 28: 'The national provisions which govern compensation for road accidents cannot, therefore, deprive those provisions of their effectiveness.'

63. Clearly once the UK leaves the European Union in approximately two years' time the European Communities Act 1972 will be repealed, effectively revoking the supremacy of European law in this jurisdiction. Individuals affected by any continuing discrepancies between the UK national law in this area and the MI Directive are likely to lose their European law remedies and for incidents that postdate the cessation the UK law will be their only recourse.
64. However, a political decision will still need to be made as to whether the UK should fully implement the MI Directive regardless, including any successor<sup>82</sup> into our national law. It should be remembered that there is a very considerable, if not complete, consensus of legislative intent between the UK and European legislatures<sup>83</sup>. The differences lie in the execution of this policy; not the policy itself. The common intention of both the UK and EU law in this area is to guarantee the compensatory entitlement of motor accident victims. In which case, it is perhaps appropriate to ask what public benefit is served by permitting exceptions to the basic compensatory principle when in most cases, the victims are unable to influence or otherwise avoid their operation.
65. It also seems plausible to suppose that in future trade negotiations between the Government and the European Union the latter is likely to insist on a full implementation of the MI Directive if UK citizens are to continue to enjoy the valuable benefits of the various cross border remedies provided for in Chapter 7 of the MI Directive<sup>84</sup>.
66. Furthermore, as we have already noted, the Commission's ongoing regulatory review contemplates a seventh directive that will restrict the current scope of the Article 3 insurance requirement<sup>85</sup>.

### ***Legal challenges and delayed reform***

67. One could be excused for believing that over the past few years the Department for Transport (DfT) has had a consistent policy of favouring the commercial interests of

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<sup>82</sup> See above under para 58 regarding the European Commission's *Inception Impact Assessment, Adaptation the scope of Directive 2009/103/EC on motor insurance*, 8 June 2016

<sup>83</sup> One need only compare Lord Mance's account of the legislative aim of the MI directives in *Moreno v MIB* [2016] UKSC 52 [para 2] – 'The expressed and obviously beneficial purpose of the arrangements introduced by the Directives ... is to ensure that compensation is available for victims of motor accidents occurring anywhere in the Community (now the Union) and to facilitate their recovery of such compensation.' ...with Waller LJ's account of the UK Parliament's intention in *Churchill v Wilkinson* [2010] EWCA Civ 556 [para 3] – 'Compulsory insurance has been a feature of legislation in the United Kingdom for many years. The aim is to provide a guarantee that an injured person will obtain the compensation that he or she is awarded against the negligent driver.' Lord Hailsham makes a similar observation in *Gardner v Moore & Ors* [1984] 1 All ER 100- 'Part VI of the Road Traffic Act 1972 is designed to protect the innocent third party from the inability to pay of a driver who incurs liability by causing him death or personal injuries.'

<sup>84</sup> Such as the provision in Article 21 for claims representatives, the provision under Article 23 for international insurance information centres and provision under Articles 22 and 24 of the special claims procedure where a foreign insurer or claims representative fails to respond to a claim within a reasonable time

<sup>85</sup> See para 59 under *The pressing need for reform*

motor insurers at the expense of the accident victims whose interests the entire edifice of this European and national law provision is supposed to protect.

68. Few would challenge the DfT's need for a close working relationship with motor insurers and their representative bodies (such as the Association of British Insurers and the MIB) and for some of its discussions to be confidential. The motor insurance sector is an important strategic partner and it plays a vital role in providing motor accident victims with relatively prompt compensatory redress. However, there is also a corresponding need for open and accountable governance, which is not always evident in the DfT's dealings in this area.
69. The DfT's refusal to enter into an open dialogue with claimant representative bodies, the arguably tendentious nature of its earlier consultations, which was particularly noticeable in the way the DfT ignored the consistent calls for wide ranging reform made in response to its February 2013 consultation on the MIB Agreements<sup>86</sup>, and the unacceptable delay in implementing properly the MI Directive (and its predecessors), in circumstances where the need for reform has been clear and obvious for many years- does nothing to disabuse the perception that it is acting partially.
70. The following track record appears to support this perception:
  - 1996: *Bernaldez* CJEU
    - The DfT intervened, arguably unsuccessfully, in a case that had been referred to the Court of Justice from Spain. *Bernaldez* is an important case because it provides the first authoritative confirmation from the CJEU that the directives' protective objective had been fully formed by this time.<sup>87</sup> It ruled that member states had no discretion to introduce or permit their own idiosyncratic exclusions or restrictions in the compensatory guarantee required under Article 3 of the First Directive On Motor Insurance.<sup>88</sup>
    - The DfT then failed to apply the clear and obvious implications to be derived from the CJEU's decision based on Advocate General Lenz's Opinion of 25 January 1996, whose principles applied equally to the duty and scope of the insurance obligation as to the compensating body's obligation. See Jay J's observations below.
  - 1999: New Uninsured Drivers Agreement
    - The DfT approved a new scheme with draconian strike out penalties for the least procedural non-compliance with an excessive range of conditions precedent in circumstances that would not be permitted in an equivalent action under the Civil Procedural Rules, along with new exclusions of and restrictions in liability that are not permitted by the MI directives.
    - In 2014 Jay J's offered the following analysis in *Delaney v SoSfT [2014]*: 'In my judgment, the language of the Second Directive was, and is, clear and

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<sup>86</sup> Concerns that have been largely vindicated by the *Delaney* and *Vnuk* decisions

<sup>87</sup> See *Rafael Ruiz Bernáldez* [1996] CJEU Case C-129/94 paragraphs 15 to 24

<sup>88</sup> Council Directive (72/166/EEC) of 24 April 1972

obvious.... Any fair reading of the Opinion of Advocate General Lenz and the Judgment of the ECJ in *Ruiz Bernaldez*<sup>89</sup> would, or should, lead to the conclusion that as between insurer and victim the former cannot rely on an exclusion clause which is not within the express derogations set out in Article 2.1 [of the Second MI Directive]<sup>90</sup> now Article 13 of the MI Directive]. True it is that it was not until the decision of the ECJ in *Farrell*<sup>91</sup>, promulgated .... that there was unequivocal case-law to the effect that the same line of reasoning applied to the Article 1.4 [now Article 10 of the MI Directive] national body, but in my judgment - and as I have already explained - the point was close to being self-evident.'<sup>92</sup>

- ‘the language of the Second Directive - even unadorned by authority - was and is clear enough, and that the case of *Ruiz Bernaldez*, coupled with a basic understanding of Community law principles, ought to have led any reasonable official acting with the resources of the department to conclude that the insertion of clause 6(1)(e)(iii) could not lawfully have been achieved.’<sup>93</sup>
- 2001: *White v White & MIB* [2001] UKHL 9
  - The House of Lords ruled that the passenger exclusion in clause 6 of the Uninsured Drivers Agreement (UDA) of 1988 was inconsistent with the single permitted exclusion of liability in what is now Article 10 of the MI Directive which required actual knowledge in the passenger that the vehicle was uninsured.
  - The DfT failed to correct this in clause 6 of the UDA 1999 (which had by then replaced the 1988 version) and this scheme continues to apply to uninsured driver claims arising out of accidents that predate 1 August 2015.
  - In 2015 the DfT agreed what appear to be misleading and semantical revisions to the wording of the knowledge requirement in the new UDA, ostensibly in response to the Court of Appeal’s ruling upholding Jay J’ first instance finding in *Delaney*. The new agreement substitutes ‘knew or ought to have known’ from the 1999 Agreement with ‘knew or had reason to believe’ in the new agreement. It appears that these phrases carry precisely the same meaning and so conflict with the European law requirement as well as the ratio of the House of Lords decision in *White*.
- 2003: *Evans v SoSf Transport CJC*
  - In this case an earlier version of the UtDA was found to have failed to provide an equivalent level of compensatory protection on the basis that that the version under consideration did not allow for the payment of interest on the claim. By then the 2003 edition was in force. Once again, the DfT appears to

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<sup>89</sup> In 1996

<sup>90</sup> 84/5/EEC of 30 December 1983

<sup>91</sup> *Farrell v Whitty* [2007] CJEU Case C-356

<sup>92</sup> *Delaney v Secretary of State for Transport* [2014] EWHC 1785 (QB,) para 108. In march 2015 the Court of Appeal unanimously upheld Jay J’s finding that the UK was liable to compensate the claimant on the ground that the unlawful guilty knowledge provision was sufficiently serious to warrant damages under *Francovich* principles

<sup>93</sup> Ibid, *Delaney*, para 112

- have failed to appreciate the wider implications or to revise the current version.
- Flaux J made the following observation in 2007 in his judgment in *Byrne v MIB*: ‘... notwithstanding the *Evans* judgment of the European Court in 2003 which highlighted that the Untraced Drivers Agreement [of 1988] did not comply with the Second Directive in other respects, the Department does not seem to have checked through the entire Agreement at that time to ensure that it complied in every respect with the Directive’<sup>94</sup>
  - 2003: New Untraced Drivers Agreement (UtDA)
    - The DfT introduced new exclusions of liability that are clearly not permitted by the MI directives, such as in clause 4 (c) which absolves the MIB from any liability whatsoever if the victim has failed to report the incident to the police within 14 days, no regard being had to the victims’ age or capacity. The MIB can and does rely on these provisions.
  - 2007: *Byrne v MIB & SoSf Transport* [2007] EWHC 1268 (QB),
    - When the MIB’s failed to succeed in a defence that relied on the strict application of an absolute three-year time limit for presenting a claim under the Untraced Drivers Agreement 1996, regardless of the victims minority, the DfT introduced minimal changes to made to the UtDA 2003 to bring the strict year limitation period into line with the Limitation Act 1980. Unfortunately, once again it failed to undertake a proper compliance review (or if it did, it failed to implement its findings) which would have revealed various other provisions that were non-compliant: such as the unlawful property damage limitation period<sup>95</sup>, the unlawful property damage exclusion<sup>96</sup> the unlawful offset of insurance payments from damages<sup>97</sup>.
  - 2011: *Churchill v Wilkinson* CJEU<sup>98</sup> & EWCA<sup>99</sup>
    - When the DfT was confronted with a CJEU decision that section 151(8) Road Traffic Act 1988 was inconsistent with the MI Directive, it conceded to notional wording added by the Court of Appeal to bring the provision into line with the MI Directive. It failed to publish an official amendment of the legislation or to address a near identical provision in Section 148 (4) of the 1988 Act. When confronted with this instance of non-conformity, it failed undertake a compliance review of Part VI of the 1988 Act, which if undertaken, would have revealed numerous infringements of the MI Directive.
  - 2011: New property restriction introduced to UtDA

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<sup>94</sup> *Byrne v MIB* [2007] EWHC 1268 (QB), *Byrne*, para 72

<sup>95</sup> Clause 4 (3) (a)(ii), only removed ten years later by way of a supplementary agreement in 2013

<sup>96</sup> Clause 4 (3)(f) UtDA 2003

<sup>97</sup> Clause 6 UtDA 2003 which conflicts with the disregard under the rule in *Parry v Cleaver* [1970] AC 1

<sup>98</sup> *Churchill Insurance v Wilkinson; Evans v Equity Claims* [2011] CJEU (Case C-442/10)

<sup>99</sup> *Churchill Insurance v Wilkinson; Evans v Equity & Secretary of State for Transport* [2012] EWCA Civ 1166

- In April 2013 the DfT sanctioned a supplemental agreement which amended the UtDA 2003 by introducing a new property damage restriction that excluded all such claims unless a ‘significant’ injury had been sustained in the accident (not necessarily by the claimant). Such a measure was permitted by the Fifth MI Directive 2005/14/EC of 11 May 2005. However, the new UK law provision defines ‘significant injury’ as: ‘bodily injury resulting in death or for which 4 days or more of consecutive in-patient treatment was given in hospital, the treatment commencing within 30 days of the accident...’.
  - By importing into the term ‘significant’ a meaning that is in effect a serious injury requirement the DfT has permitted a flagrant breach of the Directive in circumstances where the European Commission’s clearly stated objective was simply to restrict the recovery of property damage to cases where there was some independent evidence that an accident had taken place; in the interests of preventing fraud.
- 2013: DfT consultation on the MIB Agreements<sup>100</sup>
    - In February 2013 the DfT announced its consultation on its proposals for review of MIB Agreements. The announcement followed within a matter of days a four-part series of articles by Nicholas Bevan<sup>101</sup> in the New Law Journal that exposed the failings in the UK transposition of the MI Directive and warned the minister that his department might incur liability for failing to properly implement this law. Various informed respondents warned the DfT of the widespread European law non-conformity of the UK statutory and extra-statutory implementation of the MI Directive, urging the DfT to undertake a wide ranging review of the entire UK transposition of this law. It was specifically warned that the proposed exclusion of terrorism exclusion clause was unlawful. It was also advised that the geographic and technical scope of the duty to insure and the third party cover required by sections 143 and 145 Road Traffic Act 1988 were too narrow.
    - The DfT was warned that the UDA and UtDA contained numerous unlawful restrictions and exclusions of liability<sup>102</sup>.
    - The DfT later abandoned the consultation and refused even to enter into a dialogue with various claimant representative bodies.
  - Later in 2013, further evidential requirements were introduced to the UtDA 2003
    - These were set as a condition precedent to any entitlement to compensation for property damage and they were incorporated into the UtDA 2003 by way of a supplemental agreement.
    - They were introduced within 4 days of the date set by the DfT for closure of responses to its consultation and without being mentioned in the consultation and without any prior notification.

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<sup>100</sup> *Review of the Uninsured and Untraced Drivers’ Agreements*, DfT, 28 February 2013

<sup>101</sup> *On the right road? Parts 1 – 4*, Nicholas Bevan, New Law Journal, February 2013

<sup>102</sup> Nicholas Bevan’s response was 64 pages long and included a comparative law spreadsheet that referred to over forty potential infringements of European law.

- October 2013, Infringement complaint to the European Commission
  - When the DfT refused to enter into a dialogue or to publish its final proposals as promised in the Summer of 2013, Nicholas Bevan filed a private infringement complaint at the European Commission. The complaint was accepted. According to the Commission the complaint has set in train a much wider investigation into the way every member state complies with the MI Directive and it is part of the regulatory review described above with reference to the Road Plan of 8 June 2016.
  - The DfT has been provided with extensive details of over 50 separate infringements and there have been a number of lengthy meetings between DfT officials and the Commission on this subject.
  - The DfT have been supplied with updated comparative law schedules from time to time.
- Early 2014, The DfT block the involvement of the Law Commission
  - When the Law Commission approached Nicholas Bevan in July 2013, seeking his proposals for reform in this area, with a view to incorporating this in its next triennial reform agenda, he submitted a detailed report setting out the relevant EU and UK law along with a detailed comparative law analysis that was submitted in October that year.
  - The Law Commission later wrote to indicate that they were unable to proceed with the project as the DfT were not prepared to support a review.
- September 2014: *Damjan Vnuk v Zavarovalnica Triglav d. d.* [2014] (Case C-162/13)
  - The CJEU judgment provided unequivocal confirmation that the UK had no legislative discretion to restrict the geographic scope of the third party insurance requirement to roads or other public places or to restrict the insurance requirement to motor vehicles intended or adapted for use on roads, as stipulate in the 1988 Act.
  - The CJEU judgment also confirmed that the Article 3 insurance requirement extends to any use made of a motor vehicle intended for travel on land that is consistent with its normal function and it elevates the importance of the legislative objective of protecting victims to equal importance with the aim of liberalising the free movement of people, vehicles and goods within the EEA.
  - The DfT is fully aware of the implications of *Vnuk* and the extent to which that judgment vindicates numerous concerns raised by several respondents to its February 2013 consultation and in the infringement complaint. Over two years have elapsed and yet the DfT has failed or refused to take any steps to rectify the numerous defects in its transposition that this decision exposes.
- 2013/14 DfT ignore further warnings of newly identified defects
  - The DfT was informed by Nicholas Bevan that the UtDA failed to provide any equivalent and effective protection for minors and mentally incapacitated victims. The DfT has failed or refused to bring its provision in this respect into line with the minimum requirements of CPR Part 21 in line with *Dunhill v Bergin* [2014] UKSC 18.

- February 2015: *Delaney v SoS Transport* [2015] EWCA Civ 172
  - The Court of Appeal upheld Jay J's first instance finding that the UK was in serious breach of European law in its transposition of Article 10 MI Directive in the UtDA 2003.
- August 2015
  - In August last year the DfT announced a new UDA as well as changes to the UtDA. Whilst removing two clearly unlawful passenger knowledge exclusions of liability contained in the 1999 version, the new UDA still contains a number of provisions that undermine the effectiveness of the MI Directive, such as the new terrorism exclusion. The ineffectual changes to the guilty passenger knowledge requirement<sup>103</sup> (ostensibly introduced to remove the constructive knowledge element held to be unlawful in *White v White* in 2011 and in *Delaney* in 2014) and the widened scope of the deductions it purports to be entitled to make from damages, appear to be also inconsistent with the European law requirement.
  - Despite having amended the UDA 1999 in the past, the DfT appears to have decided to allow the old scheme to continue to apply, unamended, for accidents predating 1 August 2015. This decision is likely to have been taken in the full knowledge that the UDA 1999 contains a number of unlawful exclusions and restrictions of liability that conflict with the MI Directive.<sup>104</sup>
  - The DfT was informed of these defects within a week of the new UDA being published but has failed or refused to act.
- October 2015: *RoadPeace v SoS Transport* CO Ref: CO/4681/2015
  - A national road safety charity invited the DfT to bring the UK national law provision into line with the minimum standards of compensatory protection required under the MI Directive but it refused. Accordingly, the charity has applied for judicial review of the UK's national law transposition of the MI Directive.
  - The judicial review concerns a number of discrete/illustrative legal challenges that the UK's statutory and extra-statutory implementation of MI Directive.
  - The Government Legal Department has already made a number of open concessions within the proceedings, including the following:
    - In an open response from October 2015
      - Ground 2 re: failure to extend the geographic limit to include all use within territory. DfT claims that it will consult on how best to amend domestic law, including both the UDA and UtDA in this regard, so as to reflect the position under EU law.
      - Ground 7 – re: the Terrorism exclusion in the UDA 2015 and UtDA. The DfT admits that these exclusions are unlawful.

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<sup>103</sup> See above in this section under 2001: *White v White & MIB* [2001] UKHL 9

<sup>104</sup> Between 2013 and 2015 Nicholas Bevan has provided the DfT, directly and through the legal office of the European Commission, with detailed schedules that list and explain which statutory and extra-statutory provisions appear to conflict with the MI Directive.

- Ground 8 re: the lack of suitable safeguards for children – the DfT concedes suable safeguards need to be put in place and says that further consideration on this will need to be given.
- Other points conceded
- Ground 9.1 – re: Statutory definition of motor vehicle, the DfT accepts that domestic legislation, the UDA and UtDA would need to be amended to give effect to the *Vnuk* decision.
- Ground 9.7 – re: the Rights Against Insurers Regulations 2002, the DfT admits that the definition of ‘accident’ in regulation 2(1) (which is confined to accidents occurring in the UK) fails to comply with the Directive.
- Grounds 9.12 & 9.19 & 9.22 – re: the exclusions of third party vehicle damage in c 6.1.di UDA and 5(1)(f) UtDA and 7(1) UDA 2015, the DfT admits that these need amending.
- Ground 9.16 re: Clause 2 UtDA, the DfT accepts that suitable safeguards to protect minors are necessary and the UtDA may need amending, and says this will be considered as part of the ongoing negotiations with the MIB to review the UtDA.
- Ground 9.18 re: the unlawful exclusion of property damage caused by unidentified vehicle – ‘significant’, the DfT accepts that this is likely to be amended.
- Additional and clearly referenced inconsistent provisions have been cited and explained within the proceedings and these points have yet to be conceded or determined.
- The DfT is contesting the application and a three-day rolled up permission and substantive hearing of the issues has been fixed for mid-February 2017.

71. The DfT’s failure to promptly address the longstanding and extensive illegality that permeates its entire national law implementation of the MI Directive is in our view egregious and its conduct, in refusing to enter into a dialogue with representative organisations and ignoring their calls for an urgent and wide ranging review, threatens to undermine public confidence in the DfT’s good offices.
72. In the meantime, the DfT continues to provide individual victims of uninsured or untraced drivers with a direct online link to the MIB<sup>105</sup>, presumably in the full knowledge that the MIB agreements fail to give full effect to the minimum standard of compensatory protection required under European law.

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26 October 2016

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<sup>105</sup> <https://www.gov.uk/compensation-victim-uninsured-driver>

## **Professor Simon Blackmore, Harper Adams University (HAU) – Written evidence (AUV0034)**

### **Preamble**

This evidence is based on my experience of autonomous vehicles and robotic systems gathered over the last 20 years in the agricultural sector. At HAU, we are currently designing and developing a complete range of new agricultural and horticultural equipment that will have significant economic and environmental benefits in how we interact with the natural environment by reducing the introduced energy (in all its different forms such as herbicides, fertiliser, fuel etc.) needed to support production agriculture and make food production more sustainable.

At HAU we have our own autonomous research tractor mostly compliant with ISO18497 (Safety of highly automated agricultural machines) and a range of smaller autonomous vehicles being developed for robotic strawberry harvesting, laser weeding, mowing golf courses, phenotyping and agricultural drones. We are just starting a new project to see if we can grow a complete crop with autonomous vehicles and without any person entering the field area.

In the context of this paper, I am extending the scope of ‘autonomous vehicles’ to include smart information systems, automation and robotics used to support them in crop production. If we have driverless cars and lorries on the road, we need provision for driverless tractors. **Please note that I do not currently support the use of driverless tractors on the road.**

### **Impacts and benefits**

#### *1. What are the potential applications for autonomous vehicles?*

The agricultural sector employs a lot of people to do simple repetitive tasks that can now be safely automated. A significant part of the cost of food production is paying a person to drive agricultural vehicles while carrying out simple field tasks or transportation of goods often on private land.

Just removing the driver is only part of the solution. Once we have the catalyst for change, robotics and autonomous system methods can be used to reinvent agricultural machinery that not only operates by itself but can have enough embedded intelligence to ensure that only the minimum amount of energy is used to achieve the desired outcome, which we are now calling intelligently targeted inputs, e.g. laser weeding.

Applications for autonomous vehicles range from simple field operations such as harrowing and rolling, through to the automated transport of logistics like strawberry crops or grain carting.

The first commercial autonomous systems will probably be in the high value horticultural crops where the tasks are semi-skilled, time consuming and highly repetitive.

2. *What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?*

The main user benefits are likely to come from reduced input costs (intelligently targeted inputs) and the reduced need for cheap, often seasonal, labour.

One of the biggest benefits will come from the economics of employing less seasonal labour to carry out simple repetitive tasks. Seasonal labour is becoming more expensive and increasingly more difficult to come by. Some of these workers can be replaced by automation but not all of them as even the robots must work in a human supervised and supportive environment.

Many farmers are experiencing fears over the lack of cheap labour in terms of potential added restrictions embedded in the Brexit negotiations but the UK is in a good situation to be able to use and support high technology in the agricultural sector to not only compensate for this but to also make production more efficient.

Disadvantages of using autonomous vehicles in agriculture will be the inherent disruption to a set of mature businesses. It will be disruptive to the farmers as they will have to think about farming in a different way.

**Example:** Instead of damaging the soil each year with large tractors and then having to plough and cultivate to repair the damage, I now estimate that 90% of that energy can be saved by not creating the damage in the first place if we use small smart machines. If we do not damage it, we do not need to repair it.

Autonomous vehicles will be disruptive to the machinery industry as over the last 70 years we have seen a linear development of machines getting bigger due partly to the cost of the driver and partly due to economies of scale. Tractors have now reached their maximum size and cannot be made any bigger due to road and rail transport restrictions.

Autonomous vehicles will be disruptive to the service sector as farmers now have access to unprecedented data about their farms, fields, tractors, weather, soils etc., now commonly called big data. With the advent of drones and new tractor mounted sensing systems we can virtually measure every important crop parameter in real time on an individual plant basis.

3. *How much is known about the potential impact of deploying autonomous vehicles in different sectors?*

Very little, because we are trying to understand the implications of a proposed system that is changing week by week. The need is clearly there; the economics seem to be justifiable in the longer term but it is unclear how the commercial system will be implemented.

4. *How much is known about public attitudes to autonomous vehicles?*

The popular media has shown a number of instances of robotic agriculture that have captured the public's imagination in a positive way, such as Interstellar and Wall-E which showed robots tending crops. This is countered by others that predict robots and AI will

take over the world. In my experience most people believe that small smart machines helping us to grow food in an efficient and environmentally sensitive way is a good thing.

5. *What is the scale of the market opportunity for autonomous vehicles?*

The scale of the market opportunity in the UK is a difficult one to estimate. The agricultural and horticultural sector is huge, but to what extent the robotic systems will penetrate is difficult to foresee as some tasks are clearly ripe for automation and others will always need people.

### **Creating an enabling environment**

#### **Research and development**

6. *Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?*

As far as I am aware there are no current or planned demonstration facilities for autonomous agricultural vehicles in the UK. There is one in Montpellier, France. At HAU we have our own test track and farm that we currently use for these purposes.

7. *Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?*

There have been significant funds (£160m) input by the Government to the Agri-Tech Strategy that has funded 98 projects to date, including some of the projects mentioned above. Three new centres have been launched in 2016 one of which is the Agri-EPI Centre (Agricultural Engineering Precision Innovation Centre) which will give the high-tech agricultural sector very good facilities. One hub of that centre is based at HAU.

There is the concern that as the Agri-Tech funds are now diminishing, there may not be a follow up scheme to keep innovation going. In my experience companies find it hard to innovate in disruptive technologies without Government help. **I would strongly advocate the continuation of the Agri-Tech Strategy, within the Industrial Strategy now being developed by Government, to ensure that innovation in the UK is continually, and consistently, nurtured.**

8. *How effective are Innovate UK and the CCAV in this area?*

In my experience Innovate UK has been very influential and supportive in meeting the Government's aims. We have had little contact with CCAV probably due to their focus on cars and ours on tractors.

9. *Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?*

Due to the disruptive nature of these technologies and the hesitance of the big machinery manufacturers to get involved, I feel that the start-ups are more likely to exploit radically different technologies as they have no legacy baggage and are ready to exploit new paradigms. The Agri-Tech strategy has certainly helped many SMEs commercialise these opportunities.

### **Real world operation**

*10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?*

From the agricultural perspective we need wide area broadband technologies that can cover a farm. We already have good coverage from GPS and virtual base stations but for all the autonomous vehicles we envisage, it is important to be able to keep in touch, both from a user's point of view (as the person responsible for the vehicle must be able to monitor and control it via WiFi) and from the requirement to move large data sets to and from the vehicle with telemetry.

In the past we have modified the environment to suit the machines (big flat fields) but my philosophy is we should now make the machines smart enough to deal with the complexity of the real world.

*11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?*

There are many autonomous agricultural vehicles being developed around the world, but unlike the car sector there are no long term demonstrations in the agricultural sector as far as I am aware. I see demonstration as being the key milestone to their extensive deployment in the farming community. Once farmers see these technologies being used successfully, then they are more likely to invest, which makes it easier for the start-ups.

*12. Does the Government have an effective approach on data and cybersecurity in this sector?*

I am unaware of any specific issues on this topic.

*13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?*

In my development of the HAU autonomous tractor I have tried to adhere to all the current legislation and even go beyond it to embrace ISO18497.

**There are significant legislative changes needed to allow the use of new technologies. Many laws regulating the use of chemicals are defined in terms of how they are applied. Now we have intelligent systems that can apply chemical only to the leaf of the target plant, it makes the current laws redundant and restrictive. Many of the chemical companies have very good active ingredients that cannot currently be used as the method of applying them is defined in law. As the technology has moved ahead we need new regulations that can allow such beneficial changes.**

*14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?*

In all my autonomous systems there is still a person in charge of the vehicle. They are not driving it and can carry out other non-related activities, but nevertheless they are responsible for the safe use of the machine and must be within 1km. In this manner the liability is clearly divided in two parts; that which is equipment supplied by the manufacturer that must be fit for purpose, and that which is its use in the correct way by an operator. In my view this meets all current legislation.

It is not yet clear who takes responsibility when a mass produced driverless car has an accident.

### **Wider governance**

**15. What does the proposed Modern Transport Bill need to deliver?**

Inclusion of the use and regulation of autonomous agricultural vehicles.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

HAU is leading the UK in developing these technologies for agriculture, along with Lincoln University and Sheffield University. As universities we integrate our training with research. Many of our students are actively developing autonomous vehicle skills and even successfully competing at international level.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

I feel that autonomous agricultural vehicles will have a bigger impact on agriculture than driverless cars will have on the road. My reasoning is that moving over to agricultural robotics gives the opportunity to redefine the tasks and operations we currently carry out and to use this change to significantly reduce the cost of crop production, reduce the impact on the environment, produce better cleaner food and hence improve the sustainability of the UK and world food supplies.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

The EU has been developing a strategy to embrace robotic agriculture to such an extent there is a new call out, closing in Feb 2017. We are part of a consortium that will bid in this call.

Brexit could limit farmer's access to seasonal labour but some of these tasks and operations could be replaced by automation given suitable support.

**The UK government should recognise that these new technologies will give UK agriculture a new method to improve our food production and make us significantly more sustainable, but to do this the Agri-Tech Strategy needs to be continued and the research councils need to recognise robotic agriculture as being a key technology for fundamental research.**

24 October 2016

Professor Simon Blackmore, Harper Adams University and UK Atomic Energy Authority (UKAEA) – Oral evidence (QQ 11-19)

**Professor Simon Blackmore, Harper Adams University and UK Atomic Energy Authority (UKAEA) – Oral evidence (QQ 11-19)**

[Transcript to be found under UK Atomic Energy Authority \(UKAEA\)](#)

**Bristol driverless cars project, Milton Keynes Council and GATEway (Greenwich Automated Transport Environment) – Oral evidence (QQ 31-39)**

[Transcript to be found under GATEway \(Greenwich Automated Transport Environment\)](#)

## **British Motorcyclists Federation (BMF) – Written evidence (AUV0019)**

*Submission made by Anna Zee, BMF Director, Political and Technical Services*

### **Introduction**

The BMF is not qualified to answer many of the questions posed by the enquiry but as our members have serious concerns with respect to the use of autonomous vehicles we venture to put these before you. Our principal concerns centre around road safety, especially the road safety of motorcyclists.

### **Q2: User benefits and disadvantages**

There could undoubtedly be considerable benefits resulting from the use of autonomous vehicles. The on-road behaviour of a computer-driven vehicle should be rather more predictable than that of human drivers; human error is a factor in most road accidents and taking it out of the equation should have major safety benefits. Systems able to prevent cars from turning into the path of other vehicles will certainly be welcomed by motorcyclists.

However, the above will only be true if the systems on autonomous vehicles are developed to behave correctly at all times. Such vehicles will need to be equipped with sensors capable of correctly detecting all other road users besides the environment itself, and the software must be built to use the information as well as possible. Above all the systems must be tested so that it can be proved that a vehicle will perform as it should. This is a major issue for us when it has recently been shown that some existing systems perform poorly with respect to motorcycles. A motorcyclist in Norway was seriously injured when a Tesla with in "autopilot" mode hit the bike hard from behind.<sup>106</sup> I also draw your attention to a paper presented recently at the IFZ conference<sup>107</sup> which shows that the Forward Collision Warning systems currently available are not reliable, especially with respect to detecting stationary motorcycles; while this is only a preliminary study it is, I think, sufficiently rigorous to raise serious concerns.

It seems plain to us that vehicles with increasing levels of automation must be subjected to extensive testing before they are allowed on public roads. The current requirements for Type Approval and NCAP testing must be expanded to take into account the functionality of all the systems on the vehicle - it must not be left to the manufacturers. An additional consideration here is that we do not think it acceptable to have wide variation in the behaviour of systems, dependent on the manufacturer. This could be dangerous both for drivers switching from one car to another and for all other road users, if they are not sure how a highly automated vehicle will behave.

It is also apparent, if only anecdotally, that drivers of highly automated vehicles will be less likely to be paying full attention to the road - it's probably why they got the vehicle in the

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<sup>106</sup> <http://www.fema-online.eu/website/index.php/2016/10/07/nmcu-asks-elon-musk/>

<sup>107</sup> Preliminary Study of the Response of Forward Collision Warning Systems to Motorcycles, John F Lenkeit, Terrance Smith, Dynamic Research Inc. USA (Not currently available on the internet - I can supply a soft copy if desired).

first place. And therefore it is even more essential that the car itself must be programmed to behave correctly.

In summary, the answer to Q2, at least with respect to road safety, is that autonomous vehicles could be a very good thing but only if the systems can be proven to work in formal and thorough testing. Allowing their use on the road without proper testing is not acceptable.

#### **Q4 - public attitudes**

While the motorcycling community welcomes the idea of cars that won't turn out of sideroads in front of them riders do have concern that there is currently no rigorous testing scheme in place. Nor will riders accept autonomous vehicles if it means that other vehicle users suffer restrictions on their use of the roads.

#### **Q7 - is the government doing enough?**

What the government should do more of is put effort into ensuring that extensive and rigorous test regimes are in place for highly automated and autonomous vehicles. This will not be easy, especially with respect to software. Manufacturers will not wish to submit their software for code inspection but recent events (i.e. VW diesel testing) demonstrate they should not be trusted.

#### **Q10 - changes to infrastructure**

Infrastructure may require changes to cater for autonomous vehicles, though on the road this may be as simple as ensuring that lane markings are always clear. Co-operative ITS systems are expected to require digital and physical infrastructure development for applications such as management of congestion, Green Light Optimisation System Advisory, emergency vehicle prioritisation.

#### **Q14 - ethical issues**

Ethical issues have received little attention so far. If truly autonomous vehicles are to be realised then there must be clear guidelines as to the expected behaviour of systems. If an autonomous vehicle has a choice between crashing into an HGV, possibly killing the owner, and mowing down a bus-queue of schoolchildren then its priority should not be the protection of the owner. Perhaps with sufficient market penetration such situations need not occur but is that achievable?

#### **Q18 - effects of leaving the EU**

In the runup to Brexit UK institutions are finding that they cannot take the lead in EU funded projects, though so far this is not preventing them from participating altogether. Certainly a lack of co-operative work with the EU would be detrimental to UK efforts in this field.

*24 October 2016*

## **British Parking Association (BPA) – Written evidence (AUV0038)**

*Evidence submitted on behalf of Patrick Troy, Chief Executive of the British Parking Association.*

### **Driverless Vehicles**

The British Parking Association (BPA) welcomes your inquiry regarding driverless vehicles. As the largest professional parking association in Europe we represent around 690 organisations by promoting and influencing the best interests of these members and the parking and traffic management sector throughout the UK and Europe. These organisations are many and varied and include manufacturers, car park operators, local authorities, health authorities, universities and higher education facilities, airports, railway stations, shopping centres, theme parks, construction companies, learning providers and consultants. We have 250 local authorities amongst our members.

For more information about the BPA please see the [endnote](#).

Accessibility continues to underpin economic regeneration, as shown in the BPA's [Master Plan for Parking](#). Our response provides proposals on how encouraging innovation and investment, and the fair and effective use of technology will improve the delivery and management of parking services for the benefit of all.

Our response to your specific questions is provided in the [Appendix](#).

Technology is revolutionising the way people travel, and we want to drive innovation, investment and social responsibility in the parking profession. Parking policy has a major influence on people's travel decisions and therefore on how people move and become mobile. Proper and effective traffic management is vital in our towns and cities and as society evolves and the likelihood of congestion increases, it is important to encourage public acceptance of advances and innovations in new technology helping to deliver parking solutions and services which enable a mobile society.

With the majority of trips starting or ending with parking, parking must be at the heart of future mobility discussions as we prepare for a future increasingly dependent and driven by technology.

### **Research into technology and innovation in parking**

The BPA has identified a need to explore the various opportunities in technology as well as potential threats and challenges that face the parking profession and those working within it. There is little doubt that we are witnessing a major shift which will transport us from what is perceived by many motorists as a relatively fragmented way of delivering parking services to something which is consistent, simpler, aided by technology and where practitioners and providers can deliver a much more holistic service that benefits everyone.

The BPA is keen to connect emerging technology to people's mobility aspirations through developing new parking policy. The BPA has formed a new group of parking and transport experts to explore these exciting and yet thought-provoking opportunities, commissioning research to identify trends in future intelligent mobility.

Our report *Parking 20:20* follows research commissioned to explore the future of parking and intelligent mobility. Conducted by Imperial College Graduate Justus Loebler, the report identifies seven key areas where the BPA's efforts must be directed:

- Data and Apps
- Payment
- Integration
- Real-Time Data
- Shared Mobility and Car Clubs
- Electric Vehicle Charging
- Autonomous Vehicles

The research seeks to identify the future role of parking and the impact of changes in technology and mobility, pointing to changes in the way that parking services are being managed and delivered.

The future of parking will change rapidly over the coming years and new products and services will enter the market, disrupting many aspects of the parking profession. As the leading association for parking professionals, the BPA is committed to supporting our members, and helping to identify the opportunities and threats that change and innovation will bring to the sector.

Taking action in fields such as data integration, innovation in payment processes, autonomous and electric vehicles will ensure parking is at the heart of future mobility discussion and that the parking profession is well prepared for the future. The research suggests that despite the majority of trips starting or ending with parking, the parking profession needs progressive integration with the rest of the Transport Network. We therefore want to ensure that the parking profession and the services it provides are integral to the Government's National Innovation Plan in order to create holistic transport policies that meet local needs and address environmental concerns.

We believe that by establishing links to other stakeholders including, but not limited to, intelligent mobility groups, mobile phone companies, car manufacturers, intelligent transport providers, academia, government, local authorities, health trusts and the private sector, we can together build a policy consensus and ensure that the parking profession is integrated with the rest of the Transport Network.

The BPA will be conducting further research to focus on establishing progressive standards for the usage of new technology within the parking sector. Also, it will showcase where the parking profession has an important impact on the development and deployment of future intelligent mobility.

For example data is seen as an important area, covering three of the seven areas identified as a priority in the Parking 20:20 research (Data & Apps, Integration and Real-Time Data). To provide a better service for the consumer operators need to access real-time data. This data needs to be accurate and useful. To ensure this the BPA will be exploring opportunities to establish a standard in terms of criteria for a format for the collection and presentation of parking data.

The type of technology to utilise and how the public, businesses, and local government access the data will significantly alter the provision of parking as we know it. What it will look like ultimately depend on everyone working together to provide an exceptional experience for the end user.

The BPA are keen to research and be involved in work on autonomous vehicles to ensure that parking operators are up to date and providing the best possible service to their customers.

### **Camera technology in parking**

Much of the work we have done demonstrates that there is a need for local authorities and private operators managing parking to be flexible in how they manage their car parks where they make a charge. One of the most effective ways of making it easier for motorists to park without the stress of having to worry about how long they are parking is to embrace new technology and the increasing use in the private sector of automatic number plate recognition (ANPR) which enables motorists to park without paying, to stay as long as they like but to make payment either on their return or online within, say, 24 hours. This is the same principle as applies to London's congestion charging scheme and the governments' Dart-charge on the Dartford crossing.

Driverless cars will be connected to other technologies, and to streamline the journey furthermore there will be the opportunity to connect the vehicle with camera technology in car parks.

However, local authorities do not have the powers to use ANPR in this way, the Deregulation Act placed restrictions on the use of CCTV by local authorities operating Civil Enforcement Powers under the Traffic Management Act.

Surveillance cameras play an important role in the management and use of parking facilities. We set out in our [Master Plan](#) that it is important that the use of cameras and surveillance technologies is fair and responsible, in accordance with Data Protection rules, and providing benefits to operators and motorists, with protocols in place to identify unfair or inappropriate enforcement activity.

Cameras (CCTV and ANPR) are useful tools to properly manage parking and Government should not ban them but should properly regulate their use for specific, locally-defined purposes. In some areas where the use of a Civil Enforcement Officer is not practical the use of cameras can be helpful.

We urge the government to revisit this issue as part of this discussion and to recognise the value such technology brings particularly to users in pre-booking technology, paying on departure and improved access for people with disabilities, and most particularly in relation to hard pressed traders and shopkeepers who rely on trade from car-borne customers in many UK towns and cities.

Safeguards need to be put in place to ensure such technology is not used simply for enforcement but as much technology is readily used in private car parks we believe local authorities should be able to use it too.

#### **Driverless cars as an enabler**

Parking services impact on everyone, for people who travel about, regardless of their mode of transport, few things impact on people's daily lives more so than parking services. Even pedestrians can be affected by poorly parked vehicles, obstruction of footways, dropped kerbs road crossings and junctions and parking at bus stops can impede access to public transport services.

Technology is an enabler of equality and improved access and services in parking. The use of ANPR in car parks in particular is a technology which enables the delivery of many new customer friendly systems and improves accessibility for the elderly and disabled motorists by enabling hands free entry and exit and the use of internet based pre-booking systems and parking accounts.

Driverless cars may provide further improvements to access and travel for disabled motorists and elderly motorists. Disabled people may be unable to drive. Elderly people may be judged unfit to drive. Others may simply not want to drive or be concerned about their ability to do so.

Without the need to operate the vehicle either at all or for long periods or perhaps as much as they do now, driverless cars could ensure equality and enhance their quality of life.

#### **Consistency in parking rules and regulations**

Driverless cars will need to understand parking rules and regulations to park themselves. With the vehicle programmed to carry out a minimum risk manoeuvre such as pulling over to a safe parking place, if the driver is no longer in control, then the vehicle must be able to identify a safe parking place and understand parking terms and conditions.

Autonomous vehicles necessitate the consistency of signage across the country to ensure the cars understand the rules.

The legislative framework for managing parking needs to be carefully examined to ensure it can continue for the best of the community. Liability for parking offences needs to be defined in the instance of autonomous vehicles, where driver liability would come into question.

Currently there is confusion for motorists when faced with parking tickets. On private land, parking is often managed by private parking companies who issue their own parking tickets. The rules about issuing these tickets are different to the rules about tickets issued by local authorities. Mainly private parking tickets, parking charge notices, are issued on the grounds of ‘breach of contract’, local authorities issue parking tickets, officially called ‘Penalty Charge Notices’, which are of course ‘regulated’ by traffic law.

In 2007 the BPA established its Approved Operator Scheme to ensure that its members involved in managing parking on private land behaved responsibly and complied with the Code of Practice which was established in consultation with other stakeholders including motorists and consumer representatives including people with disabilities, motorists, consumer organisations, vehicle hire companies and freight operators as well as AOS members. Abiding by a code of practice helps businesses ensuring fair treatment of the motorist and high professional standards of conduct. The BPA continues to raise standards, over recent years, seven companies have been expelled for serious breaches of the code.

In addition the BPA and its approved operator member companies have established POPLA, the Parking on Private Land Appeals service<sup>108</sup>, which came into being at the same time as The Protection of Freedoms Act in 2012 and since its launch over 65,000 appeals have been submitted. This is the equivalent of 1% of all parking charge notices issued on private land and compares favourably with the levels of appeal to the statutory traffic penalty tribunals in London and in England and Wales. POPLA is judicially independent, with an Independent Scrutiny Board guaranteeing absolute independence.

As time has moved on we believe that there is a need for government to introduce some light touch regulation to ensure that standards in this sector continue to rise and you will see from the [enclosed document](#) that we are proposing the establishment of a standard setting body accountable to the Government but at no cost to it which would ensure a consistent set of standards across the sector.

We also believe that there should be a single appeals service to serve quick, easy and free independent redress to motorists. This change will become all the more important when cars need to understand the rules.

## **Conclusion**

The BPA is always very willing to work with government to develop car parking policy and the Association is at your disposal to assist with any further information, advice or support in relation to this very important area of public policy. We would be delighted to give oral evidence of best practice in the parking community if it was helpful to the Committee and inquiry.

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<sup>108</sup> The processes of POPLA

The motorist has 28 days to appeal to POPLA from an operator’s rejection of their representations. This is for POPLA to decide and will then feed back to the BPA to investigate any breaches identified. POPLA operates as an independent resolution for non-statutory parking charges. POPLA is independent of all parties to appeals, including the operator and the BPA.

Once the appeal is lodged, the operator has 28 days to submit evidence they allege proves the breach. POPLA is free to the motorist.

We hope you will find these comments of interest. The BPA is ready to work with the government to achieve these desired aims and we look forward to discussing with you how we can assist in taking these issues forward.

*26 October 2016*

## **Appendix**

### **Impacts and benefits**

#### **1. What are the potential applications for autonomous vehicles?**

Driverless vehicles are a new technology and countless opportunities have not yet been explored.

We believe in the first instance HGVs and the commercial sector will take on driverless vehicles. Freight trains could be provided, using connected autonomous vehicles providing quicker and more efficient transportation of goods.

Driverless buses could provide better and more frequent services, especially in rural locations.

Driverless cars would be accessed and used more as taxis and car sharing vehicles than as bought personal property as they are now.

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

Possible advantages include more free time for everyone and improved safety of both motorists and pedestrians. As we have explained above improved access for the elderly and disabled people.

We could see a reduction in emissions due to quicker, smarter journeys and the easing of congestion with the vehicles ensuring optimal usage of road capacity.

The vehicles in combination with smart technologies could reduce labour costs while boosting equipment and facility productivity.

Disadvantages could include in the short term a feeling of lack of control for many motorists, that initially could cause a slow take up and problems caused by motorists taking back control from the vehicle.

#### **4. How much is known about public attitudes to autonomous vehicles?**

Little is known about the public attitudes and the potential take up of autonomous vehicles.

We held a poll on our website in early 2015, the question was ‘Are driverless cars the future of motoring?’ It identified that out of 220 respondents 86 said there was ‘no chance’, 57 said ‘definitely’, with the remainder of respondents unsure.

However the Millennial Generation (covers people born between the 1980’s and the year 2000) make up a large proportion of the population. This generation has been shaped by the technological revolution that occurred throughout their youth. They, as does every new-born child now, grew up with technology, so being connected and tech savvy is in their DNA. Equipped with the latest technology and gadgets, they are online and connected 24/7, 365 days a year.

They expect technology in every aspect of their lives, and we believe will welcome autonomous vehicles.

## **5. What is the scale of the market opportunity for autonomous vehicles?**

Autonomous vehicles will impact our members and the wider parking profession directly.

We estimate there are 17,000 – 20,000 parking facilities across the UK and the parking profession employs approximately 82,000 people of whom the vast majority (72,000) are employed in the private sector<sup>109</sup>.

The size and value of the businesses supporting parking operators is unknown as we do not know the size of the support sector, just as we do not know the number of operators thus it is impossible to quantify readily. Companies evolve continuously, for example BMW et al are developing self-parking vehicles, and camera technology companies are developing systems to support parking management, just as Visa is processing more and more payments for parking operators.

Autonomous vehicles will also impact on roads and the traffic management infrastructure.

### **Creating an enabling environment**

#### *Research and development*

## **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

We know that connected and autonomous vehicles are already being developed and tested. There are several UK cities already testing autonomous vehicles, including:

- UK Autodrive, based in Milton Keynes and Coventry
- The University of the West of England campus in June 2016, with subsequent trials to follow in Bristol City Centre
- Drive Me London, a private scheme with plans to unleash a fleet of self-driving Volvos on public roads in London
- GATEway (Greenwich Automated Transport Environment)

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<sup>109</sup> [BPA and Skyblue Research, The Size and Shape of the UK Parking Profession, 2013](#)

- Jaguar Land Rover has said it will create a fleet of more than 100 research vehicles over the next four years to test autonomous and connected technology, with the first hitting the streets later this year. They plan to test the vehicles near its headquarters in Whitley, Coventry

We understand that the Department for Transport (DfT) Code of Practice for how driverless cars should be tested on UK roads is useful and encouraging.

We own Europe's largest trade exhibition for parking, Parkex, last year we invited a connected police car to the event and hope to invite more demonstrators in the future.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

We have found that parking is often forgotten about, despite having a major influence on people's travel decisions and therefore on how people move and become mobile.

The Government could do more to provide more information on different funding streams for businesses or associations to fund research in this area and could improve the way they connect organisations interested in this area.

**8. How effective are Innovate UK and the CCAV in this area?**

The BPA began working with Innovate UK in 2015 to ensure that parking was part of the discussion. The organisations have been helpful leaders in this field, however they could do more to join up the conversations and get as many organisations involved as possible.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

The BPA receives many requests from small enterprises for introductions to local authorities to test and use their new innovations. However local authorities have little time and funds to try new technology out.

We think Government should be helping local authorities to develop and improve their services through new technology and should provide them with funding to test new technology and help small enterprises.

To enable the discussion we have created the Parking 20:20 group to ensure all of this interested and working in innovation and technology can network and join up the conversation.

*Real world operation*

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

We are sure that autonomous vehicles will affect the altering of car park structures to ensure they cater for the vehicle's needs, however the BPA believes it will be a chicken and

egg conundrum, that will require careful assistance and wide sharing of best practice examples.

Autonomous vehicles; For example, self-parking autonomous vehicles do not require open-door space for dropping off passengers when parked, allowing them to occupy parking spaces that are 15 percent tighter.

We could also witness less demand for parking as a result of autonomous vehicles if they become more like car sharing vehicles and are in use for longer periods than they are parked.

Britain's many aging car parks need to be assessed and refurbished to accommodate autonomous vehicles. Funds should be made available by owners and operators to ensure car parks are properly serviced and maintained.

We believe that good quality, well designed and properly maintained car parks can contribute significantly to the prosperity of Britain's towns and cities. The lack of investment could significantly reduce visitors to the car parks and of course to the high street.

We replied to the Department for Transport's consultation on *Driverless vehicles: connected and autonomous technologies*, specifically addressing their suggestion of remote control parking. We outlined that the driver will need to get out of the vehicle and, using a mobile device command it to automatically drive itself into, or out of, a parking space the car park structure may need to be altered to provide a place for the driver to stand.

The cost of these changes may be vast and cannot be undertaken by car park operators immediately.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

The BPA believes autonomous vehicle take up will start with industrial fleets.

We believe take up by the public may be harder and should start with pilots with funding to help local authorities and companies make vital changes to structures and market it to the public. The key findings of the pilots can then be shared and the process rolled out to the rest of the UK.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

Government need to look at regulations to support other technology in parking too. Cameras (CCTV and ANPR) are useful tools to properly manage parking and Government should not ban them but should properly regulate their use for specific, locally-defined purposes. In some areas where the use of a Civil Enforcement Officer is not practical the use of cameras can be helpful.

As explained above data is seen as an important area, covering three of the seven areas identified as a priority in the BPA's Parking 20:20 research. To provide a better service for

the consumer operators need to access real-time data. The BPA will be exploring opportunities to establish a standard in terms of criteria for a format for the collection and presentation of parking data.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

As explained above regulators need to play a role in establishing progressive standards for the usage of new technology within the parking sector. This will showcase where the parking profession has an important impact on the development and deployment of future intelligent mobility.

Driverless cars will need to understand parking rules and regulations to park themselves. With the vehicle programmed to carry out a minimum risk manoeuvre such as pulling over to a safe parking place, if the driver is no longer in control, then the vehicle must be able to identify a safe parking place and understand parking terms and conditions.

Autonomous vehicles necessitate the consistency of signage across the country to ensure the cars understand the rules.

The legislative framework for managing parking needs to be carefully examined to ensure it can continue for the best of the community. Liability for parking offences needs to be defined in the instance of autonomous vehicles, where driver liability would come into question.

The current regime for parking on private land is confusing for motorists and will be for autonomous cars too.

We believe that there is a need for government to introduce some light touch regulation to introduce a single standard setting body, a single code of practice and a single appeals service to serve quick, easy and free independent redress to motorists.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

It is essential to ensure that the technology does not impair things rather than improve things. For example good parking management is vital to ensure that parking facilities remain accessible and provide access to town and city centres. This technology has the potential to cause congestion in the car park, either by many drivers taking back control when believing they have identified hazards, or by cars operating at very low speeds and stopping when they identify hazards.

*Wider governance*

**15. What does the proposed Modern Transport Bill need to deliver?**

It will be necessary to make revisions to the Highway Code to accommodate automated vehicle technologies; we want to see changes in the waiting and parking (238 to 252 of The Highway Code rules).

Autonomous vehicles will need to fully understand parking rules, when the Bill identifies the 'higher standard of 'driving' demanded of vehicles operating in an automated mode than would be expected of a conventional driver'. Government will need to bring in some changes to private parking before this particular Bill is passed to ensure all of it is much easier for motorists and now cars to understand.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

To ensure the safety of motorists and pedestrians the BPA believes that autonomous vehicles may necessitate changes to the driving test or a new test to ensure those using the vehicles are fully equipped to use them and understand how they work.

It is also obvious that with the roll out of autonomous vehicles proper training for mechanics is necessary to ensure that the vehicles are properly maintained and safe on our roads.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

We have found that parking is often forgotten about, despite having a major influence on people's travel decisions and therefore on how people move and become mobile.

The Government could do more to provide more information on different funding streams for businesses or associations to fund research in this area and could improve the way they connect organisations interested in this area.

To enable the discussion for our members and stakeholders we have created the Parking 20:20 group to ensure all of this interested and working in innovation and technology can network and join up the conversation.

**Endnote**

**About the British Parking Association:**

The British Parking Association (BPA) is the largest professional association in Europe, representing around 690 organisations in the parking and traffic management profession. Our members include manufacturers, learning providers, consultants, local authorities, car park operators, including those managing parking on private land such as retail parks, healthcare facilities, universities and railways stations. We have 144 members managing parking on private land and 250 local authority members. We provide our members with knowledge and a range of benefits and resources that assist them in their day to day work.

As the recognised authority within the parking profession, we represent, promote and influence the best interests of the parking and traffic management profession throughout the UK and Europe. We also manage initiatives for the sector including the Safer Parking Scheme (on behalf of the Association of Chief Police Officers), the Approved Operator Scheme (for those managing parking on private, unregulated land) and our stakeholder engagement group, the Parking Forum.

We place the consumer at the heart of our thinking and as the recognised authority in parking we actively represent and promote the sector by advancing knowledge, raising standards and professionalism, and using our influence to deliver excellence for the benefit of all.

For more information regarding us here at the BPA, please click [here](#).

## **British Standards Institution (BSI) – Written evidence (AUV0060)**

1. BSI (British Standards Institution) is responding with interest to the House of Lords Science and Technology Committee's enquiry on the future of driverless vehicles. In doing so our response on the benefits of standardization is relevant to each of the following two questions posed:
  - *Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?*
  - *Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?*
2. BSI is working on new research with the Transport Systems Catapult Centre (supported by the Centre for Connected and Autonomous Vehicles) to explore priorities for standardization to support the development of CAVs in the UK. The project is primarily considering road vehicles including driverless cars, trucks, along with pods and shuttles, and both the challenges and opportunities (for standards) as systems become more centralized, software-dependent and automated.
3. Standards play an important role in helping establish innovative, emerging technologies such as Connected and Autonomous Vehicles (CAV). Standards can offer a flexible, adaptive alternative to regulation by providing common languages, terminologies, test methods, guidelines and good practice developed for and by industry.
4. In this capacity standards are vital tools in enabling interoperability, reducing risks to businesses and consumers, promoting safety and the acceptance of products and services.
5. Our initial research findings have indicated a number of possible areas for standards to support the deployment of autonomous vehicles across topics including communications and digital infrastructure, safety and security of both vehicles and systems. There may also be opportunities for the UK to play a leading role in international standards relevant to the field of CAV.
5. The research is due to be published between December 2016 and January 2017 and BSI would be happy to provide more information on the findings.

### **About BSI**

BSI is the UK's National Standards Body, incorporated by Royal Charter and responsible independently for preparing British Standards and related publications and for coordinating the input of UK experts to European and international standards committees. BSI has 115 years of experience in serving the interest of a wide range of stakeholders including government, business and society.

BSI also presents the UK view on standards in Europe (via the European Standards Organizations CEN and CENELEC) and internationally (via ISO and IEC). BSI has a globally recognized reputation for independence, integrity and innovation ensuring standards are useful, relevant and authoritative.

BSI, as the UK's NSB, is responsible for maintaining the integrity of the national standards-making system not only for the benefit of UK industry and society but also to ensure that standards developed by UK experts meet international expectations of open consultation, stakeholder involvement and market relevance.

British Standards and UK implementations of CEN/CENELEC or ISO/IEC standards are all documents defining best practice, established by consensus. Each standard is kept current through a process of maintenance and review whereby it is updated, revised or withdrawn as necessary.

Standards are designed to set out clear and unambiguous provisions and objectives. Although standards are voluntary and separate from legal and regulatory systems, they can be used to support or complement legislation.

Standards are developed when there is a defined market need through consultation with stakeholders and a rigorous development process. National committee members represent their communities in order to develop standards and related documents. They include representatives from a range of bodies, including government, business, consumers, academic institutions, social interests, regulators and trade unions.

*26 October 2016*

## **Darren Capes, City of York Council – Supplementary written evidence (AUV0093)**

*Letter from Darren Capes, Transport Systems Manager, City of York Council and Member of the Transport Policy Panel, IET*

Please note the opinions expressed in this submission are mine, based on my experience as an engineer working in the delivery of local transport technologies and they do not necessarily represent the views of City of York Council or IET.

I am sure I speak for a large number of the smaller local authorities when I write to thank you and your Committee for the opportunity to give evidence to the Autonomous Vehicles Enquiry. When closing the session you invited Michael Hurwitz and I to write in with any subsequent thoughts regarding evidence and I thought it might be useful to do so to emphasise some points that were touched on during the discussions.

There are more than 140 Highway Authorities in the UK ranging from those serving the major city conurbations (Transport for London, Transport for Greater Manchester etc) to those even smaller than York. These authorities are all faced with the similar challenges of meeting increased demand for transport and increasing complexity in the services we are expected to provide, against a backdrop of continuing reductions in levels of resourcing and staffing. There are two serious consequences of this challenge which may not be immediately obvious.

First the cuts in staffing and resources mean that many Authorities no longer have a critical mass of technical specialists in post, yet transport provision is moving into the connected and digital age in which we need more, not less, support to understand what technology decisions need to be made as existing infrastructure reaches the end of its life and new systems are considered. More specifically Authorities need to understand what supporting connected and autonomous vehicles will mean for the policy and funding decisions they need to make now. We also need clarity on how the co-ordination of countrywide delivery of connected and autonomous vehicles will be managed between national and local government and the public and private sectors.

Most local authorities, and I include the big ones, have very little understanding of how a mixed autonomous / manual vehicle fleet could operate on the UK road network, and we do not see any guidance or much research to help us with that. There is a lot going on both here and abroad regarding the technologies but we feel that there is not enough sufficient activity at a UK national level to collect evidence and formulate best practice around how the deployment transition could be managed. For example, how might we manage the use of mixed vehicles in the same road space? Do we need to segregate them? How might we manage autonomous vehicles with pedestrian and cycle flows – more segregation between autonomous vehicles and pedestrians and cyclists or less?

There are a few associations of Authorities, usually with a regional grouping, who share experience and discuss common problems and there are also excellent technical interest groups organised by ITS(UK) and by the IET, but these groups have no funding and no powers to designate standards. There is also a national group linking local authorities and suppliers starting to form in the shape of the Transport Technology Forum. However, if steps are not taken by DfT towards long-term further support of these activities then study of the issues I have highlighted will be restricted to the few Authorities able to find resources, or will be undertaken in isolation by well-intentioned researchers funded either independently or by interested parties in industry. There will be much duplication and wasted effort and the danger that technological development lead by industry will result in proprietary standards and may not yield outcomes that are most beneficial to the public sector or nation as a whole. The work required needs to be done once, properly, with a steering group of representative Authorities so that in the same way as DfT issues sets of standards and guidelines for traffic signals, road signing etc we will have one common set of guidance. This is essential for all Authorities to support our planning and policy development for city centres to help us across the next 10 or 15 years when we will be in some sort of mixed environment.

Second, I mentioned when answering the Committee's questions the difference between the majority of UK local authorities and the very large ones such as Transport for London. TfL is of a size where it can influence the market and negotiate as an equal partner because of that size. Most of us are too small to carry that weight so we react to what the market does. That is the way it is, unfortunately, or fortunately and cities such as York are in the hands of the manufacturers. If there are no recognised standards or procedures for deploying autonomous vehicles – as seems to be the case – then many Authorities will be vulnerable to manufacturer lock-in as a result of having to use proprietary standards. We need DfT to intervene and give guidance on open standards so that we can in turn have genuinely open procurement and guaranteed interoperability. There is nothing new in doing this: it is exactly what DfT did some years back when the smart card market had no open standards.

*27 November 2016*

## CAVT Ltd – Written evidence (AUV0061)

### A crucial issue not captured under the questions posed, and its salience

There is a widespread and partly mistaken view that dramatic decreases in incidents will be achieved by adoption of autonomous vehicles (AVs); this is often used to justify promotion of autonomous vehicle programmes and policies. A figure of 90% or higher is commonly quoted as the potential reduction in crashes, attributed variously to official USA data. Here follows a summary analysis made by CAVT Ltd of the data which has already been presented at conferences<sup>1,2,3</sup> but not yet published in full. It is therefore included here in the hope that it can be considered to meets the Guidance for this call for evidence.

In 2015, the Conference Board of Canada published a report by Gill, Kirk and Godsmark entitled *Automated Vehicles: The Coming of the Next Disruptive Technology*<sup>4</sup> which included the statement:

AVs have many benefits: the most significant is safety. By removing the driver from behind the wheel, AVs are expected to eliminate most of the 93 per cent of collisions that currently involve human error.

It then proceeded to calculate the economic benefits of such a change without claiming all 93% would be eliminated but also without considering the many inherent failures and shortcomings that could be introduced by errors in design of hardware and software, nor by the expectable failure rates of electronic components and assemblies.

The 93% has been popular with advocates of AVs, in good faith since the report referenced the source authoritatively as:

National Highway Traffic Safety Administration (NHTSA), U. S. Department of Transportation, National Motor Vehicle Crash Causation Survey.

Following up this reference results in several documents that include cautions against exactly the kind of conclusion that has been perceived perhaps unjustly as drawn by Gill et al<sup>4</sup>.

Before dealing with the specific numbers and documents, it should be noted that the National Motor Vehicle Crash Causation Survey (NMVCCS) was based on a sampling of collisions in certain states reported to the police authorities and investigated in depth on a basis representative of the national occurrences of collisions and then adjusted to scale back to the national situation in terms of accident type, location, etc. The survey was undertaken beginning in 2005 and reporting in 2007.

Furthermore, there are several facts which mean that the NMVCCS cannot be directly applied to AVs, to current or future traffic conditions, nor to European and specifically UK circumstances:

- NMVCCS was many years before widespread and mandatory adoption of antilock braking systems (ABS) in USA, although there were regulations governing ABS if fitted. Unlike existing European regulations, which had ABS and were beginning to make Electronic Stability Control (ESC) mandatory on all passenger cars, one-axle were permitted for USA ABS systems, which was counterproductive in some situations such as single vehicle loss of control, pickup trucks and SUVs, leading to resistance to adoption of ABS in the USA market<sup>5,6</sup>. Therefore the accident rates and types are not transferable to current markets where ABS and ESC are mandatory on most classes of vehicle.
- Urban, suburban, interstate, rural main and minor roads and tracks are all built, signposted, maintained, controlled and used differently from European and specific UK equivalents, leading to a different distribution of accident types and severities such as urban side impacts and road departure, and rollover propensity. Prospectively, this could affect differences in the attraction of AVs of different categories in respective markets in combination with settlement patterns.
- Vehicle mix was and still is, different in the North American and European parc, again leading to a different distribution of accident types and severities such as SUV/truck into passenger car side impacts, more extreme vehicle sizes and masses, and rollover propensity.
- Regulations on vehicle roadworthiness inspections vary across the USA affecting vehicle condition and accident involvement.
- USA state driving licenses and tests have different requirements, as well as different controls on driving with use of alcohol, prescription and illicit drugs.

The data most commonly referenced from the NMVCCS comes from a recent document<sup>7</sup> focusing on one aspect, the ‘Critical Reasons for the Critical Pre-Crash Event’:

“The critical reason is the immediate reason for the critical pre-crash event and is often the last failure in the causal chain of events leading up to the crash. Although the critical reason is an important part of the description of events leading up to the crash, *it is not intended to be interpreted as the cause of the crash* nor as the assignment of the fault to the driver, vehicle, or environment.”

This alone means that the data cannot ascribe “human error” as being categorically the cause of an accident in the way that the report of Gill et al<sup>4</sup> has been understood. The methodology in fact considers a range of contributory factors that cause the situation where a crash can finally avoided by a single critical reason. That means that a human driver fails to extricate themselves an almost inevitable crash scenario in almost every case, as opposed to the vehicle or environment being responsible. It

is difficult to conceive otherwise, apart from falling trees, collapsing bridges or road surfaces.

So immediately after the above quotation, the summary states:

“A critical reason can be assigned to a driver, vehicle, or environment. Normally, one critical reason was assigned per crash, based upon NMVCCS researcher’s crash assessment. The critical reason was assigned to the driver in an estimated 94 percent ( $\pm 2.2\%$ ) of the crashes (Table 1). In addition, the critical reason was assigned to the vehicle in an estimated 2 percent ( $\pm 0.7\%$ ) and to the environment in about 2 percent ( $\pm 1.3\%$ ) of the crashes.”

While “93%” appears nowhere, it is accompanied by a table in which vehicles, environment and unknown critical reasons were all assigned 2% (with different confidence limits):

Table 1. Driver-, Vehicle-, and Environment-Related Critical Reasons

Critical Reason Attributed to	Estimated	
	Number	Percentage* $\pm 95\%$ conf. limits
Drivers	2,046,000	94% $\pm 2.2\%$
Vehicles	44,000	2% $\pm 0.7\%$
Environment	52,000	2% $\pm 1.3\%$
Unknown Critical Reasons	47,000	2% $\pm 1.4\%$
Total	2,189,000	100%

\*Percentages are based on unrounded estimated frequencies

(Data Source: NMVCCS 2005–2007)

Understanding the full implications requires deeper analysis of the all the data in the full Report to Congress<sup>8</sup> which deals with the contributory factors in more detail. A crash may have many contributory factors, frequently the combination is more important than the individual factors. Put simply, as CAVT stresses, for a collision to occur, a vehicle and one other object (vehicle, pedestrian, tree, etc.) must be in the same place, at the same time and there must be a relative speed and direction difference. Remove any of those three conditions and there is no collision. Similarly many collisions will not occur if just one of the contributory factors is absent: low sun, worn tyre, driver impairment from fatigue, etc. The data is broken down into finer detail such as ice/loose debris, signs/signals, road design, and “Other highway-related condition”.

If one takes a top-level summary of these contributory factors from the Report to Congress<sup>8</sup> in which the total number of factors will be much more than the number of cases, and normalises them to 100% to show the relative role, the picture is very different:

Contributory Factor (USA)	Relative Frequency of Involvement
Driver	43.4%
Vehicle	16.4%
Road & Weather	30.4%
unknown	0.7%
total	100.0%

This immediately highlights that taking the driver out of the loop has far less potential than 93% to affect the incidence of collisions and that far more weight must be attached to the vehicle, road and weather. Adding systems to a vehicle will bring their own failure modes and rates which must at least be compensated by improvement to the vehicles themselves (probably well in progress since 2005-2007) and that the systems must be better than humans in handling road and weather extremes, which currently they are not.

Having implied above that it is unwise to apply USA data directly to UK conditions, one should also apply recent causation data from DfT Road Accident GB<sup>9</sup> collected with the STATS19 system with the proviso that:

"It is important to note that it may be difficult for a police officer, attending the scene after an accident has occurred, to identify certain factors that may have contributed to a cause of an accident.

The contributory factors are therefore different in nature from the remainder of the STATS19 data which is based on the reporting of factual information. This should be kept in mind when interpreting the data.".

The table below summarises the details normalised to all accident total cases, with rounding errors

Contributory Factor (UK)	All Accidents, normalised %
Road environment	8%
Vehicle Defect	1%
Driver	75%
Error or reaction	41%
Injudicious action	13%
Impairment or Distraction	7%
Behaviour or inexperience	14%
Vision Affected by external factors	6%
Pedestrian only	7%
Special./other	5%
Total	100%

Although categorisation differs, it can be seen that the UK data does not reflect the USA data. The strict category Driver Error only accounts for 43%.

Many of the statements in this response below take into account these statistics of contributory factors to collisions as background; the source data do not always bear out the conclusions often attributed to them.

It is however clear that there are many other important factors that will prevent the dramatic improvements promised to AVs and ADAS by taking the driver out of the loop based on existing data, quite apart from the many new uncertainties introduced by known and unknown system inadequacies.

Policy decisions may need to be influenced by these data, particularly the necessity of improving safety for both human drivers and AV in the short and medium term by infrastructure and enforcement expenditure

1. Thomas, Alan V; Reality is not ideal: Autonomy and Driver Assistance challenges; Autonomous Vehicle Test & Development Symposium, Stuttgart 16-18 June 2015
2. Bham NEC
3. Thomas, Alan V; ADAS & Autonomous Systems – a sense of reality; Automotive Sensors and Electronics Expo 2016 Annual Conference, June 15 – 16, 2016 Detroit
4. Gill, Vijay, Barrie Kirk, Paul Godsmark, and Brian Flemming. [“Automated Vehicles: The Coming of the Next Disruptive Technology”](#). Ottawa: the Conference Board of Canada, 2015.
5. “Fatal Single Vehicle Crashes More Likely With Antilocks”, [Status Report Vol 31](#), No. 10, Insurance Institute for Highway Safety (IIHS), Highway Loss Data Institute (HLDI), Arlington VA., USA, December 7 1996..
6. “Cars with antilock brakes are no longer overinvolved in fatal crashes”, [Status Report Vol 35](#), No. 4, Insurance Institute for Highway Safety (IIHS), Highway Loss Data Institute (HLDI), Arlington VA., USA, April 15, 2000
7. Singh, S.. Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey. (Traffic Safety Facts Crash•Stats. Report No. [DOT HS 812 115](#)). Washington, DC: National Highway Traffic Safety Administration. February 2015
8. National Motor Vehicle Crash Causation Survey Report to Congress. Report No. [DOT HS 811 059](#) Washington, DC: National Highway Traffic Safety Administration. July 2008
9. File [RAS50001](#) Contributory factors in reported accidents by severity, Great Britain, 2013, in Reported road casualties Great Britain: annual report 2013, Department for Transport, London, September 2014

## Impacts and benefits

1. What are the potential applications for autonomous vehicles?  
**The largest potential may ultimately be in Mobility-as-a-Service, short of full replacement of all-purpose personal transport, but earlier successful implementations are more likely in geo-fenced mobility and materials handling**

**because these applications are in environments that are easier to predict and control.**

**By the same token these may be followed by freight and logistics on fixed, regular routes using platooning, and where payload and operating costs can be improved by reducing some or all provision for a human driver such as sleeper cabs. In that phase there may be issues with use of ad-hoc alternative routes for such vehicles in the event of road closures or severe weather limitations of the sensor technologies and heavy goods vehicles not carrying a human driver may have to be parked somewhere until they can be re-mobilised appropriately.**

2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?

**One wonders how much is based on thorough consideration of all the positive and negative impacts of the use of autonomous vehicles in any sector: much of the information appears to derive from optimistic promotion of the technology or pessimistic critiquing.**

**This will rapidly become evident in either direction now that such vehicles are being tested in more varied situations such as the UK, and equally while partial (ADAS, SAE L2-L3) systems are rolled out on the market. While not confusing L2 and L3 with L4 and L5, much of the basic technology is the same but less comprehensive and theoretically more prone to restricted situational awareness.**

**More research and far more data capture is required in order to provide definitive answers to this question. This is unlikely to be achieved without recording and self-reporting of all traffic conflicts as well as just those resulting in collisions. This will involve complex issues of data ownership and privacy in incidents that do not currently warrant insurance or police attention which currently put data into third party organisations in the case of property damage or personal injury.**

**At present, any lessons learnt from sensor, algorithm and actuator shortcomings in traffic by vehicles operated by the general public are, if captured at all, retained in corporate knowledge based, most notably by Tesla. Only in serious cases does the fact of an incident become public, and even then no verified detail of design or operation of the systems emerge in a timely fashion.**

**In conventional vehicles a gradual accumulation of safety knowledge and application of technology over decades has enabled steady decrease in casualties (until very recently despite increasing traffic densities, speeds, and necessity of driving for people) who otherwise might have had no interest and motivation to become skilled. The changes and timescales now occurring are showing signs of outpacing the ability of the authorities to respond with necessary measures or approval.**

4. How much is known about public attitudes to autonomous vehicles?

**What surveys there have been may be questioned on the grounds of how accurate the public's perception of what is meant by autonomous vehicles, their capabilities, limitations of their technologies, and any required inputs from humans (at L4).**

5. What is the scale of the market opportunity for autonomous vehicles?

### **Creating an enabling environment**

#### *Research and development*

6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?

**As first steps, yes. However, until the vehicles can be assured of handling all conceivable situations at least as well as a skilled and experienced human driver beyond reasonable doubt, the answer remains qualified. It must not be overlooked that due to extraneous circumstances such as emergency motorway or urban route closure anything less than a 100% L5 vehicle must be able to operate "off-piste" safely without inconveniencing other road users unless full licence holders must always be in the vehicle, thereby undermining some of the attraction of autonomous vehicles.**

7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?

8. How effective are Innovate UK and the CCAV in this area?

9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?

#### *Real world operation*

10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?

**Referring to the answer to Q6, and based on the demands from some quarters for a minimum standard of infrastructure such as road markings and infrastructure-to-vehicle I2V services, a massively great deal more needs to be spent on upgrading all classes of road and communications, including standardisation of road layouts, traffic control, etc. in urban canyons, tunnels and remote rural areas. The likelihood of continual software and hardware updates and obsolescence make the cost of ensuring no critical mismatch between all vehicles and all infrastructure, i.e. full backward and forward compatibility, near prohibitive.**

**Paradoxically, such improvements to the road and traffic systems will improve the safety performance of drivers of conventional vehicles, thus eroding the safety case often made for autonomous vehicles, quite apart from the current proven**

**beneficial application of L1-L2 technologies such as AEB. Expenditure on infrastructure measures that improve human performance could be seen as an immediate priority that will reduce incidents in both the short term and the long term when autonomous vehicles become a significant proportion of the vehicle park.**

11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?

**The transition needs to be made with considerable caution, and evidence of satisfactory performance of each system in terms of designed capability and fail-safe in all possible failure modes whether internal to hardware and software or occurrence of out-of-scope scenarios.**

**The long gestation and acceptance of systems such as steer-by-wire and brake-by-wire up to the current levels in highly automated vehicles has given guidance as to how to approach design, development, testing and approval, but does not give licence to rush the process with higher levels of dependence and integration which have immensely higher complexity and propagation of undesirable behaviours.**

12. Does the Government have an effective approach on data and cybersecurity in this sector?

**It is doubtful whether anyone has an effective approach currently. Certainly enough partially attacks on IT systems have produced evidence of inadequate cybersecurity and immunity to external factors within the general IT world. The culture in automotive IT needs to be distinct and guided more by military and aviation levels of protection than some, not all, current implementations.**

**There are many levels that need to be considered here along with appropriate countermeasures:**

- **Cybersecurity in terms of prevention of access to sensitive data on the use of the vehicle i.e. related to personal privacy – journeys undertaken, etc.**
- **Cybersecurity in terms of immunity to deliberate subversion of software or data to affect the performance of the vehicle, and by implication its safety whether with malicious intent, curiosity, and tuning or “chipping” to modify performance, by remote or physical access to the systems.**
- **Cybersecurity in terms of immunity to deliberate subversion of software or data to affect the control of its routing, for instance for criminal or terrorist purposes such as delivering drugs, firearms or explosives as a car bomb, kidnapping, driving into crowds of people, etc.**
- **Functional Integrity which should be assured by correct application of ISO 26262 standards of safety-critical examination of data paths and inputs versus required outputs, but this depends on comprehensive understanding and coverage of all potential inputs and all desired and undesirable outputs.**
- **System integrity – immunity to both software and hardware failure in design or service using multiple active redundancy (not just passive fall-back), graceful decline, controlled handover to trained and competent**

humans and other aviation concepts. There is less discussion of these risks, but recent recalls of existing vehicle for control and sensor systems faults has displayed their existence. The ubiquity of consumer electronics devices with a limited battery life and short product life cycles with constant addition of new features leading to less concern over consumer tolerance fault, durability and replacement is at odds with the security and functionality needs of automotive electronics and software. The involvement of the manufacturers of consumer devices in automotive systems may need strict certification procedures for a large number of criteria.

- Access to the vehicle systems is required for diagnostics and upgrades which represent a definite vulnerability as the means of interfacing will be quite widely available and understood.
- There is interest in law enforcement access to autonomous vehicle systems by police, local authorities etc. both retrospectively for criminal and collision investigates and in real time for enforced control, quite apart from I2V and V2V traffic control, parking and other non-moving infringements such as taxation and insurance. These are all vulnerable channels for fault propagation, tampering and criminal interference.

13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?

14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?

**Strict liability culture from automotive safety best practice rather than consumer IT and electronics.**

#### **Legal framework for courts and law enforcement**

##### *Wider governance*

15. What does the proposed Modern Transport Bill need to deliver?

16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?

**More interdisciplinary at secondary and tertiary level for both design and development engineers and technicians as well as technicians to support service, repair and recovery businesses**

17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?

18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?

*26 October 2016*

## **Chartered Institution Highways & Transportation (CIHT) – Written evidence (AUV0082)**

CIHT is a charity, learned society and membership body with over 14,000 members spread across 12 UK regions and a number of international groups. We represent and qualify professionals who plan, design, build, manage and operate transport and infrastructure networks. Part of our vision is to demonstrate transport infrastructure's contribution to a prosperous economy and a healthy and inclusive society. Our values are to be Professional, Inclusive, Collaborative and Progressive.

### **Introduction**

- 1** The UK lacks a coherent, integrated national transport strategy<sup>110</sup>. Some elements of the transport system have had strategies determined for them, but there is no clear national motoring strategy that sets out how private vehicles integrate with other transport modes both on the highways and other networks. Such a strategy would be essential to cover the Connected Autonomous Vehicles (CAV) and related technology strategy ecosystem and overlap with strategies on infrastructure and industry.
- 1.2** An integrated transport strategy must work across modes, nationally and at reasonable sub-national levels. This strategy should be set in economic, social and environmental contexts to which motoring – and travel more generally – is a key factor. Transport and spatial planning should be better integrated, helped by collaborative planning by the Highways Agency and local authorities. Revisions also need to be made to the Digital Communications Infrastructure Strategy to ensure that it is able to adequately support smart transport.
- 1.3** The pressures to maintain an efficient, safe and functional transport system is growing. Urban areas are expanding, and the UK's population is ever increasing and ageing. Transport activities support increasing demands from passengers and freight, however associated activities from the transport sector are affecting the environment, health and congestion. The development of smarter technologies in the automobile sector can play an important role in addressing some of these challenges. Innovations such as adaptive cruise control, autonomous emergency braking, lane departure warning systems and lane keeping assist systems available in many new vehicles today and are contributing to improved safety on the road network.
- 1.4** CIHT believes that the continued development of Connected and Autonomous Vehicle (CAV) technologies has the potential to significantly improve road safety, reduce congestion and enhance car users and drivers experience. However, there are many challenges and hurdles to overcome if these technologies are going to be successfully implemented and effectively used by the wider population. Safety, security and

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<sup>110</sup> <http://www.ciht.org.uk/en/knowledge/policy/ciht-manifesto-for-transport.cfm>

resilience should be taken into consideration when looking at future models. This must include the cyber-security of digitally-enabled technologies.

## **Impacts and Benefits**

### **2 What are the potential applications for autonomous vehicles?**

- 2.1** There are a number of potential applications for Connected and Automated Vehicles (CAVs) some more achievable in the short to medium term than others.
- 2.2** Initially CAVs will most likely be used on motorways and major roads where segregation is possible. The more advanced the technology becomes, moving towards a fully automated system, the more we will be able to move towards activities performed by private cars, taxis, shared cars, and vans and lorries.
- In confined geographic spaces such as University campuses, farms and some industrial complexes.
  - Another potential area is providing transport for older people or people with disabilities who may feel less confident about driving themselves (particularly beyond their immediate comfort zone) as they age.
  - Various taxi style demand responsive transport services are being tested e.g. Google is currently testing automated vehicles in the States in preparation for offering robo-taxi services in the coming years.
  - Opportunities to contribute to the commute journey with ride sharing opportunities.
  - Local trips from residential areas to transport hubs on main bus/rail/tram transit routes.
  - In commercial trucking and freight. Truck platooning technology is being developed making it possible for two or more trucks to “electronically couple” this enables inter-vehicle spacing to be greatly reduced.
- 2.3** Many of these applications will still require the presence and potential intervention of a driver in the short to medium term. The full benefit of CAVs will only be fully realised when the technology does not require the presence or intervention of a driver.
- 2.4** Good examples of current automated systems in service are:
- Fixed transport - Docklands Light Railway and the Heathrow Ultra PRT
  - New advanced sensor software products such as the TRL GATEway project in Greenwich or the Transport System Catapult LUTZ Pathfinder pods in Milton Keynes.
  - Manufacturers are also progressing, producing more sophisticated systems such as Tesla’s AutoPilot system and trials underway in Gothenburg (Volvo) ‘Drive Me’ project<sup>111</sup>.

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<sup>111</sup> [Volvo Drive Me Project](#)

**What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

**3 Benefits**

- 3.1** The deployment of fully automated vehicles could potentially provide major social and economic benefits. Improved road safety, accessibility, assisting an ageing population and help those with disabilities. There is the possibility of improved network performance, health benefits achieved through reduced congestion, emissions and ride sharing opportunities.
- 3.2** Full CAV would allow people to undertake a wide range of activities, increasing the value of journey times, as that time could be spent working, giving people back time wasted when traveling. This in turn might lead to more innovative designs, e.g. 4 seater cars with passengers around a table. However, the unintended consequence of this is that the demand for transport will increase significantly as travel time is no longer wasted time.
- 3.3** CAV could also encourage shared ownership via car clubs, allowing people to hire a specific type of vehicle to suit the purpose of the journey. ‘Safer’ streets could potential increase in the numbers of pedestrians and cyclists. Both of these initiatives could lead to a reduction in the provision of the need for car parking space and subsequently an improvement in place.
- 3.4** The nature of the technology would suggest that CAVs could lead to denser traffic flows on our major networks as platooning would achievable, resulting in shorter braking distances between vehicles effectively increasing route capacity and reducing congestion.
  - Benefit of not having to drive, or indeed to hold a licence.
  - Possible reductions in insurance premiums for e.g. younger drivers.
  - Benefits of not having to own a car (or a second car) with potential cost savings.
  - Health & safety benefits - removing driver error from the roads – improved air quality
  - Automatic compliance with speed limits, thus creating a calmer and more reliable environment in which to walk and cycle<sup>112</sup>.
  - Improved mobility for the disabled, elderly and young people.
  - Users could spend travel time engaged in other activities, so the costs of travel time and congestion are reduced.
  - Improved fuel efficiency.
  - Because such vehicles won't need proximate urban parking, space used for parking could be repurposed.

**4 Disadvantages**

- 4.1** It is important to note that there is relatively little data available to substantiate the listed potential benefits and there maybe unintended consequences that could provide

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<sup>112</sup> [WSP/Parsons Brinckerhoff/Farrells ‘Making Better Places: Autonomous vehicles and future opportunities](#)

dis-benefits. The technology may benefit society in the long term, but there is a great deal of work that has to be undertaken. There will be a period over which there will be a mix between non, partially, highly and fully automated vehicles. This throws up issues with different user expectations and behaviours, not just with the owners of the vehicles but interactions with pedestrians and cyclists.

- 4.2** CAVs will be designed to be risk-averse, this could result in more congestion as they give absolute priority to pedestrians and cyclist. Pedestrian and cyclist behaviours may change as they begin to cross randomly rather than using a pedestrian crossings knowing that CAV will always stop rather than hit them.
- 4.3** CIHT notes there are other key issues, such as environmental concerns with perceived increased vehicle miles leading to increased congestion, demand for more road infrastructure and knock on dis-benefits in terms of road danger, noise and emissions.
- More vehicles on the road due to the potential increase in the numbers of people who could use them and increased mileage overall.
  - Failure of the technology. Passengers will need to have confidence in the technology and safety to accept.
  - Drivers over reliance on the technology – will they be ready to take over control when required
  - If CAVs are only available via a car club people would need confidence that a vehicle will be available when they need it and in a condition that is safe.
  - Increased use of (autonomous) cars will abstract demand from public transport, which may as a result deteriorate or become more dependent on subsidies.
  - There are fears that CAV technology may be risky and unsafe and cannot match the information processing, reaction and communication skills that humans bring to driving.
    - What road markings (quality, type) are required to enable full CAV operation? Destination markings; lane lines; edge lines etc. – CAVs will only be as good as the infrastructure it uses.
    - What will be the impact on permanent signage requirements and how will this effect TSRGD<sup>113</sup>?
    - How will roadworks notification; layout and sign design and maintenance work? E.g. How will the vehicle know that an emergency roadworks permit is in operations

## **5 How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

- 5.1** The real evidence of the impact on different sectors of CAVs is unknown. Some sectors such as agriculture and truck freight will perhaps feel the immediate impact sooner than others.
- We can also see this technology being deployed in commercial trucking - with platooning. There is research that concludes that these sectors offer stronger

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<sup>113</sup> [Traffic Signs Regulations and General Directions](#)

business propositions such as improving fuel economy, reduced frequency and severity of accidents and more. Highways England will be conducting trials in the near future.

- Sectors and economies based on public transit, crash repair, and automobile insurance might suffer as the technology improves making certain aspects of these occupations obsolete. Thus impacting socially and economically.

## 6 How much is known about public attitudes to autonomous vehicles?

- 6.1** Transport System Catapult published a study on Traveller Needs last year and 39% of people said they would consider using driverless cars today<sup>114</sup>. In a recent consultation response on UK testing ecosystem for connected and automated vehicles by the Centre for Autonomous and Connected Vehicles, CIHT provided a joint response ITS UK. The response<sup>115</sup> reported that there is currently some confusion in public perception as to what CAV is or can do and little awareness of Connected Vehicles themselves, let alone the potential benefits. The model being used in testing suggests that each test bed user will be responsible for all outreach and publicity activities. Whereas engagement with, and support from, road authorities and network operators (e.g. Highways England) and other stakeholders including the public will be essential. PR and marketing, particularly the communication of benefits, therefore, need to be a core and coordinated activity of the testing facility.
- 6.2** Developing the right stories and messages will be essential – and this activity needs to be coordinated so that messages are consistent and meet the needs of the various target audiences.
- The government-funded on street activity in Bristol, Milton Keynes, Greenwich and Coventry is probably the best way of communicating effectively and positively with citizens – there is no substitute for seeing and experiencing the real thing.
  - The upcoming lorry platooning trials will also be important in this regard, providing an opportunity for public engagement in another type of CAV functionality.
  - Safety and land use benefits are important but harder to get across to the general public. Rigorous testing of technologies and systems is need to raise confidence.
  - Government information needs to be clear on the difference between CV and AV. It can already demonstrate that government (for example Highways England) uses CV data to reduce costs to taxpayers. It can also help to create opportunities for businesses outside transport infrastructure to provide solutions.
  - Once possible, the public sector can do something very important by switching to CAV fleets wherever possible. This approach has been important in the adoption of Intelligent Speed Adaptation<sup>116</sup> (ISA) and alcolock<sup>117</sup> technology in other countries.

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<sup>114</sup> [IM Traveller Needs and UK Capability Study](#)

<sup>115</sup> [CIHT ITS response on UK Testing Ecosystem](#)

<sup>116</sup> [Intelligent Speed Adaptation](#)

<sup>117</sup> [alcolock](#)

## **7 What is the scale of the market opportunity for autonomous vehicles?**

- 7.1** CIHT believes that if the technology is going to be successfully implemented in the UK then the scale of the market opportunity could be large and many sectors could benefit from the technology. Previous Transport Systems Catapult research has suggested that this global market will be worth around £900bn annually by 2025<sup>118</sup>. However we believe that the scale of the market would depend on the depreciation of current fleet and cost of replacing conventional cars with the technology and the provision of appropriate support infrastructure. It is envisaged that these vehicles will cost more than conventional vehicles as manufacturers add the electronic functionality and other complexities needed to operate them therefore impacting on affordability.
- 7.2** CIHT notes that although alternative power sources such as gas, electricity and hydrogen cells have been available for years take up by the public has been low due to issues of cost, demand and infrastructure.
- 7.3** Research by the SMMT<sup>119</sup> show that based on current trends, it is expected that all vehicles produced in the UK by 2027 will have at least Level 3 (conditional automation where the driver does not need to monitor the dynamic driving task nor the driving environment at all times; must always be in a position to resume control) technologies embedded in them and that there will be a 25% penetration of fully autonomous vehicles by 2030.

## **8 Creating an enabling environment & Real world operation**

- 8.1** CIHT and ITS UK reported recently, that testing ecosystem should include both “urban” and “interurban” environments to enable the widest set of use cases and scenarios to be tested.
- 8.2** A “rural” road environment is less essential and could be developed later if it becomes desirable. The focus should be on real road testing and less on the pre-road trials phases which will, more likely, be undertaken by manufacturers in closed conditions to protect IPR, “brand” and commercial advantage, etc. Current testing model seems designed more for R&D type tests than real-life - the UK should concentrate on attracting real-life tests using commercially available cars and ordinary drivers, as by Volvo in Gothenburg and London. This will require more emphasis on nurturing public interest and engagement, currently, public perception is based upon news stories generated by software corporations and is not based on the potential use cases or benefits.
- 8.3** CIHT and ITS UK believe that understanding the various human factors issues (both of vehicle users and of other highway users) is essential for the success of CAVs and should be given a higher priority and more emphasis in the testing model. Many of the ingredients in the testing model – connectivity, mapping, virtual testing, and cyber security – evolve very quickly and it should be made clear in the model that the test

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<sup>118</sup> [IM Traveller Needs and UK Capability Study](#)

<sup>119</sup> [SMMT – CAV’s The UK Economic Opportunity](#)

bed operators will be expected to keep pace with these developments. This would make the offer more confidence inspiring.

**8.4** The UK is at a comparatively advanced stage compared to many countries.

- The government has undertaken a review of the regulatory framework and established that CAVs can be tested on any road in the UK and consulted on necessary changes to regulations.
- Published a Code of Practice to for testing CAVs on UK roads.
- The government has helped fund research, development and demonstrations through the creation of the Centre for Connected and Autonomous Vehicles (CCAV) and Innovate UK. It is important that the government continue to provide support to both.
- There are several test and research programmes underway, including GATEway at Greenwich, Bristol, Milton Keynes - LUTZ Pathfinder pods and Coventry

**8.5** There will need to be changes to the digital or physical infrastructure to realise the full benefits of CAVs. There will be issues around the quality of the infrastructure (road markings etc) and the quality of 3D mapping and security of digital data etc. Failure of either poses huge safety and cyber security issues. Manufacturers will have to ensure robust cyber security measures within their systems to guard against identity theft and deliberate collisions. Government will need to ensure that the regulatory framework holds manufacturers to account when meeting minimum security standards.

**8.6** Appropriate insurance for CAVs, as with insurance currently for conventional vehicles, will need to be in place to protect those affected by accidents. Manufacturer liability will need to be in place for incidents involving fully autonomous vehicles. There will be a requirement for:

- Extended compulsory insurance requirements for CAVs.
- Compulsory product liability
- Correct insurance classification requirements

These have been consulted on by the Government.

**9 Modern Transport Bill**

**9.1** The Bill will need to enable innovation whilst ensuring safety security and privacy.

**10 Education and Skills**

**10.1** Skills development is a key area of concern for the growth and progression of the highways and transportation industry. Industry trends show that with fewer graduates entering and an ageing current workforce, action must be taken to secure the pipeline of skilled engineers and transportation professionals for the future<sup>120</sup>. It is also essential to widen the talent pool from which new entrants are drawn to increase recruitment and create a more diverse and inclusive workforce. In a recent survey of

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<sup>120</sup> Engineering UK (2014), Engineering UK 2014: The state of engineering, Engineering UK (2014), [http://www.engineeringuk.com/research/Engineering\\_UK\\_Report\\_2014/](http://www.engineeringuk.com/research/Engineering_UK_Report_2014/)

CIHT's Corporate Partners, 96% of respondents anticipated having a skills shortage in the next few years.

- 10.2** CIHT has recently launched a suite of career materials and guidance as part of a programme to help the industry deal with the range of technical skills shortages. This includes a diversity and inclusion toolkit<sup>121</sup> which provides practical guidance on data gathering, attracting and retaining a more diverse workforce and on changing culture and behaviour. It is the first toolkit of its kind for the highways and transportation sector and provides a route map to success through diversity and inclusion.
- 10.3** CIHT welcomes the Department for Transport Skills strategy<sup>122</sup> and is actively with the Department for Transport in exploring the key action points for taking this forward.

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<sup>121</sup> [http://www.ciht.org.uk/en/education--cpd/skills\\_initiatives/index.cfm](http://www.ciht.org.uk/en/education--cpd/skills_initiatives/index.cfm)

<sup>122</sup> [Department for Transport Skills Strategy 2016](#)

**City of York Council and Transport for London (TfL) – Oral evidence (QQ 40-47)**

[Transcript to be found under Transport for London \(TfL\)](#)

## **Dr Tom Cohen and Dr Clemence Cavoli, UCL – Written evidence (AUV0070)**

1. We suggest that the developed world in general, and the UK in particular, are at the peak of the hype cycle (van Lente et al. 2013) with respect to automated vehicles.<sup>123</sup> This is partly thanks to the media and the prominent work of organisations such as Google and Tesla. But, in the UK, it can also be attributed to the government's explicit ambitions in terms of commercial opportunity and a more general "being at the forefront". Whilst we do not take issue with the government's desire to capitalise upon this opportunity, we believe it quite possible that this has prompted an optimistic way of thinking about the likely consequences of increasing automation in vehicles. That same optimism can be seen in this inquiry's terms of reference which appear not to question the government's objectives but to take them as read. This seems a missed opportunity since, if we are going to ask whether the scale of facilities is "sufficiently broad and ambitious", we might equally ask what that scale should actually be.
2. This question of scale is legitimate because our current position in the hype cycle is associated with a tendency to assume positive outcomes of this technology and at best play down the more negative possible implications. Allied with this is a strong vein of "technological determinism", a belief that automation will come and that we (society, government) will need to adapt accordingly. Both traits are very prominent in the academic and grey literature on the subject. The bulk of writing reflects an enthusiasm for the technology and a general lack of circumspection on the authors' part. To give a specific example, there is practically nothing in the literature to date about the possible public-health impacts of automated vehicles; yet it seems obvious that an increasingly "door-to-door" transport system is very likely to lead to an increase in obesity, all other things being equal.
3. A supine approach to the governance of this new technology, as shown by most of the research done to date and the pronouncements of government (which appear to reflect a belief that regulation is the natural enemy of innovation), is far from desirable. Automated vehicles may bring huge benefits but considerable costs too and government at all levels is uniquely equipped to determine the balance. Therefore, we argue that, in addition to asking questions about breadth and ambition, the committee should also be asking questions about whether the government has given sufficient attention to the possible wider impacts of automation and to its own role in managing these positively.
4. There are good examples in the UK of well governed technological advance, of "responsible innovation". One such is the work of the HFEA, whose concerted efforts to capture and act on public opinion and to address the potential ethical consequences of the advance of embryology are argued not only to have resulted in positive outcomes for

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<sup>123</sup> We argue that "automated" is a more appropriate term than "autonomous" given this inquiry's terms of reference. What is at issue is whether a vehicle requires a human driver, and some vehicles will successfully conduct the driving task largely on the basis of instructions received from outside (e.g. a central control system). Such vehicles would not be autonomous, strictly speaking.

the users of IVF etc but to have secured a good economic position for UK organisations working in the sector (Wilsdon & Willis 2004).

5. To illustrate our points further, it is worth exploring briefly three aspects of the current debate concerning automation:
  - Safety
  - Congestion
  - Ethics
6. With respect to safety, there is broad consensus in the literature that automated vehicles will bring safety benefits. Conclusions are overwhelmingly based on the observation that 90 per cent or so of current collisions arise from human error, the assertion being that self-driving technology will eliminate at least a substantial proportion of these. Less fully explored so far is the relationship of levels of automation, traffic mix and highway regime with the volume of collisions: the greatest gains can be expected once the entire fleet is fully automated, for example, but the pattern could be very complex during the lengthy period of transition. Also very significant from the technological point of view is that attention is focused in the literature on the human error that leads to a large proportion of the crashes that do occur today. There is less acknowledgement of the fact that human drivers make good decisions a great deal of the time, many of them based on interpretation, generally acknowledged to be the weak suit of artificial intelligence. The presumption that self-driving technology will definitely be able to match humans in making such decisions may in time be proved right but the transition could again be a lengthy one.
7. With respect to safety, there is broad consensus in the literature that automated vehicles will bring safety benefits. What is not generally made clear is that this outcome very probably relies on either full automation across the fleet or segregation of fully automated vehicles, together with a host of assumptions concerning the ways in which other road users conduct themselves around such vehicles. It seems quite possible, though, that a fleet consisting of a mixture of fully automated, partially automated and, in effect, unautomated vehicles would be associated with an *increase* in collisions compared with the status quo, at least in the short term, as the various categories of “driver”, human or otherwise, learned how to deal with one another. What is perhaps more significant from the technological point of view is that attention is focused on the human error that leads to a large proportion of the crashes that do occur today. Less thought is given to the fact that human drivers make good decisions most of the time, many based on interpretation, generally acknowledged to be the weak suit of artificial intelligence. The presumption that self-driving technology will definitely be able to match humans in making such decisions seems very bold.
8. As with safety, there are numerous assertions that automation will increase the practical capacity of the highway system, with decreasing headways and vehicles negotiating (or being assigned) optimal paths through the network. If levels of travel do not significantly increase, congestion might therefore be expected to fall.<sup>124</sup> Whilst this is a plausible

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<sup>124</sup> It must be said that there is less of a consensus on this front than with respect to safety.

scenario, it is only one. We must acknowledge that current loads on our networks reflect extensive use of mass transit, walking and cycling, together with the fact that many potential journeys do not take place because they are not currently feasible. So another plausible scenario involves a significant increase in vehicle-kilometres as automation enables trips not currently made and, possibly, encourages travellers to change to a mode that is less space-efficient. And there is so far only scant acknowledgment that some users (of manually driven vehicles, say) might exploit the necessary timidity of AVs, causing numerous emergency stops. This combination of developments seems likely to be associated with an increase in congestion.

9. Finally, much attention has been devoted to hypothetical situations in which an automated vehicle may be confronted with moral dilemmas – so-called “trolley problems”.<sup>125</sup> Here, the lack of circumspection takes a different form: instead of choosing to disregard the possibly less positive alternative scenarios (as with safety and congestion), researchers are ignoring the significant social and political questions that precede a situation in which cars might choose between Person A and Person B. Would society countenance assigning that power to a computer? Who would develop the algorithm(s) and on what basis? Who would be ultimately responsible for the consequences of the algorithms’ operation?
10. In summary, this is a much more complex and more nuanced topic than most discussion and writing to date reflects. And, more specifically, government needs to acknowledge that the scope of its potential influence extends far beyond merely providing a fertile testing ground.

## References

Van Lente, H., Spitters, C. & Peine, A., 2013. Comparing technological hype cycles: Towards a theory. *Technological Forecasting and Social Change*, 80(8), pp.1615–1628.

Wilsdon, J., & Willis, R. (2004). See-through science: Why public engagement needs to move upstream. Demos.

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<sup>125</sup> MIT has in fact established a website devoted to such problems - <http://moralmachine.mit.edu/>

## **Cranfield University – Written evidence (AUV0086)**

### About Cranfield

1.0 As the UK's only exclusively postgraduate university, Cranfield's world-class expertise, large-scale facilities and unrivalled industry partnerships create leaders in technology and management globally.

1.1 Our key areas of expertise and capabilities are grouped under seven main themes: aerospace, defence and security, energy and power, environment and agrifood, manufacturing, transport systems and water, along with our world-renowned School of Management.

1.2 81% of our research is classed as world-leading or internationally excellent by REF (Research Excellence Framework, 2014) and we are ranked in the top five of UK universities for commercial research income.

1.3 Around 2,400 students graduate from Cranfield each year and we award over 5% of the UK's engineering and technology PhDs every year.

1.4 In its specialist areas, Cranfield is at the heart of postgraduate education. Of those that study in the UK, 47% of aerospace engineering postgraduates, 24% of automotive engineering postgraduates and 16% of production and manufacturing postgraduates choose to study their master's at Cranfield.

1.5 We are home to many world-class, large-scale facilities which enhance our teaching and research. We are the only university in the world to own and run an airport on campus and to have airline status.

### Cranfield's work with Autonomous Vehicles

2.0 Cranfield has a leading reputation in autonomous systems, established with over 15 years of research in this field. Our expertise covers all types of autonomous vehicles including airborne, ground, marine and space. We work with a number of organisations across various sectors including defence, military, aerospace, transport, research councils and UK/European Government in this area.

2.1 Our research on autonomous vehicles includes Sense and Avoid, Insertion into Airspace, Navigation and Path Planning, Energy Management, Autonomous Maintenance and Health Management, Network Decision Systems and Cyber Physical Systems.

2.2 Our facilities include the Autonomous Vehicles Laboratory which is equipped with a netted area for flight tests and a variety of sensors, used for testing in the areas of guidance, navigation, control and surveillance.

2.3 Cranfield University is in the process of building IMEC, a new STEM teaching and learning facility dedicated to the provision of education, training and qualifications for the burgeoning Intelligent Mobility workforce, supported by HEFCE and SEMLEP.

2.4 The Intelligent Mobility Engineering Centre (IMEC) will provide access to further education providers, collaborating universities and industry to deliver sector-relevant education and training in a multi-level environment to provide a skills and qualifications pathway to Cranfield University's new MSc IM (Intelligent Mobility) offer. IMEC will also offer post qualification leadership, management, executive and entrepreneurial continuing professional development open and bespoke courses. The aim is to provide real-life team-working in the transport systems sector, equipping individuals and partners with the knowledge required for the 21st-century workplace.

2.5 Multi-User Environment for Autonomous Vehicle Innovation (MUEAVI) is a £9m project under development at Cranfield University that will begin to operate as a 'full scale living lab' in the spring of 2017. The UK government has invested £3m in the project, through the UK Growth Deal initiative, as an investment in national infrastructure to facilitate research and development for the rapidly developing Intelligent Mobility sector.

2.6 The road, its surroundings, and its day-to-day users, will provide an open research, development, test and demonstration environment for autonomous transport innovation. The MUEAVI facility will integrate research and development, not only in the fields of autonomous technologies, but also in systems engineering, sensing and prognostics, technology diffusion, societal adoption, safety and regulation, complexity science, human factors analysis, risk and policy assessment and ergonomics.

2.7 As well as the technology of autonomous vehicles themselves, research across the University also develops the applications of autonomous vehicles in wider society.

- Academics within the Cranfield Soil and Agrifood Institute are using 'drones' for remote sensing imagery to improve crop monitoring.
- Work within the Cranfield Institute for Resilient Futures includes the use of drones for flood extent mapping and damage assessment, robust hydromorphological characterisation and floodplain forest restoration monitoring. Further research activity also includes underwater vehicles for coral reef habitat identification, as well as radio controlled and autonomous boats for freshwater ecosystem monitoring
- The Centre for Safety & Accident Investigation is developing the use of drones to improve accident investigations.
- As a University, we are also working with a number of SMEs helping to test and prototype Autonomous Vehicles applications and services.
- In the Centre for Logistics and Supply Chain Management, based at Cranfield School of Management, the potential impact of autonomous vehicles on the supply chain is being examined.

#### Impacts and benefits

3.0 The fundamental technology for managing autonomous vehicles and systems is available - but the bigger question is how it can best be used for economic and social benefits.

3.1 This is disruptive technology that could impact on all areas of society, many of which were discussed at a recent conference held at Cranfield University '[Visions of an Autonomous Future](#)' featuring leading academics and industry figures from across the UK.

3.2 Some jobs are likely to be replaced; in other areas autonomous technology will be a solution to skills shortages, such as freight lorry drivers; and, more broadly, there will be many more jobs created in technology development, maintenance and management.

3.3 The economic benefits from a world-leading industry around autonomous vehicles (AVs) have already been mapped out: a potential [£51 billion for the UK economy each year](#) according to research from KPMG.

3.4 The most obvious benefit of the technology is the movement of people and goods. As transport systems become more crowded and more complex, there is a general need for more autonomous technologies to reduce the increased potential for human error and improve safety.

3.5 The increased sophistication provided by autonomous systems will be an essential underpinning of increased traffic volumes in airspace, on roads and at sea.

3.6 [Ninety-three per cent of road accidents are said to be caused by human error](#); by 2030, the introduction of driverless vehicles is expected to save 2,500 lives and reduce the number of serious accidents by 25,000. In general, roads and central public areas will be safer for pedestrians through anti-collision and speed control technology. Greater traffic management will reduce congestion and lower journey times, reduce CO2 emissions and noise.

3.7 Cranfield is currently working in collaboration with others on [CogShift](#), one of five projects which are part of an £11 million UK Government investment in autonomous vehicle research. CogShift is studying driver attention and cognitive control characteristics. The project will use these to develop an optimal control-authority shifting system which takes driver attention into account

3.8 As a step on the way to fully self-driving cars, we will see cars that are self-driving part of the time but must still be human-driven at other times. For comfort and safety, it is important that there is a smooth and swift transition between the self-driving and human-driving modes. A particular risk is that human drivers may not be ready to take over safely, as they may be preoccupied with non-driving tasks.

3.8 More use of unmanned aerial vehicles for deliveries and some public services such as security and monitoring will also cut traffic volumes. Driverless vehicles won't need to be parked in crowded central areas but tidy themselves up and park out of town. There'll be better access for emergency vehicles due to reduced traffic and their ability to interact and alert other vehicles.

3.9 The technology will also be of particular value in helping governments and societies address issues of transport for the ageing population, allowing for independent and mobility for people into older age. Driverless cars will allow older people to be mobile and independent to any age, without relying on public transport and subsidies.

3.10 They would also offer local authorities a lower-cost option for delivering services like security, environmental monitoring and refuse collection. Fewer accidents and risks in general means lower insurance costs. Investments into the infrastructure for AVs will be repaid from attracting more business and additional residents looking for next generation access and mobility.

3.11 Autonomous ground vehicles can also speed up air travel with less time spent refuelling, removing and loading luggage, and generally improving the efficiency of ground operations. One of the biggest factors in airport delays is ground vehicle collisions – a greater use of autonomous vehicles will help reduce this. Cranfield is currently seeking funding for the Digital Aviation Research and Technology Centre (DARTeC) which will pioneer research in this area.

3.11 Cranfield University research is already demonstrating the benefits autonomous vehicles can have on crop monitoring, flood damage assessment, water pollution monitoring and accident investigation among many others.

#### Research and development

4.0 Most important of all will be securing public understanding and acceptance to support implementation into towns and cities in stages, the opportunity for lessons to be learnt without the level of opposition that means the transformational benefits are lost.

4.1 At Cranfield we'll soon be opening an intelligent mobility road running through the campus, allowing for projects to test combinations of road and aerial vehicles in a real-world environment.

4.2 With our own airport, intelligent mobility road and autonomous vehicles research facilities Cranfield's campus can become a 'living lab' to test autonomous vehicles and help strengthen the confidence in how autonomous vehicles can be combined in populous areas.

4.3 Cranfield University is currently involved in AIRSTART (Accelerated Integration of Reliable Small UAV systems Through Applied Research and Testing) funded by the Aerospace Technology Institute (ATI). AIRSTART is a collaborative £3.2 million project led by Airbus Group Innovations. Running until December 2017, it involves a number of stakeholders including SMEs and other research institutions

4.4 AIRSTART seeks to drive UK leadership in small commercial UAS (lighter than 150kgs) by overcoming major barriers to growth.

4.5 The barriers, that AIRSTART is examining, are mainly the lack of affordable, lightweight, sense and avoid and fast and secure, communications technology required to enable its safe operation ‘Beyond Visual Line of Sight (BVLoS)’, as well as increased endurance. This will be achieved through research and development in new technologies that also have applications in manned aviation and space sectors. We are testing novel hybrid power systems and laser communication systems as part of the AIRSTART project.

### Real world operation

5.0 There’s nothing inevitable about the transition to autonomous vehicles given the critical role of public understanding and support of sharing our transport systems with ‘robots’. However, we already do it – around 95 per cent of everyday passenger aeroplane flights are under computer control – but it’s a question of perception.

5.1 There’s a stark difference between autonomous features already available in our cars, the assistive technologies like cruise control, self-parking and collision detection, and the principle of allowing computer-controlled ‘robot’ vehicles onto roads. At the moment, the public tend to trust technology when it’s under human control, based on human decisions, even when all the evidence shows that it’s the human frailties that cause accidents and not the technology.

5.2 The reality is that any accidents or incidents involving AVs in pilot trials on UK roads will be emphasised as evidence of the unreliability of the technology, and for prejudices to be confirmed.

5.3 The development of the technology is moving much faster, driven by the interest of hobbyists and vast potential for useful applications in environmental monitoring, security and logistics, than the regulations governing autonomous vehicles.

5.4 [Aerial UAVs create a plethora of regulatory](#) hurdles – how do you regulate the hobbyist and the SME looking to develop an application and the large-scale companies looking to develop their logistics and supply chain operation, all under the same regulations?

5.5 It will be a challenge to regulators to maintain safety and allow innovation to flourish. Too strict regulation and business will be discouraged to take risk, too lax and safety issues will see the public unwilling to embrace technology and provide demand in the marketplace.

### Skills requirement

6.0 Building the engineering skills base is essential for the UK to capitalise on the emerging market around autonomous vehicles. The shortage of engineers that the UK faces not only threatens the development of autonomous vehicle technology but also the creation of applications for autonomous vehicles.

6.1 The roll-out of autonomous vehicles will be disruptive and will demand changes in education and skills. In agriculture for example, a farmer may need to know how to

programme an autonomous vehicle and how to interpret the vast amount of data that the vehicle has captured.

### Conclusion

7.0 The question around autonomous vehicle technology is when will it be available rather than if it will be available. This raises questions for regulators, industry and the public as a whole, as the technology leaps ahead of regulation and societal acceptance.

7.1 The technology is disruptive – its introduction will change everything from the way we farm, to the way we receive goods, to the way we travel.

7.1 Public attitude will be an important factor in how fast the UK moves in this market, potentially worth £51 billion to the UK economy, will the public be prepared to trust and accept the technology and its applications?

7.2 Cranfield University's research facilities offers an ideal place for regulators and industry to work through some of the challenges that they face in developing technology, its applications and building public confidence.

*2 November 2016*

## **DAC Beachcroft LLP – Written evidence (AUV0067)**

### **About Us**

DAC Beachcroft LLP is a leading international legal business with offices across the UK, Europe, Asia Pacific and Latin America.

We partner with our clients to help them achieve sustainable growth and to defend their business and reputation. We do this by taking a tailored approach to providing commercial, transactional, claims, risk and advisory legal services.

We are recognised leaders in Insurance, Health and Real Estate and draw on the knowledge, industry experience and commercial expertise of our outstanding 2,200 lawyers and support colleagues in these sectors and beyond.

We are forward-thinking, flexible and easy to engage with and we're proud that our clients tell us regularly that we're great to work with.

We know that our clients value advice that is innovative, practical and personal to them, and we pride ourselves on getting to the heart of their businesses. We measure our performance against their expectations and embrace change as a necessary stage in evolving and strengthening our relationships.

The close working relationship we enjoy with our clients has not been built overnight but honed carefully over the last 250 years. This means today our clients can remain confident they have the very best legal expertise available.

### **Preamble**

1. We feel it is important to make a clear distinction between Advanced Driver Assistance Systems (ADAS) and Autonomous Vehicle Technologies (AVT). The technologies expected to reach the market in the next 2 to 4 years are all forms of ADAS. These systems provide the driver with "assistance", but do not "control" the driving task. In short, they will still require the driver to be driving "in-the-loop" at all times. Drivers need a clear understanding of what is expected of them and must not be misled into thinking their car can 'drive itself' when it cannot.
2. The development of ADAS and AVT will be incremental by nature, and full automation remains some years away. However, the work that this committee is undertaking is important for two reasons. First, it is laying the groundwork for the smooth development and integration of autonomous vehicles (AVs). Second, several aspects of the work are relevant to ADAS-equipped vehicles, especially issues of cybersecurity.
3. It is in the spirit of welcoming the work done by this committee that DAC Beachcroft

LLP is delighted to respond to those questions posed where we are able to provide meaningful comment.

4. At the outset and as an overview, we applaud the UK Government's ambition in seeking to lead the world in developing AVT. The opportunities for the UK in doing so, in terms of inward investment, are obvious. The recognition that the complex regulatory environment in which such technology will operate must be as enabling and flexible as can be consistent with the overall aims of safe development is also very important.

#### **Creating an enabling environment – Real world operation**

##### **10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

5. Deployment of AVs will require significant changes to digital and physical infrastructure.
6. The recent DfT consultation made reference to the 'Connected Corridor' which uses different connection types -- LTE, local WiFi hotspots, LTE-V and DSRC -- that could be built into cars and roadside infrastructure such as traffic lights and overhead gantries. These are roadside elements that will play a vital role in the development of both vehicle to vehicle (V2V) and AV technologies.
7. The Connected Corridor proves how important infrastructure improvements will be in deploying AVs. It is our contention that for AVs to work across the country, significant investment in internet connectivity will be required.
8. There are many parts of the UK that presently lack the necessary internet connectivity to use AVs, which need to be able to communicate with both other AVs and with infrastructural elements. To make AVs available outside urban centres, a great deal of digital and physical infrastructure changes will be necessary: digital in the form of expanding adequate access; and physical in the means by which that access is granted (wires, towers, servers, etc). These infrastructure requirements will be necessary to implement the further changes that will come in the form of connected traffic lights and overhead gantries.
9. We are concerned about the interactions between AVs and human driven (conventional) vehicles (including those with ADAS). These concerns are especially acute when considering the concept of AV HGV platooning, which could result in catastrophic outcomes should something go wrong. Because of this, in our response to the DfT consultation we recommended that AVs, at least HGV ones, be limited to special AVT-only lanes (similar to bus lanes). This would require a significant alteration of the road network.
10. As AVs become more widespread, we envisage the potential need for further infrastructural changes in the form of alteration to parking spaces, car parks and

garages. By storing vehicles at a higher density in areas of low land value, landowners would be able to free up large volumes of more valuable land for development, and the resulting changes to urban landscapes. Equally it would mean the need for more expansive drop-off and pick-up zones, bringing with it management issues akin to those currently experienced at busy airports and railway stations. Car sharing could also require rethinking the role of public transportation and the infrastructure that accompanies that. However, as these potential changes are many years away, we see little merit in doing more than pointing them out at this stage and commenting that infrastructural development will be an ongoing process accompanying the changing nature of AVs.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

**Data**

11. Data-recording is an important consideration. It is vital that telematics is uniformly formatted such that it can easily be used in a court of law. Consideration should be given to a standardised data set; who owns the data; and any issues (e.g. human rights) to consider regarding data usage.
12. Access to data will play a vital role and provision should be made for data sharing between manufacturers and insurers. In the current ADAS market and in the near future, where many features will be optional rather than standard fit, it will be important for insurers to have information about the options fitted to a particular vehicle, to enable them to reflect these developments in the competitive pricing of the insurance product. Information on vehicle usage and accident data should also be readily available to insurers, to enable all concerned to deal with issues of fault. A general climate of sharing data and information in this way will help to encourage collaboration, risk sharing and innovation in product and service delivery for the benefit of the consumer.

**Cybersecurity**

13. Modern vehicles are becoming increasingly connected to the internet. In 2015, Chrysler Fiat (USA) recalled over 1.4 million vehicles only after the technology journal *Wired* invited hackers to take over a Jeep via their laptop computer. The hackers stated that Chrysler Fiat knew of the security deficiencies and failed to issue the recall until they were made public. And just last month, Chinese hackers claimed they were able to gain control of a significant portion of a Tesla's controls from 12 miles away, again with a laptop.
14. These incidents took place in ADAS-equipped vehicles. AVs will be even more at risk of hacking because they will be reliant on the internet for everyday use. It is imperative that consumers feel confident that they can use their vehicles safely and with minimal threat of hacking. The UK government will need to have a policy in place that requires manufacturers (of both AVs and the infrastructural components)

to provide the best possible security for their products.

15. Additionally, the UK government will need to ensure that consumers who embrace this emerging technology do not suffer unnecessarily because of it. In short, innocent victims of hacking should be able to recover fully any damages they have suffered due to a hacking incident. To protect consumers, insurers need to pick up innocent party claims regardless of hacking, subject to a right of recovery against the vehicle manufacturer (VM) and/or systems manufacturer and/or software manufacturer. Considerable thought is needed as to whether this should exclude coverage for terrorism.
16. The current protection of certain interests against terrorism risks via Pool Re is not an acceptable means of providing coverage for hacking of AVs by terrorists for several reasons. First, Pool Re excludes damage caused by hacking from its terrorism cover. Second, it specifically covers only damage to commercial property and does not extend to life or personal injury. Finally, it does not cover any property covered under a motor policy. The new Terrorism Insure also seems inadequate to deal with the potential, unique threats that hacking of AVs presents.
17. We are strongly of the opinion that use of AVs as a weapon by terrorists and the related rights of innocent parties and insurers' rights of recovery will have to be addressed in forthcoming regulations.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

**Insurance**

18. We agree strongly that third party liability for harm caused by the car, when operating in autonomous mode, must be included within the extended scope of compulsory motor insurance required by the Road Traffic Act 1988.
19. However, the current law and insurance practice in relation to "product liability" cover makes this model unsuitable for delivery of the UK Government's stated objectives, in particular the continued full protection of external (third party) road users which now extends to protecting the "not at fault" automated vehicle 'driver' (whether or not they can be properly said to be 'driving').
20. It is unarguable that the 'use' of vehicles must continue to be covered by compulsory insurance and that insurance claims should continue to be handled quickly so that there is certainty in the market and so that victims of road traffic accidents have easy access to appropriate compensation in the event of loss or injury. We therefore support the UK Government's stated policy objectives<sup>126</sup> of:
  - a. extending the compulsory insurance requirements for automated vehicles

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<sup>126</sup> See paragraph 2.9 of the DfT consultation.

- b. providing cover for the “not at fault” driver as well as passengers and (external) third parties
  - c. developing a system of classification for identification of automated vehicles which will require the extended cover to be in place.
21. These goals can best be achieved by requiring the extension of existing compulsory motor insurance legislation and terms and conditions (maintaining the approach that consumers can buy a single policy to cover all needs) and by creating associated statutory rights of recovery. Only in this way can all the questions of risk and recovery raised by compensating victims of a road traffic accident involving an automated vehicle be fully addressed.
22. In our view, it is too simplistic to stretch the existing product liability insurance model, for several reasons:
- a. There is no legal requirement to provide or purchase product liability cover. Manufacturers and suppliers can choose to defray risks as they wish, through insurance or otherwise.
  - b. The terms of product liability insurance policies are not controlled in the same way as for road traffic policies. By statute, motor insurance cover for personal injuries has to be unlimited, whereas the cover provided by a product liability policy may have defined limits. It would be wholly unfair if the level of recovery by an injured victim was to be dictated by the type of insurance in place rather than by the severity of losses he or she sustained.
  - c. The long stop cut off for product liability claims. An amendment to the Limitation Act 1980 sets this at ten years: “An action to which this section applies shall not be brought after the expiration of the period of ten years from the relevant time”. [The relevant time being when the product was first put into circulation.] Simply importing all elements from the product liability field into the sphere of motor insurance so as to deal with autonomous vehicles would therefore produce the unacceptable outcome that claims associated with any autonomous vehicle more than ten years old would be legally barred.
  - d. The law underpinning product liability does not cover damage to the product which is caused by the product, per section 5(2) of the Consumer Protection Act 1987. In the context of autonomous vehicles, this may be a difficult concept depending on how the damage to the vehicle is to be treated. If one regards the disengaged driver as wholly ‘innocent’ when the vehicle goes wrong (in autonomous mode) then why should the driver/owner not be able to recover for what could be regarded as third party damage to his or her car (even if it is actually caused by the car?) It may be that cover for one’s own vehicle (often referred to as comprehensive insurance) is treated in many cases as an optional element (ie not part of the compulsory insurance required by road traffic legislation), but where someone relies on their vehicle for employment or other essential activities, they may feel unfairly penalised if they lost their mobility as a result of an accident that was not their fault but that was caused by the car.

- e. *Vnuk*. This European Court of Justice (ECJ) case requires that the regime for compulsory motor insurance set out in the Directives should be interpreted as covering “any use of a vehicle that is consistent with the normal function of that vehicle”. As the normal function of an autonomous vehicle includes self-driving, the decision in *Vnuk* would appear to point to a motor - not a product liability - policy being a necessary legal requirement.
- 23. For the reasons above, we suggest that it would be more proportionate to extend the scope of compulsory motor insurance to include autonomous driving than it would be to alter dramatically current law and practice applying to the product liability insurance market.
- 24. An extension of existing compulsory insurance obligations under a single motor policy, rather than devising a system under which a vehicle owner or user has to have in place both motor insurance and product liability insurance, would, in our view, promote relative simplicity of regulation, new product development and distribution & sale to drivers to a far greater extent than the potential complexity of merging motor insurance and product liability insurance law and market practice.

### **Regulation**

- 25. In response to question 12 above we have outlined that regulations are required to deal with the rights of innocent parties and insurers in the event of an AV being used as a weapon by terrorists.

### **Legislation**

- 26. Legislation will be necessary to extend existing compulsory insurance obligations under a single motor policy to provide adequate product liability coverage, taking into consideration the deficiencies of current product liability law as outlined above.

### **14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

- 27. The development of AVT is absolutely dependent on fostering public trust and confidence in the technology to the point that there is an adequate customer base to make the product viable. To achieve this, manufacturers need to highlight the safety features that potential customers will enjoy.
- 28. From a practical perspective, the ethical side of this question may be moot if AV manufacturers follow Mercedes-Benz's example of putting the safety of passengers foremost in the programming. Commercially, this approach is not surprising, as potential customers are unlikely to purchase vehicles that do not place their protection above that of all others.
- 29. However, we feel it is incumbent upon us to answer this question from an insurance perspective. The problem is that AVs will have to be programmed to replace human

judgement, and that this programming may result in injury (including death), loss and damage.

30. When an AV makes a judgement decision it is simply doing what it has been programmed to do – the manufacturer is responsible for that programming. The question that must be addressed is how this affects the relationship between the manufacturer, the customer and the insurer.
31. Many of the statements currently being made on this subject are little more than articulations of either a theoretical concept or even of a market positioning. Safety of all road users is an essential and unarguable priority: no one will gain if use of this technology fails to keep all road users safe.

#### **Creating an enabling environment – Wider governance**

##### **15. What does the proposed Modern Transport Bill need to deliver?**

32. Regulation should act as an 'enabler', whilst ensuring the safe development and implementation of new technologies. To achieve this, it will be vital to educate consumers as to the fundamental difference between ADAS and AVT, the former requiring the driver to remain 'in-the-loop' and providing assistance to the driver rather than assuming control of the vehicle.
33. The development of ADAS and AVT will be incremental by nature, and full automation remains some years away. Imposing too much regulatory change now may stifle innovation, and may result in vehicle and systems manufacturers looking to develop elsewhere, other than the UK.
34. Any additional regulation should be decided and implemented in a proportionate manner, so that the net gains of autonomous driving can be realised in full. This approach will also allow future regulatory changes to be based on experience and reflection (both from within the UK and elsewhere) as the 'close to market' technologies of today are tested and performance is analysed.
35. Additionally, deployment of AVs into the marketplace will require substantial changes to the infrastructure, and the Bill will need to create the framework by which this will take place.
36. The Modern Transport Bill will serve as the first of many to come to facilitate the development and implementation of AVT, and needs to be seen as such. It needs to provide a framework by which this technology can successfully grow but also must refrain from implementing far-reaching restrictions that could limit growth. This is a fast-growing and evolving area of technological development, and the Bill must reflect that.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

37. We see the UK Government's strategy and work in this area as providing opportunities outside AVs, particularly in reference to modernising cities, diversifying the British economy through the Northern Powerhouse and contributing to London's plans for its future development.

**Northern Powerhouse**

38. For northern cities to become as productive as those of the southeast, it will be necessary for them to focus on maximising the effect of agglomeration in the city regions. This means increasing the benefits and reducing the negatives, including congestion and the costs of commercial space. AVs will assist in reducing these negatives; and so could assist in enabling the Northern Powerhouse.

39. More efficient use of urban space would also allow for better and cheaper commercial space and associated amenities, both of which could be facilitated by widespread adoption of AVs and the space this could free up.

40. Recent studies have shown that population density is directly linked to a city's productivity. To make more densely populated cities both more realistically achievable and attractive to prospective residents, the UK Government should integrate AVs into their plans, including those for the Northern Powerhouse.

**London**

41. The London Plan calls for reducing congestion, improving traffic flow, increasing road capacity and improving the parking situation. Each of these goals would be aided by encouraging the development and spread of AVT. This would be especially true if such technology were coupled with the development of greater vehicle sharing platforms, which would reduce individual car ownership and could result in more efficient use of parking facilities.

42. The London Plan also calls for a reduction in CO<sub>2</sub> production. AVs, through their increased reliance on electrical power and their improved efficiency, could assist in achieving this goal.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

**Insurance**

43. Leaving the EU could mean the loss of the mutual recognition of motor insurance

policies across the EU via the Motor Insurance Directives. At present, there is talk of a green card scheme, which would operate outside the EU and allow a continuation of mutual recognition. However, like so much else involving extraction from the EU, that idea is still a theory only.

44. Whilst the UK may no longer have to apply the strict effect of the *Vnuk* decision, it will still have to ensure its policies are in line with EU policies so that UK residents can drive their vehicles in the EU. This will be especially important if the UK wishes to continue to send its HGVs to the EU.
45. There is an additional and obvious benefit in the UK leading the way on AVs: it will create a climate in which inward investment into the UK should flourish, whether from countries in the EU or elsewhere.
46. In short, it is vital that the UK ensures that its regulatory framework is ahead of the curve, and it will need to work closely with the EU even after Brexit has been finalised.

### **EU Standards**

47. It seems unlikely that those manufacturers producing AVs in the UK will be able to alter the standards of their vehicles. This is because of the need for harmonisation of vehicle design and construction standards. While there has been some criticism of the EU-wide type approval process for vehicles, a return to UK-only type approval, with some sort of mutual recognition scheme for all other countries, seems unlikely and has not been suggested. This is due in large part to economy of scale - harmonisation of vehicle design and construction standards keeps costs down.
48. Additionally, if UK manufacturers want to sell their AVs within the EU, they will need to continue to conform to EU vehicle design and construction standards. Rather than negotiate mutual recognition schemes, it seems economically practical to abide by the standards of the EU.
49. It is worth observing that two of the leading manufacturers developing AV technology are Volvo and Daimler/Mercedes, both of which are based in the EU and do not manufacture in the UK.

### **Investment**

50. The UK automotive industry supports 800,000 jobs and contributes £15.5 billion to the economy each year. More than half of all vehicles and automotive products made in the UK are exported to the EU. Before the referendum the Society of Motor Manufacturers & Traders stated that remaining in the EU would mean that the UK automotive industry would continue to benefit from "unrestricted access to the world's largest single market, the negotiating strength of the EU to secure international trade deals, the ability to shape technical regulations and free movement of labour".

51. It is obviously very unclear what deal will be negotiated to exit the EU and how that will affect the automotive and insurance industries. For example, we still do not know if the UK will remain within the single market, membership of which would result in few changes for the automotive industry. As such, we cannot offer more than high level possible outcomes.
52. Failure to stay in the single market or achieve an adequate free trade policy would almost certainly result in tariffs on UK AVs going to the EU. This runs the risk of harming the UK automobile industry (both conventional and AV). In that event, manufacturers could be less likely to invest in the UK, making advancements in AVT less likely. Instead, that same investment could go to the EU. As a result, leaving via a 'hard Brexit' could hinder the UK's automotive industry and emerging AVT.
53. Alternatively, Brexit could make the UK a better place for investment. First, with the recent devaluing of the pound we have already seen foreign capital pour into the FTSE. It is possible that foreign investors could be enticed into putting their capital into the UK AV industry: purchase of UK property and equipment from abroad would look more lucrative. It would also make wages more affordable for those companies whose finances are based on other currencies. Second, a lack of EU regulations could make advancements in technology easier/more likely. Again, this could entice foreign investors into the UK. Finally, locating itself outside the EU could strengthen the UK's global position through attainment of better trade deals with China, US etc, although it has to be recognised that such trade deals might take years to finalise.

*26 October 2016*

## **Deloitte LLP – Written evidence (AUV0045)**

### **Introduction**

Deloitte welcomes the opportunity to contribute to the House of Lords Science and Technology Committee's inquiry into autonomous vehicles.

Deloitte works with central and local government transport bodies in the UK and around the world, as well as with private sector companies in both the automotive and technology sectors.

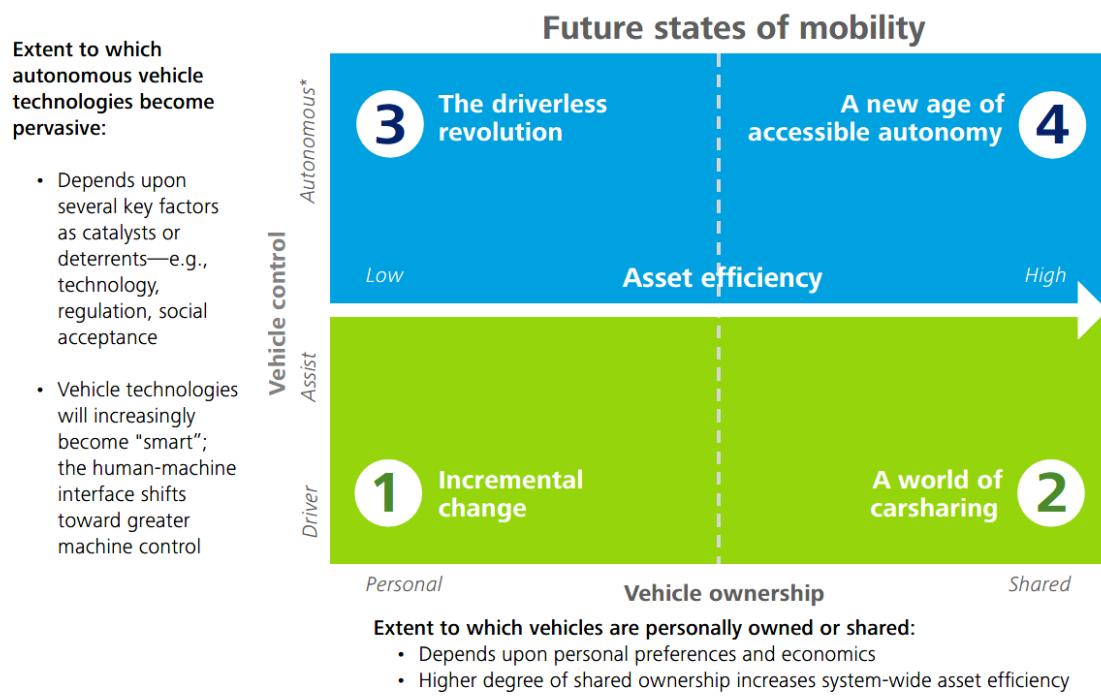
Deloitte's submission draws on the thought leadership published and the work done on behalf of its clients, which includes central governments, local governments and businesses. This submission also draws on research conducted by Deloitte's US member for client use. Full access to Deloitte publications on the topic can be found at:

<http://dupress.deloitte.com/dup-us-en/focus/future-of-mobility.html>

### **1. What are the potential applications for autonomous vehicles?**

- 1.1** Deloitte envisions that potential applications for autonomous vehicles will be widespread. Naturally the primary focus of the debate around autonomous vehicles has been on vehicles moving people and goods from place to place, especially in 'last-mile' delivery of people and goods in urban areas. However, they could also have much wider applications, such as transporting materials that might be dangerous to human drivers or operating in potentially hazardous environments, such as in mines or where toxic materials are present.
- 1.2** The most important application, in our view, will be as part of a mobility ecosystem that incorporates multiple modes of transport. Deloitte sees driverless vehicles playing a key role in larger trends that address population growth and rising urbanisation, promote asset efficiency and road safety, and reduce the environmental costs of more people and goods travelling from place to place.
- 1.3** Deloitte believes that change will happen unevenly, with different populations requiring different modes of transportation—which means that four future states may well exist simultaneously. Transport systems will need to factor in that different technologies may be in use on the same roads and the same time. These states are set out in the graphic below and range from driver owned and driven vehicles, where we are at the moment, through to shared ownership and machine driven vehicles.

**Figure 1. Four futures will coexist**



\*Fully autonomous drive means that the vehicle's central processing unit has full responsibility for controlling its operation and is inherently different from the most advanced form of driver assist. It is demarcated in the figure above with a clear dividing line (an “equator”).

Graphic: Deloitte University Press | DUPress.com

## 2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

2.1 Deloitte’s research and insights to date have identified the following as potential benefits from a shift to autonomous vehicles:

- Increased road safety: Autonomous vehicles remove human error which is the largest cause of most accidents.
- Improved traffic management: guidance systems permit real-time awareness of congestion and sensors allow for less space between vehicles.
- Traffic-related law enforcement decreases: autonomous vehicles are programmed not to exceed speed limits or otherwise violate traffic laws.
- Productivity increases: there are fewer cars in circulation as asset utilisation increases. Users riding in autonomous vehicles are freed from the need to watch the road, thus allowing more time to spend on productive pursuits.
- Reduced parking demand: the rise of autonomous-drive and car sharing models diminish need for parking space.
- Energy demand drops: smaller mass and weight allow cars to be propelled by more compact, efficient, and environmentally friendly powertrains.
- Speed of deliveries quickens and costs decrease: fully autonomous networks of long-haul trucks could operate for more extended time periods and cover longer distances with lower labour costs.
- Infrastructure costs funded by charges for actual usage: connected-car technology allows systems to precisely calculate personal road use.

- i) Trip costs decline: Deloitte research in the US has forecast that the average cost per passenger mile could drop from \$1 per mile today to approximately 30¢ per mile, thanks to dramatically higher rates of asset utilization.
- j) Expanded mobility access: Independent mobility for low income and non-drivers as costs decrease and transport becomes cheaper to operate over time. Mobility would therefore become a service
- k) New business ecosystems are created: the spread of transportation technology and social trends will open up growth opportunities and employment in various sectors. Further details are set out in the response to Question 3.

2.2 Deloitte's research has also identified the following potential disadvantages to autonomous vehicles:

- a) High initial costs delay adoption: infrastructure will need to be made fit for purpose to accommodate smart technologies. The cost per vehicle at the outset will likely be high and thus less widely adoptable in the early stages.
- b) In addition to the infrastructure requirements (as described below) the government will need to formulate policies to deal with the increased electricity demand that autonomous vehicles would require. Research by Bloomberg New Energy Finance has suggested that the rise in electrical vehicles could add 8% to global energy demand by 2040.<sup>127</sup>
- c) Security/data breaches: further details on this are set out below in response to Question 12.
- d) Public sector finances suffer: traditional means of revenue – such as fuel duties, licensing costs, traffic enforcement, tolls and public parking fees – could diminish.
- e) Disruption/dislocation to existing business models: autonomous vehicles could see changes to current employment models, impacting a wide range of employers and workers. For example, there is a large support network established in terms of hotels and maintenance services for HGV drivers that could be impacted by a widespread move to autonomous lorries.
- f) Initial rise of safety problems: humans will need to learn how to interact with driverless vehicles, as passengers in other vehicles and as pedestrians and cyclists.
- g) Change in driver skills: Operating autonomous vehicles will also require different or additional skills and hence additional driver training.
- h) Technological limitations delay adoption: sensors must function in all weather and 3D mapping must be widely available.
- i) Regulations and legislation do not keep up with technological advancements.

### 3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?

3.1 Deloitte has not conducted analysis of the impact of the automotive sector specifically in the UK but colleagues in the United States have estimated that the automotive industry's extended value chain generated \$2tn in revenue in 2014—11.5% of US GDP. This extends across multiple sectors of the economy and includes areas not typically regarded as

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<sup>127</sup> New Energy Outlook 2016, Bloomberg New Energy Finance.

‘automotive,’ such as the media industry, which generates advertising revenues through in-car radio, and the financial services sector, who market financial packages to drivers.

3.2 On this basis, Deloitte US has considered how various sectors could be impacted by the deployment of autonomous vehicles with the following observations:

- a) Automotive: Decrease in personally-owned vehicle sales and increase in fleet vehicle sales.
- b) Energy: Decreased energy consumption from improved vehicle efficiency.
- c) Finance: Growth in fleet financing in place of automotive loans and leasing.
- d) Media: Increasing consumption of multimedia and information due to time not driving.
- e) Medical & Legal: Reducing costs for emergency medical services and related legal fees because of fewer accidents.
- f) Public Sector: Eroding tax revenues related to property and fuel taxes, vehicle registration, and traffic citations.
- g) Retail: Increasing sales due to increased mobility of hard to reach demographic groups, such as elderly people.
- h) Telecommunications: Additional bandwidth requirements to meet increased demand for connectivity and reliability.
- i) Technology: Emergence of autonomous drive operating systems providers.
- j) Transportation: Substitution of demand for traditional taxis, limos, and rental vehicles with shared fleet vehicles.<sup>128</sup>

3.3 Where applicable, a number of these trends could similarly affect these sectors of the UK economy.

## **10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

10.1 Infrastructure will need to be at least maintained to a high standard, if not enhanced with ‘smart’ technologies, to allow autonomous cars to operate safely.

10.2 Driverless cars rely on on-board cameras, sensors and lasers to determine their location in relation to other objects. They require well-paved roads, clear signage, lane markings, and entry and exit points.

10.3 Connected cars require infrastructure to be ‘smart’ to enable vehicles to interact with other vehicles, the physical infrastructure and external factors such as pedestrians and cyclists.

10.4 From a digital perspective, there would need to be an extensive roll out of fibre optic networks capable of 5G wireless broadband. Full automation is highly likely to require ‘server-level’ processing capability within cars to enable frequent and timely communication.

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<sup>128</sup> <http://dupress.deloitte.com/dup-us-en/multimedia/infographics/future-of-mobility-transportation-technology.html>

**10.5** Sensors will need to be embedded at intersections, on motorways, and in traffic lights, road signs, parking places and other spots. High-definition 3D mapping of most major infrastructure-- more detailed than GPS—would need to be layered on top of existing maps and include factors such as the location of lanes, stop lines, guardrails, and the shapes of buildings, for example. Any changes in conditions can be updated in real-time through the 5G networks, then stored in the cloud and accessed via the vehicles' telematics.

**10.6** The private sector players have taken the lead on mapping, with a number of technology and automotive companies expanding their mapping operations or partnering on new initiatives. The government can assist this to speed up the adoption of autonomous cars and generate competition among data providers, who will be major players in the new transportation landscape.

**10.7** Most autonomous vehicles will be electrified and will therefore need a denser network of charging stations. As an example, Germany is expected to have just over 1 million charging stations by 2020, while the UK currently has around 12,500.

**10.8** Longer term, a transition to autonomous vehicles as a major part of mobility would entail a rethink of how roads, residential, retail and office areas are designed.

## **11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

**11.1** The key milestones will come as a series of waves, part of the technology adoption cycle. Following the Society of Automotive Engineers (SAE) definition of automation,<sup>129</sup> Deloitte uses five levels when thinking about autonomous vehicles, ranging from no automation (level 0) to driver assistance (1), partial automation (2), conditional automation (3) and high automation (4), through to full automation (5).

**11.2** Most cars currently in use have little automation or driver assistance, some have elements of partial automation, but few have more advanced technology than this. As technology becomes more robust in the coming years, Deloitte would expect to see larger percentages of cars with more advanced levels of automation.

**11.3** Research by Deloitte's US team has forecast that driverless cars for shared use will make up 10% of US sales in 2030, 25% in 2035 and 50% in 2040. The research envisions initial roll-outs of fully autonomous vehicles to be shared fleets within contained areas in restricted urban or suburban settings. Sales of personally-owned autonomous vehicles may follow, but are expected to be adopted at a slower rate.<sup>130</sup>

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<sup>129</sup> [http://www.sae.org/misc/pdfs/automated\\_driving.pdf](http://www.sae.org/misc/pdfs/automated_driving.pdf)

<sup>130</sup> <http://dupress.deloitte.com/dup-us-en/focus/future-of-mobility/future-of-mobility-transformation-in-automotive-ecosystem.html>

11.4 The government can set safety standards, require cars to come equipped with the latest driver assistance features and offer scrappage incentives (such as the HM Treasury Plug-In Car Grant) for owners of older models to trade in for newer models. Through such measures governments can speed up the number of cars with at least partial automation on the street.

11.5 Modelling the rate of adoption in the United States, Deloitte's research envisioned that 50% of cars in circulation by 2022 would have at least some form of driver assistance, if not more advanced automation technology, and that fully driverless cars could be on the roads from 2025. However, with quicker adoption, the research also demonstrated that 45% could have high or full automation by 2040, with autonomous vehicles in use from 2021, with a faster replacement cycle of older vehicles.

11.6 Other milestones are extensive roll-outs of 'smart' infrastructure, such as embedded sensors, 5G networks, and detailed 3D maps of most roads. Conditional and high automation, unless contained within set geographic areas, will likely require extensive interactions between the vehicle and the physical infrastructure.

11.7 Deloitte's US research expects a two-pronged approach the deployment of autonomous vehicles on a mass scale. There will be 'geo-fenced' areas where most or all vehicles in circulation are autonomous, such as shopping high streets or specific commuter corridors. The rest of the roads will see human-driven and autonomous vehicles 'cohabiting' until the majority of the cars in circulation are fully autonomous.

## **12. Does the Government have an effective approach on data and cybersecurity in this sector?**

12.1 The government is in the process of assessing its approach to data and cyber security in this sector, with an eye to formulating more detailed policies in the near future. Through the work Deloitte has done with other national regulatory bodies, we believe that any approach should encompass the following:

- a) Creation of an information sharing centre: Its main role would be to collaborate with security experts, researchers and privacy professionals to actively develop and distil best-practice. It should coordinate efforts of any organisation whose remit touches on autonomous vehicles, such as the Automotive Council, the National Cyber Security Centre (NCSC), the Centre for Connected and Autonomous Vehicles (C-CAV) and Euro NCAP.
- b) Establish national data protection standards and regulations: the government should create an automotive cyber security rating system (like US NHTSA) to establish rules and guidelines for the safe development of new systems and develop imminent hazard protocols in the event of cyber security vulnerabilities or safety threats.
- c) Verify security design: The government needs to assess compliance with standards and enforce software verification and updates. It will need to perform

its own security tests to check for cheating software (e.g. used to influence test results) or unwanted data capture.

- d) Inform end-users: as part of the standards it establishes, the government can create the guidelines for a “cyber dashboard” that informs drivers about how well the vehicle protects drivers’ security and privacy beyond the minimum established standards. As part of its Responsible Disclosure mandates, it can create a list of (significant) components per car and their vulnerabilities.
- e) Have independent parties verify the security: the approach should leverage specialist expertise to conduct security tests to identify and address vulnerabilities in software and firmware, such as through ‘bug bounty’ programs whereby people are incentivized to find and report flaws.

### **13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

#### **Insurance**

13.1 Once autonomous vehicles are widely adopted, the motor insurance industry is likely to shrink—there will be fewer cars on road to insure, fewer of them will be personally owned and more of them will have advanced safety features, so there will be fewer accidents. This means a decrease in the motor insurance market size. More of the business will shift from personal lines to commercial lines, currently about 80/20 and expected to flip to 30/70 by 2040.

13.2 Insurance will focus on covering product liability—the vehicles, rather than the driver, will become the source of the accident—or misuse of data/personal privacy violations. More non-traditional players will seek to enter this market, leveraging their direct relationship with consumers and their advantages in data and analytics. The government will need to set prudential standards for the new entrants.

#### **Regulation**

13.3 One of the key enabling factors for the successful safe adoption of autonomous vehicles in the UK is having a citizenry that is trained and competent in operating such vehicles.

13.4 The current framework to drive a car/motorcycle/heavy goods vehicle is based on individuals passing a one-off theory and practical test set by the DVSA with no subsequent interactions with the government on driving competency unless it is for disciplinary reasons, such as having to take a driver awareness course.

13.5 Therefore, after passing their driving test, individuals can spend a lifetime of driving without receiving any formal training on new technological developments in vehicles that could impact upon driving competency. Even the current system of driver testing does not examine correct use recent technological developments such as automatic braking, assisted parking and lane change assistance, which are commonplace in newer cars.

- 13.6 As autonomous vehicles become more common, even if the practical and theory tests are updated to accommodate the new skills required to operate these for new drivers, there will be large numbers of older drivers who will not have been formally trained to operate autonomous vehicles. Assuming a separate licence to operate autonomous vehicles is not required, this could result in many drivers purchasing and operating autonomous vehicles without having had any formal, dedicated training.
- 13.7 The extent to which this is a road safety risk will depend, in large part, on whether operating autonomous vehicles is fundamentally different to operating non-autonomous vehicles. If there are key differences, and different or additional skills are required, there may be a public safety argument to requiring drivers either to have additional training before they operate an autonomous vehicle or having additional training whenever they have to renew their licence. This additional training could be provided by vehicle manufacturers (as a means of stimulating demand) or by other third parties.
- 13.8 Agencies such as the DVSA and DVLA will need to work closely with autonomous vehicle manufacturers to understand the skills sets required to safely operate them and the most effective touch points to use to reach out to drivers.

### **Legislation**

- 13.9 Laws will need to be enacted to define negligence and determine penalties for cybersecurity and privacy breaches.

## **15. What does the proposed Modern Transport Bill need to deliver?**

- 15.1 A range of issues need to be addressed in any transport bill that covers autonomous driving. These include regulation of data recording, sharing and protection; safety systems; post-crash procedures; liability; education and training; and insurance, among others.
- 15.2 The US is seen to be the furthest ahead in terms of developing automated vehicle legislation. In September 2016, the US Department of Transportation issued comprehensive guidelines for federal policy for automated vehicles.<sup>131</sup> These guidelines establishes expectations of industry by providing detailed performance guidelines that manufacturers, suppliers, and other entities should follow when designing, developing and testing autonomous vehicles, prior to commercial sale or operation on public roads; ensures a consistent national framework that delimits where new issues fit within the existing federal/state structure and provides states with model policy guidelines; reaffirms motor vehicle safety agency's existing regulatory tools and provides instructions, practical guidance, and assistance to entities seeking to employ those tools, and identifies potential new tools, authorities and regulatory structures that expedite deployment of new technologies by enabling the agency to be more nimble and flexible.

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<sup>131</sup> <https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016>

*26 October 2016*

## **Direct Line Group (DLG) – Written evidence (AUV0063)**

### **Introduction**

DLG provides a wide range of general insurance products to consumers through a number of well known brands including Direct Line, Churchill and Privilege. It also provides insurance services for third party brands through its Brand Partners division. In the commercial sector, its NIG and Direct Line for Business operations provide insurance products for businesses.

In addition to insurance, DLG continues to provide support and reassurance to millions of UK motorists through its Green Flag breakdown recovery service.

DLG would be happy to elaborate further on any of the points made in this response and would welcome the opportunity to discuss further with the select committee.

### **Impacts and Benefits**

#### **Question 1    What are the potential applications for autonomous vehicles?**

- 1.1        DLG believes that autonomous vehicles could be deployed in a number of ways to provide benefits to society. Other industries and firms (such as transport operators) would be best placed to specify these in detail but they should improve mobility services, reduce congestion, pollution and provide social and economic benefits. The insurance industry will act as an enabler to the development of these new innovations.

#### **Question 2    What are the potential user benefits and disadvantages from the deployment of autonomous vehicles**

- 2.1        DLG considers the development of automated technologies to be positive, with the aim of dramatically reducing the number of accidents on UK roads. In addition to this, automation will provide much wider societal benefits, not least for cohorts of individuals where mobility is currently restrictive.
- 2.2        From an insurance perspective, whilst it is impossible to judge with any real certainty, DLG anticipates that in the medium to longer term, vehicles with AVT will have fewer accidents than conventional vehicles, which would lead to lower insurance costs. In the intervening period, it is worth noting that there is a distinction between ADAS systems that perform assisted driving functions (such as lane keeping assistance) and safety features (such as AEB) that should be permanently operable (although it is worth noting that these can be switched off by the driver, in some instances.) DLG would anticipate that the latter should reduce the number of accidents, but we will only learn the impacts of the assisted driving functions over a longer time horizon.

- 2.3 As well as the number of accidents, the cost of insurance products will also be determined by the cost of the claims. With the development of vehicle technology, the cost of repairing and replacing parts increases, due to the placement of the hardware (e.g. sensors fitted to the windscreen). On balance, DLG believes that the reduction in the number of accidents will outweigh these increased costs.
- 2.4 There is a clear distinction between ADAS systems, that are intended to ‘assist’ the driver of the vehicle, and full AVT, which will ‘take over’ control of the vehicle from the driver. To an uninformed consumer, this distinction will become less and less clear, with the boundary between the two becoming increasingly blurred as the sophistication of the ADAS systems moves from pre crash assistance (such as AEB) to taking over some of the driving activity (such as lane keeping assistance).
- 2.5 It is crucial, therefore, that consideration is given to consumer education about the capabilities and limitations of the various ADAS systems. Vehicle manufacturers have a very important role to play in this, to ensure that over reliance is not placed on these assistance systems. This ranges from how the vehicles are marketed and sold, through to monitoring use of the systems.

**Question 3 How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

- 3.1 The insurance impacts have been detailed in answer 2 above. DLG has no comment on the impact on other sectors.

**Question 4 How much is known about public attitudes to autonomous vehicles?**

- 4.1 There have been a number of pieces of research conducted that DLG is aware of, but would add caution to any of these findings, not least because autonomous vehicles are not yet available for use on the roads. As with all new technologies, attitudes will vary and alter over time as these technologies become more common place. DLG also believes that the pace of development will be important to developing consumer confidence; regulations need to ensure that these technologies are developed in a robust and controlled fashion. Failure to do this could lead to high profile ‘disaster events’ that could disproportionately impact consumer confidence.

- 4.2 From an insurance perspective, DLG believes that simplicity for the consumer will be key to encouraging adoption. To this end, DLG recommended in its response to the CCAV consultation “Pathway to Driverless Cars” that insurance cover for the autonomy should be considered an extension to motor insurance provision, rather than any requirement for some form of additional products liability cover. In addition, this should provide the same level of cover for injured third parties, no matter whether the car was in manual or autonomous mode. This is because one of the fundamental

principles of Road Traffic Act 1988 (RTA) is that in the event of an accident innocent third parties are compensated speedily, fairly, and, in respect of personal injury, without limits. Product liability law has a number of limitations and defences and so does not provide such wide protection.

- 4.3 DLG firmly believes that the principles of the RTA should equally apply to accidents caused by failure of vehicles in autonomous mode, rather than driver error, in the future; it would be perverse if innocent third parties had different legal rights, depending on whether the driver of the vehicle, or the vehicle itself, was actually in control at the time of the accident.
- 4.4 It is also worth noting that when the vehicle is in fully autonomous mode (meaning the ‘driver’ can completely disengage from the driving task) that the ‘driver’ can then be considered to be a passenger in the event of an accident and be entitled to compensation for any loss or injury. To facilitate this, minimum data standards and access are needed, as detailed in answer 12.

**Question 5 What is the scale of the market opportunity for autonomous vehicles?**

- 5.1 As mentioned above, DLG firmly believes that autonomous vehicles will deliver many long term societal and economic benefits. There will be many factors that will influence the scale and speed of development and adoption, a key one being the realisation of those benefits. The government will also play an important role, ranging from creating a supportive legal and regulatory framework to potentially more direct intervention such as scrappage schemes for older, less safe, vehicles.

**Creating an enabling environment**

*Research and Development*

**Question 6 Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

- 6.1 No comment.

**Question 7 Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

- 7.1 Through Innovate UK, the Government is encouraging and supporting innovative trials and R&D, allowing for the new technologies to be developed and tested in controlled, but real life, environments. At this stage of their development, this is crucial to ensure that the technologies are developed to cope with real life scenarios; this is not something that can be created ‘off road’, for example on a test track.

- 7.2 The challenge will be as the technologies develop over time in the real world, how they will be sufficiently tested before type approval is permitted for each new model. The technologies will be replacing the driver's tasks and it will be impossible to create, and test, each possible scenario that the vehicle may face. The type approval process is going to need to adapt for this change.

**Question 8 How effective are Innovate UK and the CCAV in this area?**

- 8.1 As above.

**Question 9 Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

- 9.1 No comment.

*Real world operation*

**Question 10 Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

- 10.1 It is highly likely that changes to both digital and physical infrastructure will be made alongside the deployment of autonomous vehicles. Some of these changes may be required to facilitate and expedite the deployment, such as Vehicle to Everything (V2X) connectivity. Other changes may be made possible due to the positive impacts of autonomous vehicles, such as road layouts, lane widths, etc.

- 10.2 Innovate UK and CCAV should be ensuring that these impacts are being considered and investigated as part of the programme of tests and initiatives they are supporting.

**Question 11 How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

- 11.1 Whilst the development of technologies to enable more automated driving appear to be moving at pace, it is difficult, if not impossible, to accurately predict exactly how quickly certain technologies will be developed and brought to market. This is partly due to the very different approaches taken by firms developing the technology, with some taking an evolutionary approach and others looking to move straight to fully driverless cars. One of the key needs will be to understand the impacts that each of these technologies has, particularly on safety and crash rates.

- 11.2 Regulation needs to be an enabler rather than a barrier to this development, but at the same time needs to ensure it is conducted in a robust and controlled fashion. CCAV's proposals to amend regulation on a step by step

basis means that the regulatory landscape can adapt and develop alongside the technological landscape, helping to make this balance achievable.

- 11.3 It is important that manufacturers of vehicles with AVT are held accountable when they fail, not least to ensure that they develop the technologies safely, with robust testing, before releasing them into the market. It is also important that manufacturers have a financial interest, as well as a moral one, to conduct product recalls where a potential system failure is identified.

**Question 12 Does the Government have an effective approach on data and cybersecurity in this sector?**

- 12.1 There must be an agreed standard for the data recording, storage and access in all vehicles with AVT. These data standards are imperative for insurers to be able to insure vehicles with AVT. Any compensation for the ‘driver’ of the vehicle will be dependent on the ability to establish that the car was in autonomous mode at the time of the accident. At a high level DLG believes that there are two broad requirements:
- 1) A minimum standard for the type of data that the on board Event Data Recorders should hold and for how long.
  - 2) Unbiased and easily obtainable access to that data in the event of an accident in a readable format.

- 12.2 Furthermore, insurers will need to be able to identify, at a vehicle level, those that have AVT capability in advance, to ensure that sufficient cover is provided by the motor insurance policy. Without the ability to do this, consumers will not have confidence that they have the cover they need, and will be required by law to hold, under the terms of the Road Traffic Act.

**Question 13 Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

- 13.1 DLG agrees with CCAV’s proposal to extend the requirements of the RTA to make liability insurance compulsory for failure of the AVT systems, but thinks this should be considered an extension to the motor liability cover, rather than an additional requirement for product liability cover.
- 13.2 There are distinct differences between motor liability law and product liability law and to ensure that innocent victims of accidents are compensated equally, depending on whether a human or the AVT was in control of the vehicle, no such distinctions should be made (for the purposes of compensation).
- 13.3 With motor insurers ‘standing’ in place of the at fault AVT system in the first instance, it is critical that there will be statutory rights of recovery from

vehicle manufacturers so that they can be held accountable for the failure of their products. Where it can be shown that the vehicle was in autonomous mode at the time of an accident, a presumption of liability should sit with the manufacturer on a ‘rebuttal presumption’ basis.

- 13.4 From a liability perspective, it is also crucial to be able to quickly establish whether it was the driver or the AVT that was at fault at the time of an accident. This is to ensure that the driver can be treated as an innocent victim, and adequately compensated where a failure of the AVT was the cause of the accident.

**Question 14 What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

- 14.1 No comment.

*Wider governance*

**Question 15 What does the proposed Modern Transport Bill need to deliver?**

- 15.1 Under the current legal framework, recovery of costs paid out by the motor insurer to a consumer is likely to be very complex for a number of reasons. First, as cars age, it could be very difficult to ascertain who the ‘at fault’ third party is for any product failure; it wouldn’t necessarily be the manufacturer, particularly if the car has been serviced, repaired, altered or calibrated by one, or more, other firms (such as a motor trader). Furthermore, establishing precedent through case law could be challenging in an environment where the pace of change is expected to be quick, potentially rendering such precedent obsolete in a short space of time, meaning claims in tort could prove difficult and create uncertainty. The current limitations under the Consumer Protection Act for non-consumers also mean that a claim brought under that statute could be equally difficult. Insurers will require new direct statutory rights of recovery from manufacturers, once they have settled a consumer’s claim. In addition, DLG considers there ought to be a sufficiently long enough stop limitation period, to allow for the reasonable life span of the vehicle with AVT, to protect the used vehicle market.

- 15.2 There must also be a clearly defined and agreed set of minimum standards for data quality and access, enforceable by statute. Without this, there is a very real risk that when the ‘driver’ is an innocent victim, they may not receive compensation that they should be entitled to because they will not be able to prove, on the balance of probabilities, that the car was in autonomous mode at the material time.

**Question 16 How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?**

16.1 No comment.

**Question 17** **Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

17.1 No comment.

**Question 18** **What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

18.1 No comment.

*26 October 2016*

## Enders Analysis – Written evidence (AUV0085)

*Enders Analysis is an independent research group focusing on Technology, Media and Telecommunications sectors*

### Impacts and benefits

#### 1. What are the potential applications for autonomous vehicles?

Autonomous vehicles (henceforth referred to as AVs), have the potential to drive innovations in numerous sectors aside from transportation, including media and telecoms. We believe the most immediate applications of AVs will be commercial for numerous reasons. Primarily, the cost of the components to build one of these vehicles, though declining, is still high, and therefore a barrier to most consumers. Equally, commercial ventures can exploit the novelty of the technology to build consumer trust, and demonstrate that these vehicles are both safe and easy to use.

We think ridesharing will be the most immediate application of AV software that the general public will access. Rising giants, like Uber (and recently Tesla), see the market opportunity offered by AVs. Autonomy will enable them to offer more competitive pricing as the cost of human labour will be removed. Equally, AV technologies will not be limited to cars, and general consensus is that self-driving automation will come quickest to commercial applications such as truck platooning and final mile transfer (e.g. drone deliveries as piloted in the UK by Amazon). At some point private AV ownership will become more commonplace, but in the near future this will be targeted at premium models, such as Tesla vehicles, and perhaps next it will be extended to target those with mobility difficulties.

#### 2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

There are a range of benefits offered by AVs: from increased mobility to lower carbon emissions; but equally a range of disadvantages: from cyber security to job losses from automation.

#### Advantages

In 2015, the average person in the UK spent 368 hours travelling: 83% of this time in cars, vans and taxis. AVs will be more convenient than a personal commute in a car. As 95% of car accidents are due to human error, we believe that AVs will be safer than vehicles with a driver, whether passenger cars or HGVs. But safety is still a wider concern, and as such is also a disadvantage.

For the elderly and disabled, AVs would increase their mobility; in the UK 15 million people are over 60, and 12% of the population have a mobility difficulty. In our work we argue that the over 50s are more readily adopting new technology than any generation of over 50s

before them. This could make them a key target market for privately owned AVs, especially as people live longer and move out of urban areas.

There are environmental benefits of moving towards autonomy, which are explicable to users as a whole group. In terms of urban planning, when combined with ride sharing, much better land use could be achieved, with less need for parking spaces in city centres. Electric vehicles are better suited to autonomy than combustion engines, and many manufacturers are integrating autonomy into their electric vehicles, most notably Tesla. A study by Berkley labs in 2015 argued that a fleet of driverless taxis would greatly reduce per mile emissions of greenhouse gases (GHG). However, AVs are not required to be electric, and this is another barrier in terms of higher cost.

#### *Disadvantages*

Public safety remains the biggest barrier to adoption. These vehicles require appropriate and considerate safety, security and privacy testing to be conducted by a third-party, independent of the developer. Cyber security is a clear concern, cars are just as vulnerable as laptops to hackers. The ‘trolley problem’, an example of an ethical dilemma, is frequently cited in the case of how an autonomous vehicle would choose to make difficult ethical choices. Understandably, this is a minefield that AV developers so far have been avoiding, insisting that it is far more important to maximise AVs safety than attempting to overcome a range of hypothetical ethical situations that will rarely occur.

Automation will likely lead to the loss of many jobs in the transportation sector, notably in low-wage positions such as taxi and bus drivers. Reskilling this part of the workforce must be a priority in the near future.

Public perception represents that final hurdle and tech companies may be in danger of underestimating the slowness of consumers to embrace new technology in the auto industry, just look at the long adoption of hybrid cars.

In balance, we think that once the technology has been developed to ensure total safety that the social and environmental benefits massively outweigh the disadvantages.

#### *3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?*

Our research primarily covers TMT, advertising and e-commerce industries. However, in the context of AVs, we believe that AVs will cause significant disruption in the automobile industry. Traditional car manufacturers face two existential threats: that transportation as a service (ridesharing, ect.) will replace traditional models of ownership, especially among urban dwellers. And the rising capex and opex costs on tech, from in-house software to bought-in sensor and mapping systems (e.g. Google maps).

We forecast growth for both media and advertising sectors. Passengers in autonomous cars will likely spend more time interacting with media services, therefore increasing the time they consume content including advertising. As AVs are ‘connected’ to GPS and the internet

in order to operate, location data can be used for advertising in the same was as it is for mobile phones, to connect targeted ads to the consumer. In this case this is a captive and affluent audience. Tech giant Google's venture in AVs make sense in this context; their understanding of consumers' habits and attitudes enables them to target their advertising to deliver timely, localised and personalised ads. This results in an overall higher revenue per ad for all parties involved.

As detailed in response to other questions, mass adoption of AVs will affect multiple sectors as transportation is such a fundamental sector. For example, the nightlife industry could benefit: a customer drives to the pub and their car drives them home, or they use increasingly competitively priced ridesharing services. For the media industry, less time focusing on the road opens up more time to watch TV or smartphone browsing, which also benefitting telecoms. The list is extensive and the potential for other sector growth is massive and beyond a scope we could possibly forecast.

#### *5. What is the scale of the market opportunity for autonomous vehicles?*

We break the traditional car manufacturers into two broad groups: premium and mass market. We believe that on the whole, car ownership will decline when fully AV cars have rolled out, and that mass market car makers will see a sharper fall in total sales, whilst premium carmakers will see an increase. This is as premium carmakers can continue to trade on their brand strength and have the potential to dominate models used for premium ride-sharing services.

Car brands also face the threat currently posed by 'tech' giants including Google and Uber. Whilst partnerships are forming, the issue that arises is a question of who gets access to the data and intellectual property generated by pilots. Companies like Ford and BMW, by developing their own automation systems, will maintain control. Similarly, BMW, Mercedes and VW banding together also gives them control, and in the long term could protect themselves from losing business to Google and Uber. The reality facing most carmakers is that autonomous technology adoption is vital for their long term survival.

It is key to note that the fortunes of Google and Uber are likely to be dependent on very different factors to that of Apple and Tesla. The former will target mass-market ride sharing and transportation as a service. Whilst Apple and Tesla, who rely on the strength of their brand and products, are more likely to target the premium market where car ownership is still valued for reasons of status and performance. We believe that the auto industry, despite attempts to dictate terms of change, will lose out as start-ups and tech giant's capture an increasing share of the market.

#### **Creating an enabling environment**

#### *10. Will the successful deployment of autonomous vehicles require changes to digital or physical infrastructure?*

Yes. For AVs to operate, especially for ridesharing, software, and the infrastructure that supports it, is vital and more important than hardware. At present 4G is not fast enough to

support full automation, but 5G is expected to resolve this issue. Therefore the digital and physical infrastructure to roll-out 5G is necessary, especially with an increasing number of AVs expected on the roads.

In terms of the current climate in the UK, the DoT's current 'step by step' approach to regulatory reform at present does not enable testing of level 4 (fully autonomous) AVs; this needs to be amended as this is a clear requirement to ensure that safety standards can be developed. The more 'autonomously driven' miles that are accrued for both level 3 (partially) and level 4 (fully) AVs, the safer they will become. Only with real road experience can AV developers refine their software to be ready for what might happen on the road.

*Due to the nature of our research into specific applications of autonomous technologies, mostly in relation to their relevance for the media sector, we have not provided answers to questions 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18.*

2 November 2016

ERTICO – ITS Europe (Intelligent Transport Systems), Society of Motor Manufacturers and Traders (SMMT) and European Commission – Oral evidence (QQ 20-30)

**ERTICO – ITS Europe (Intelligent Transport Systems), Society of Motor Manufacturers and Traders (SMMT) and European Commission – Oral evidence (QQ 20-30)**

[Transcript to be found under the European Commission](#)

**European Commission, ERTICO – ITS Europe (Intelligent Transport Systems) and Society of Motor Manufacturers and Traders (SMMT) – Oral evidence (QQ 20-30)**

Tuesday 8 November 2016

[Watch the meeting](#)

Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Fox; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Morgan of Huyton; Baroness Neville-Jones; Lord Oxburgh; Viscount Ridley; Lord Vallance of Tummel; and Baroness Young of Old Sccone.

Evidence Session No. 3

Heard in Public

Questions 20 - 30

**Examination of witnesses**

Claire Depré, Head of Sustainable and Intelligent Transport Unit, DG MOVE, European Commission; Dr Hermann Meyer, Chief Executive Officer, ERTICO - ITS Europe (Intelligent Transport Systems); and Mike Hawes, Chief Executive Officer, Society of Motor Manufacturers and Traders (SMMT).

**Q20 The Chairman:** Good morning. Could I, on behalf of the Committee, welcome our witnesses today? We are most grateful to you for joining us. We are being broadcast, so I am going to ask you if you would like first formally to introduce yourselves for the record and, if you would like to make any opening statement as you do so, please feel free to do so. Shall we start with Clare Depré?

**Claire Depré:** Good morning. My name is Claire Depré. I work for the European Commission in the directorate-general which is in charge of mobility and transport, so the explanation I will be giving over the session today will be very focused on the benefits that we can see from these technologies, connectivity and automation, for the transport system.

**The Chairman:** And Dr Hermann Meyer?

**Dr Hermann Meyer:** Thank you, Chairman, ladies and gentlemen. I am very honoured to be here on behalf of the ERTICO-ITS Europe Partnership. My name is Hermann Meyer. The ITS Europe Partnership has a mission to bring all the stakeholders together that are important to developing intelligent transport systems in Europe. We focus mainly in our work on interoperability so that the driver, the customer, the traveller has a seamless experience of services in Europe and that there are economies of scale. We also deal with issues concerning a common

European regulatory framework so that member states do not have very different political and regulatory frameworks but one common market. We also deal with the co-operation of the necessary stakeholders because, when you look at intelligent transport systems, it is about collecting data, exchanging data and bringing the services to the users, and they are quite complex value chains. We also create within our partnership business models so that the stakeholders can sufficiently, effectively and appropriately provide the services for the customers.

In the context of today's committee meeting, for us, most important is an understanding that connected and automated vehicles can provide their full potential only if they are also seen in the context of other trends which we currently observe, such as, for instance, mobility as a service, which we believe is very important and has to be seen also in this context, and, the electrification of vehicles.

**The Chairman:** Thank you very much. Mr Hawes?

**Mike Hawes:** Thank you, my Lord Chairman. I am Mike Hawes, chief executive of the Society of Motor Manufacturers and Traders. We represent the automotive industry in the UK, which is vehicle manufacturers and is also the supply chain and after-market, not just in terms of passenger cars but buses, trucks, taxis, coaches, trailers; the whole gamut. This is an issue which affects all of them to a greater or lesser extent immediately, but certainly we see the opportunities for the industry, and indeed the industry in the UK, as significant, so it is important that we work with the Government and other stakeholders to grasp that opportunity for the benefit of all.

**The Chairman:** Thank you very much and thank you for your written evidence, which we read with great interest. There may be some specific questions to you on that which we want to come back to.

First, perhaps I could ask all three: we have the opportunity here to look at this at the European level. Perhaps you would explain how you think your own organisation contributes to the regulation and standardisation and how it can contribute effectively to the clear requirements. What is it that you can deliver which cannot be done at an individual member state level?

**Claire Depré:** If there is one topic where we should really avoid confrontation between what is happening at the national, local or European level, it is precisely this one. What we do in DG MOVE is try to foster co-operation, and I think the key word in this respect is "co-operation". Why so? Because, of course, the area we are talking about is also about regulation, but regulation should be when we are able to register all together some shared vision that we will have been able to develop all together.

In my department, we have started working on a co-operative system, which are technologies that enable communication between vehicles and between vehicles and infrastructure where, for a long time, a lot of investment has taken place in the research area, but there was a problem of chicken and egg: who would start with the investment and what would be the benefit? Late in November 2014, we started working extremely hard to try and develop, together with the industry, with local authorities, with member states and between the different Commission departments, a shared vision on this co-operative system. The same is being

developed now for automation with our colleagues from DG GROW who are in charge of the industry and the vehicle-type approval for automated vehicles.

What we hope to manage is, first, making sure that the introduction of these new technologies supports benefits for our transport system. We all know how many externalities we have in terms of daily congestion, the road safety aspects and pollution, the emissions, so we are trying to develop a shared vision on a conversion between these two different technologies, the co-operative system and automation, and making sure that, hopefully, in one decade, we do not see these elements as very different from each other, but that altogether they can bring benefit for our transport.

**The Chairman:** Dr Meyer, would you like to add anything?

**Dr Hermann Meyer:** First, vehicles and people cross borders and they expect to have a seamless experience in driving their vehicles and in travelling. With respect to automated vehicles, there are technical complexities, organisational complexities and regulations. Our aim is to achieve one market, which means that we establish interoperability of the technologies, which means, for instance, in the context of connectivity, that we have a situation where the technologies on board the vehicles in Germany, Belgium and the UK are interoperable and can provide the same communication values.

**Mike Hawes:** From the UK perspective, we must appreciate that the UK automotive industry operates globally, but is totally integrated into a European automotive sector. The issues that arise from this shift to connected and autonomous vehicles are international. The issue of interoperability is valid and significant for a number of reasons, certainly in terms of functionality, as you want the vehicles to be able to operate, and in terms of the consumer and their level of expectation around mobility, that they can take their car and travel anywhere without much hindrance. That is something we need to assure for the future, and the role of the SMMT is to try to ensure that the UK interests would obviously be represented, but there is a national interest here. The role of the SMMT is in trying to promote the UK industry and see it grow. This is a massive opportunity for growth, which I am sure we will come to, and it is important that the UK has, within its gift of a national framework, the ability to see these technologies flourish for the benefit of transport, the industry, the consumer and society. One of the roles we try to play is in bringing together the parties that would be involved, but certainly we have to recognise, given the significant investment that is required to develop these technologies, that it is a European, if not an international, agenda and the UK must play its part in that.

**The Chairman:** If I could ask you specifically about your links with other parts of the world as well as Europe, it is clearly important in the markets in which you are selling, the rest of the world as well as Europe and, indeed, for people selling into this country, that we have sufficient connectivity with other areas. Are you persuaded that there is indeed the proper amount of liaison and collaboration between European countries and other manufacturers around the world?

**Mike Hawes:** I think there is because, as I said, the industry is international and American companies operate in Europe and European companies in America, for

instance, and yes, there will be the development of national frameworks within those large markets, with the European market as one. Invariably, there are going to be some disrupters coming into this industry, and they may originate in the States, in China or in Japan, so it is certainly beholden on the industry to be cognisant of those developments internationally. Certainly, everyone is conscious of the need to try to make sure that they are alert to those developments because they may be opportunities for collaboration or they may be competitive issues, but certainly you need to be aware of them.

The challenge, I think, for the UK in particular is ensuring that we can facilitate the development of these technologies here in the UK, so it is not just contributing to a global development of them but to what extent we can grasp that opportunity for the UK. Every member state has an ambition to be a testbed for some of these technologies, so the UK would not be alone in that. We have certain advantages, which I am sure other witnesses have alluded to thus far, but again there are challenges and it is about bringing together the wider stakeholders to ensure that we grasp those challenges.

- Q21** **Lord Hunt of Chesterton:** I wonder whether you would like to outline the key benefits of automated vehicles. In doing so, I wonder if you could just clarify, because it is still not clear to me, whether the automation involves vehicles, as it were, electronically talking to other vehicles—the radar, as it were? I am very concerned about being able to tell that a car is coming around a bend in a leafy lane in Devon, where my daughter had a crash, and would that not happen in the future? The other thing is pollution. Will pollution and safety generally be improved by these kinds of automation?

**Mike Hawes:** You have raised a number of issues. The benefits are myriad, certainly in terms of improving safety. The thing to remember with the development is that it is increasingly autonomous vehicles. It will not be that we go from what we have today and then, in five years' time, it is fully autonomous vehicles; this is a step-by-step development. In terms of the shape of the technology, you are seeing increasing safety measures and equipment put on to vehicles, such as autonomous emergency braking, Lane-Keeper Assist and so forth, which are not autonomous but the vehicle tends to be independent. What you will see is vehicles being connected to other vehicles and to infrastructure facilitating those safety aspects. We are already seeing some trials of platooning of HGVs. We firmly believe that HGVs may be one of the first elements of road transport that will take advantage of some of these technologies because, clearly, if you are a road haulage operator, you are very interested in what your pence per mile rate is. If you can have a benefit in fuel economy by platooning, which also has an environmental benefit, clearly that will come through as well. There are other aspects, such as safety, environment and congestion, to a certain extent, because you can maximise the capacity on the existing road network by having vehicles potentially travelling closer together. One thing we need to look at is that famous two-second rule as an appropriate distance between vehicles. If the vehicles are connected to one another, you can potentially move them closer and get greater capacity within an existing network.

Without a doubt, there are also social benefits to be achieved by much safer vehicles and, potentially, an industrial benefit. We did some work with KPMG last year which put that benefit to the UK economy at £51 billion to GDP per annum. Only about £1 billion to £2 billion of that will naturally accrue to the automotive sector and the other £49 billion is up for grabs, given the potential monetisation of connected vehicles, data and issues such as that.

**Lord Borwick:** On the interface between fully autonomous vehicles and not the least bit autonomous, there seems to be confusion. Do you know of any simulations that have been done of integrating autonomous vehicles with normal vehicles, and do you think that the market will develop in the same way it has now, where the European market is dominated by the very large companies and the very small producers—the 1,000 to 10,000 vehicles a year—are a pretty small percentage of the total? Do you think that will change in the next 20 years as autonomous vehicles develop?

**Dr Hermann Meyer:** As an organisation, we have not done the simulation ourselves concerning the situation where you have autonomous vehicles and still conventional vehicles or only highly automated vehicles. Such simulations exist and it looks like it is possible to have this mixed situation. Nevertheless, for automation, this poses some challenges, more challenges than when you have only automated vehicles. First, we will need the different steps towards fully automated vehicles and, with fully automated vehicles, you will have a game changer, the reason being that you can then bring into the game issues, such as mobility as a service. Because you have a situation where you do not have a driver anymore, with mobility as a service, you will be able to call your vehicle, the vehicle comes and picks you up, there is no driver, and it brings you to your place. We will also then see that the differentiation between individual transport and public transport might even almost disappear. Then, I believe there may be new players coming into the market because we see very important developments from the vehicle industry side. We have in Europe, and you have in the UK, very strong companies which will prepare for this new era of automated vehicles. They have all the technologies necessary and they are further strengthening to develop these technologies, and they are companies which come from the data side, so more from the service-oriented side. What we will see is the two sides merging, and I believe that new companies and new opportunities will come up, so we cannot see the automated vehicle in isolation and we have to see it in a broader context.

**Claire Depré:** If we are looking at the trends in usage of cars today, these have nothing to do with what at least my parents were experiencing. In terms of market developments, I would be happy to have a crystal ball to know. I think we are all in the same situation where we see that transport is getting completely transformed on an evolutionary path—not a revolution—but at the same time let us not forget that cities, which face congestion today and have problems with emissions, will still look at these new technologies for what they can bring to their own agenda. It means that, if you replace a dirty and unintelligent car with a clean, smarter car, it is still one car. There are a lot of promises that this new technology brings, which need also to be seen in relation to flanking measures where we will be able to continue

managing traffic, organise how we want to provide mobility for the end user and how we manage flows of people and goods.

I come back to my first statement: co-operation. If we leave the industry alone, it will probably make the most beautiful product, but it needs to fit into one reality, and the more we are able to discuss, understand and see what the expectations are from both sides, the better we are able to provide something useful in the end in real life.

**Mike Hawes:** The idea of this mix between fully autonomous and non-autonomous will be there for many years. There is still, as I am pleased to reaffirm, a huge swathe of the population who like driving. Now, that may change in a number of years, but you also have a lot of companies, and the UK has more than most—McLaren, Aston Martin, Morgan, Bentley, Rolls-Royce—whose cars you buy to drive. The idea of an autonomous McLaren might be entertaining as a passenger, but you are not seeing its full functionality, so I think there will always be that degree of mix. Certainly, I think the industry is acutely conscious that there is that potential for disrupters, and the lessons from other industrial sectors are salutary about any industry that ignores the potential for disrupters coming in and completely changing the game.

**Lord Borwick:** With that mixed economy, which one should be immediately identifiable, the autonomous vehicle or the non-autonomous vehicle? At the moment, an autonomous vehicle has a lot of things on the top with cameras, but they may well be hidden, rather more like a Tesla is.

**Mike Hawes:** I do not think we should be seeing them as two distinct sets because there is this evolution and, even with a high-performance sports car, the introduction of more connected technology will add additional safety features and they will be embraced as rapidly in that sort of company as they will in a mainstream volume manufacturer. There are still undoubted social and economic benefits that will accrue, but the challenge for the industry is to manage that shift, recognising that there will always be that mix on the road for many years.

**Dr Hermann Meyer:** Can I add to this because you are touching on a very important point? There are different approaches that can be taken. First, should you be able to spot already if there is a fully automated vehicle? Yes, it might be necessary because of the interaction between the people who are in the car and the pedestrian where maybe the pedestrian thinks it is a driver. There is today already an exchange: you look at each other and you think you understand each other. If now this is an automated vehicle, I think we need a new approach to this.

Secondly, in the context of mixed traffic, we have to think about the transition period and the strategy for the transition period. What is our road map? How do we introduce automated vehicles? Do we need, at the beginning maybe, a dedicated infrastructure? If we use a dedicated infrastructure, how do we organise it, because we might not want to increase the complexity of traffic? There are many political issues which have to be tackled in this context.

- Q22 Lord Oxburgh:** You emphasised the importance of viewing autonomous vehicles in the broader context. If one leaves the new technology for a moment, what are the implications of autonomous vehicles for road maintenance, for example, which is a

very old technology? All parts of the world have holes in the roads and inadequacies of that sort which are not repaired in a timely way. What are the implications here?

**Dr Hermann Meyer:** First, there is a very positive one because, when we talk about automated vehicles, we talk in general also about connected automated vehicles. When you have a connected automated vehicle, the vehicle itself can spot on the road surface if there is a hole or anything which needs maintenance. In the future, when these connected automated vehicles are also linked to the road infrastructure operator, the road infrastructure operator can immediately be informed about the situation of the road surface and can intervene, so you also have these benefits. Also, when we talk about connected automated vehicles, I would put a lot of emphasis on the need also to link these vehicles with the traffic management centres because then you can improve traffic management as a whole, so there are benefits on both sides here—for the traffic management centre in organising the traffic and for the individual vehicle because the vehicle can be routed in a more optimised way.

**Lord Oxburgh:** This is all very well for major routes. I have no idea what the actual number is, but maybe three-quarters of our roads are smaller and not part of this, and maintaining them is quite a challenge.

**Dr Hermann Meyer:** There is one challenge which also has to be taken into account: when you have automated vehicles, there are also some demands concerning the infrastructure, the lining, et cetera, so that you have a safe situation, and that then incurs some investment which is necessary, which can be especially challenging on some rural roads.

**Lord Oxburgh:** But there may be roads which autonomous vehicles cannot use.

**Dr Hermann Meyer:** At the beginning, in the introduction scenario, there will be situations where you have certain roads where you can have automation and certain roads where, at the beginning, it will not be possible.

**Baroness Neville-Jones:** I am prompted by the statements that you thought there would be a declining difference between public and private transport, which implies—tell me if I am wrong—that you envisage a marked reduction in private ownership of vehicles and that it will become a service where a company will supply you with a vehicle when you want to go from A to B. Is that the case and would the fact that you do not have to own a vehicle to have the convenience of transport be a driver of take-up?

**Dr Hermann Meyer:** Owning or not owning a vehicle, the people will decide and we do not know yet, but we are certainly moving towards a service-oriented society. When you look at the future of automated vehicles, there will be service providers who own these automated vehicles and then the people can take the service of using these automated vehicles. That might also have an impact on the situation concerning car ownership. I think we have to be realistic with respect to fully automated vehicles. There are different levels which are defined for the automation of vehicles and, when we talk about the last level of automation, level 5, where you do not have a steering wheel anymore, that is far in the future and then we might also have these possibilities concerning these services.

**Claire Depré:** We have been working quite a lot on these connectivity and co-operation aspects. In the next few weeks, The Commission will be issuing a European strategy for the deployment of these technologies. We are aiming, and not because the Commission is but because the whole community is, at seeing this technology deployed in 2019, which means that vehicle manufacturers are working on that baseline scenario, and I want to link it to the benefit of automation, where this connectivity element is essential. As humans, we are not relying on only one sensor, our eyes, but we have a mouth, ears, and that is the same for a car. If we have only sensors in an automated vehicle, but we are not able to hear what is happening beyond what the eyes can see, that is a perfect recipe for accidents.

To come back to collective transport versus individual transport, if we are not able to include public transport and have public transport benefit from these technologies, again that is the perfect recipe for disaster. Of course, as I said at the beginning, we are working with local authorities and with the European Association of Public Transport. They need to make use of these technologies. This is how you make priority lanes more efficient in a way and it is how you make sure that you are providing mobility for elderly people. We all know that, when these technologies are introduced, they will be more expensive, so we need to think about getting the benefit for society as a whole.

**Mike Hawes:** I would add a quick supplementary to that where there is a UK benefit. If you look at London in particular, obviously you have Transport for London, a single authority which oversees the public transport. If you look at, in particular, the bus industry, public buses tend to be UK-developed and UK-built, so they certainly are alert to this. When you have the scale of a city such as London and the opportunity for UK companies—Alexander Dennis, Wrightbus, Optare, whoever—who build their buses in the UK, they will be working with the likes of Transport for London to take advantage of these technologies as they develop.

**The Chairman:** We are half way through the session and I am afraid we are by no means half way through all the questions we want to ask you. I will ask Lord Fox, Lord Hennessy and Lord Vallance to come in briefly, but then we must get on to Lord Ridley.

- Q23** **Lord Fox:** It seems to me that, if we were in 1903, from what you are describing, we would have to wait for the invention and the introduction of cats' eyes before we could implement any cars at all. In other words, you are trying to build the end infrastructure before these things come in. I understand the point about an open language, which obviously counts for other things as well. It seems to me that pushing the onus back on the manufacturers and saying, "Here is our definition of what is safe operation. You then deliver that safe operation", rather than, in a sense, trying to invent the infrastructure in advance of the population of that with vehicles, might be another way of looking at this regulatory challenge.

**Claire Depré:** When I look at this co-operative system, again I had a lot of questions in the beginning: is it thinking about regulating and equipping infrastructure every how many miles or kilometres? We have been doing work together and we are trying to progress together in trying to find a solution in terms of how we implement

data protection and what the expectation will be in terms of how we can address security and how we enter into interoperability. There will be a lot of different elements. Of course, the driver experience is important.

**Lord Fox:** I think that is the point I am making. You are trying to second-guess every single possibility of everything before anything can happen.

**Claire Depré:** No, on the contrary. Indeed, as I mentioned, with the co-operative system, when I started three years ago, there was no light at the end of the tunnel. Eric Sampson has been working with us. We have dedicated a year of I do not know how many meetings to progress on the same path. The same should happen for automation. The point is, and on this I insist, that we need to be able to think about how we want this system to be deployed. If I make the comparison with the co-operative system, we have tried to understand what kind of services we want out of these technologies. Of course, they can provide a lot of driver comfort, but is it the role of a public authority to look for driver comfort? My role is that we introduce this vehicle and I hope we can make our road safety figures better and our role is that we do not bring in more congestion and that we try to address it, so there is a lot of work in, first, understanding each other, believe me. We are using automation, but do we understand automation in the same way? With services, and I am talking about roadworks, if I talk to an Austrian colleague or a French colleague, the understanding is not the same, so a lot is about understanding the semantics in the first place and then trying to move together towards this shared vision and moving step by step, because it will not happen from one day to another.

**Dr Hermann Meyer:** What you are saying is, “Do you try to second-guess everything that could happen?” Yes, the industry does because the most important thing is safety, safety, safety when we have automated vehicles. Therefore, in Europe, in the US, in Japan, South Korea and China, there are test-beds. We need these test-beds and to test the systems in all different situations, and we are learning enormously because we have machine-learning capabilities—the vehicles themselves learn in these situations—and we want to ensure safety. Therefore, for instance, the connectivity is important because it gives you additional redundancy concerning the systems if the sensors do not work, but an automated vehicle at the beginning also has to be able to work properly without connectivity because we cannot rely on it, so we are second-guessing everything.

**Lord Hennessy of Nympsfield:** You referred twice to potential disrupters. What did you have in mind?

**Mike Hawes:** We would not have full sight of any potential disrupter, but we see other companies looking to develop autonomous vehicles—the likes of Google, Apple and so forth. There may be others that we are not aware of, but equally the industry recognises these challenges and develops the technologies. With the different offerings in mobility, safety, connectivity and autonomous, that whole suite of technological change, which is hugely complicated and, as a consequence, usually expensive, it means that you are seeing a lot of collaboration equally going on across manufacturers.

**Q24 Lord Vallance of Tummel:** Connectivity will depend in the end on the

telecommunications infrastructure one way or another. We understand some of it, the satnav stuff is pretty obvious, but vehicle-to-vehicle and vehicle-to-infrastructure and so on is a different matter. You will need international standards on this to get it off the ground at all. Is there any agreement yet as to what kind of technology will be used, other than the satnav, who is driving it and how will the international standards be achieved?

**Dr Hermann Meyer:** There is tremendous work on this concerning vehicle-to-vehicle, vehicle-to-infrastructure and communications. There is already one technology, ITS-G5, which is very mature. There was work done in ETSI, CEN and ISO on this technology, which are foreseen to be used in Europe, the US and other countries. There are also technologies with respect to cellular communication where e.g. LTE-V is now in the last stages of standardisation and they could provide the technology for vehicle-to-vehicle and vehicle-to-infrastructure communication, but some work still has to be done. Then, we are all looking forward to 5G, which is the next step concerning cellular communication. Currently, we have 4G and, with 5G, we will see the latency and the robustness of the communication further improve, security improve and, with the network slicing, we will see that there will also be new opportunities concerning the business models.

For the vehicle industry in the context of network neutrality, it is also important that we have different levels of quality of service. If there is communication in the context of a critical safety item, we need priority for it, so it is also important in the context of the debate on network neutrality that we take the quality of service and the different levels of the quality of service into consideration.

- Q25 Viscount Ridley:** I want to try to pin one of you down on the timescale of how long it will be before this comes in. I understand that it is evolutionary and not revolutionary, as Ms Depré said, and I understand that there are five different levels of automation. None the less, there will be milestones and I would like you to give me a date for one of these milestones. For example, when will Dr Meyer first step into a car that has no driver to take him on an ordinary road, maybe not on every road, to a destination? Is it 2019?

**Claire Depré:** 2019 for the co-operative system, which means information that is being provided to the driver, and always the driver, in front of the wheel.

**Viscount Ridley:** When will it first happen?

**Dr Hermann Meyer:** There are 120 partners who have different views on this topic, so I will give you my personal view. Highly automated driving already means a lot; it means already that, in certain situations, you do not have to care about your driving, so highly automated driving provides already a big step. Highly automated driving, I think, we will see between 2020 and 2025.

**Viscount Ridley:** In that period, I will be able to read my emails while on the motorway?

**Dr Hermann Meyer:** Yes. I cannot speak for all motorways and I do not know the UK motorways, but I am very optimistic that, on a motorway with a “highway chauffeur”, which it is called, you will see it between 2020 and 2025.

**Mike Hawes:** I would endorse that. For the fully automated, L5, it is looking more like 2030. That is the no steering wheel model.

**The Chairman:** That is level 5 you are talking about?

**Mike Hawes:** Yes.

**Lord Hunt of Chesterton:** German motorways have an autobahnkapelle, a church for road drivers.

**Mike Hawes:** Certainly, there are three or four major manufacturers which have said that they will be introducing the level 4 technologies in early 2021 and so forth.

These will be very limited numbers to start with, so there is that question. Yes, technically, those cars are available, but they are not necessarily in widespread use.

- Q26** **Baroness Young of Old Scone:** This is a question that perhaps should have been raised in the previous one, but it is to Mr Hawes about the report that you commissioned from KPMG on the benefits, talking about the up to 320,000 new jobs being created in the UK. I was rather mystified by that and I could not find any of the background figuring out in the report. If we are talking about this as being an efficiency measure and a productivity measure, one would imagine that there must also be efficiencies and reductions in jobs as a result of automating many of these processes, so I was not quite sure how you could say that there was a net gain in jobs of that scale.

**Mike Hawes:** We need to distinguish between autonomous vehicles and connected vehicles. The growth opportunity is about the connectivity. I go back to that figure we said in terms of the potential benefits to GDP and the monetisation of that. The largest swathe of that benefit comes from the connected vehicle. The autonomous vehicle is about efficiency and productivity and there are potential benefits to that, but in terms of jobs, with any new technology, invariably there is a shift in the types of jobs and skills that are required. I know that SECAB have produced a report recently on the level of skills that are needed to facilitate this transition, and we have, as you might expect, a big skills gap in that area, but we see this development of the connected vehicle and all the data that it will generate, which is of huge interest to other sectors of the economy, creating jobs in that regard rather than specifically in the automotive sector or the public transport sector.

**Baroness Young of Old Scone:** So your figures were of gross increases in sectors as a whole?

**Mike Hawes:** Correct.

**Baroness Young of Old Scone:** But they did not take account of any of the reductions as a result of the productivity factor?

**Mike Hawes:** I think to a degree. The question about productivity does not necessarily mean job cuts. Certainly, in terms of increasing productivity, it means you can increase your capacity and, as long as there is a market for whatever you are producing, you can see that develop. That is a much harder thing to forecast. Productivity, in essence, is a good thing because you can do things potentially more cheaply, but that can allow you to do other things with those resources.

**Claire Depré:** These are important elements because, of course, new opportunities for new jobs mean also, in some cases, the reduction of jobs, so that dialogue with the social partner is crucial also. The truck- driving sector and taxis will be impacted. We should not stop changes, but we should be able to start discussing and understanding how this will indeed impact those sectors.

**Lord Cameron of Dillington:** I was going to ask you about the appropriate level of the regulatory regime, but, to a large extent, you have answered that previously, so perhaps I could add to my supplementary. At what stage of the development of these vehicles do you consider that you will need to bring in a regulatory regime either nationally or internationally, because I suspect it will lead from one to the other? Also, in terms of developing a regulatory regime, to what extent are you building up partnerships among each other, nation to nation, legislature to legislature, government to motor manufacturers and, most importantly, bringing in the insurance industry, because I suspect that not so much the development of the programme but certainly the utilisation of automated vehicles will depend upon how the insurance industry approaches the whole issue?

**Dr Hermann Meyer:** The insurance industry is included within our partnership so they are already part of the debate, and that is related to a situation where in the future an automated vehicle causes an accident because of some mistake, and we certainly have to see how this will be dealt with in the context of the insurance industry. There is legislation in place, the motor insurance directive, and I think that is sufficient. If you ask me about the main challenges on the regulatory front—one issue concerns the homologation of vehicles. At the moment you cannot homologate—type-approve, an automated vehicle.

**Lord Hunt of Chesterton:** Can you repeat that?

**Dr Hermann Meyer:** You cannot type-approve, certify, an automated vehicle. The reason is the Vienna Convention and the Geneva Convention, which say there must be a driver in full control of a vehicle. Maybe you can interpret driving a vehicle as in a piloted vehicle, but that is not clear at the moment; the understanding at the moment is that you cannot type-approve an automated vehicle in Europe.

The second major challenge is cyber security, so that in the future systems with this connectivity cannot be hacked. There is a lot of work going on in the context of the different technologies, and we believe this can be dealt with, but that will be an ongoing challenge because it is not that you fix it once and you have fixed it for ever; you have to work on it continuously.

- Q27 Lord Vallance of Tummel:** On the insurance point, it is conceivable that there are accidents due to failures in the communications network. Have the insurance companies taken that on yet?

**Mike Hawes:** Here is where we see the real benefit of connected vehicles. Over 90% of accidents at the moment are generally due to human error, and you are absolutely right that the insurance industry is certainly looking at future models, as indeed potentially are the Government. They are consulting at the moment about what insurance should apply to the vehicle, whether to move from driver insurance

to a product liability model. Certainly that will account for the instance that you describe. This goes back to the earlier question. These are some of the issues that need to be discussed, and that is why you need all the stakeholders contributing to the development so that you have where you need it a regulatory framework, but where you do not need it, you have the ability to let the technology flourish.

**Lord Vallance of Tummel:** I am not sure it deals with the issue I am talking about. If there is a telecommunications infrastructure, say, up and down the motorway networks which somebody is running who is neither a manufacturer nor a driver, and there is a failure in that, presumably whoever is running the communications network has some liability.

**Mike Hawes:** Yes. That compounds the need for all parties to talk.

- Q28 Baroness Neville-Jones:** My question follows rather closely on this last exchange, concerning liability when there has been an accident, say. In the EU, at any rate, although we have product liability, we do not have an agreed regime on this kind of liability. What is your view about the state of the law, and how would you go about getting a degree of certainty about who is legally liable in a vehicle that is thinking for itself when there is an accident of some kind, a Tesla type?

**Dr Hermann Meyer:** First, I think we have a product liability directive and at the moment we are content with it.

**Baroness Neville-Jones:** Yes, but this is not the situation I am talking about.

**Dr Hermann Meyer:** The situation is if you are in an automated vehicle and the vehicle makes a mistake, the liability is certainly with the product itself. What you have to know in this context is if at the moment the mistake was made the vehicle was in automated driving mode or if the driver was in control; that you have to know, and the driver has to know if he is in control, because there can also be a situation where the vehicle thinks the driver is over-steering but the driver himself has not noticed this. There can be very complex situations. It has to be clear who was in control at the moment when something went wrong. That is the first part. The second part is that you need some data to prove it. That is an area where some work has to be done so that we have a clear situation concerning liability, but if the vehicle itself has made the mistake, it falls certainly under product liability.

**Mike Hawes:** Which underscores the need for event recorders in cars.

**Lord Hunt of Chesterton:** The black box.

**Baroness Neville-Jones:** Do you think it will be necessary to have some legislation on this subject or is this something that will have to be tested through the courts?

**Mike Hawes:** You are going to hate me for this answer; I suspect the answer lies somewhere between the two. The Government will obviously set the appropriate regulatory framework but, again, they want to do so such that the technology will flourish, but the limits of that level of responsibility are invariably tested through the courts.

**Lord Hunt of Chesterton:** To what extent will this black box and other devices mean that cars will all have Big Brother looking after them? For example, in the United

States you are driving along and the car in front of you probably has a gun behind the driver. If you have been to Colorado or Arizona, the places I have been to, that is quite the norm. You want to know the contents of people's vehicles. We are now in a very complex security situation in Europe. It seems to me that this may be an advantage, in fact, that in order to have autonomous vehicles, they must be part of a global or a national security system, and therefore obviously police computers will be there monitoring what is going on. Once we start down that road, it has to be done thoroughly.

**Mike Hawes:** It is a very important point that you raise, and this comes down to society's attitude towards privacy and so forth, and different societies will be in a different position on data privacy. Clearly, such technology presents an advantage to society, and you need to ensure that the consumer is in control of a large part of the data that will be generated from vehicles. You clearly have to have some sort of protocol or agreement that in the event of an accident that data is available for the responsible authorities to be able to interrogate, and potentially only in the event of those extreme circumstances.

**Claire Depré:** We need to be firm on this. There is now a strong framework in place in Europe for data protection, and it has to be respected in this field too. I come back to the co-operative system element; we are looking at the conditions under which a broadcast could happen. Should we ask not the owner of the vehicle but the driver each and every time if he wants to broadcast the data, and for what purpose? Is the situation different when it comes to road safety-related services, whether safety is at stake or not? We have talked about event data recorders. That of course does not mean that this general data protection regulation should not be applied. It is true that we are at an early stage in understanding how the two things need to co-exist so that we are not taking rights away from people but allowing them to benefit from technological development.

**Dr Hermann Meyer:** To qualify this a bit, with an event-data recorder, you would not get into a situation where you have the data for the whole trip. It is only when you have an accident that you have access to what happened in maybe the two or three minutes leading up to the accident. The other data will always be deleted, so there are already precautions taken so Big Brother is not watching you. We also have to look at where the data is stored, whether it is stored in the Cloud or in the vehicle itself in a black box. There are different possibilities on how to organise it but it is clear that the data event recorder only stores the data very close to the accident itself.

**Claire Depré:** We could make the analogy with the eCall system, the emergency call system.

**Lord Hunt of Chesterton:** Is it eCall?

**Claire Depré:** Yes, which will be in vehicles as of March 2018. It is the same system. You only record what you need and it is limited to the time of the accident.

**The Chairman:** I am sorry. We have to curtail that one because I have three further contributions to try to fit in in five minutes.

**Q29 Lord Mair:** Public confidence is crucial here, and of course, confidence in the technology is equally crucial. Can I ask you a bit more about testbeds and large-scale testing? Dr Meyer, you mentioned the crucial role of testbeds in regard to safety. Mr Hawes, in your evidence you talked about the need for comprehensive testbeds in the UK certainly, but can I get your views on what more is needed? What do you mean by comprehensive testbeds?

**Dr Hermann Meyer:** We are currently working together with the European Commission to develop a European testbed. We are currently looking at existing or upcoming testbeds in Europe, and we see that a lot of testbeds already exist and new ones are coming up. You are very strong on this in the UK. They are on motorways and in cities. We would like to create a situation where these testbeds co-operate with each other in the context of the use cases which they deliver and implement, and in the context of the technologies and organisational frameworks which they implement. We would like to avoid fragmentation and silos. Most important for the future of automation are economies of scale; we have to move in the same direction, and that we can do with a European testbed.

**Claire Depré:** This has already started with the c-roads platform, whereby 13 European countries are already sharing experience, allowing interoperability, doing the tests cross-border. The European Commission has put on the table quite a significant budget to allow for the conversion between this co-operative system and automation with the precise aim of doing the same for automation, so as to be able to understand quicker, avoiding duplication all over Europe without talking, without understanding, without being able to allow interoperability from day one.

**Q30 Baroness Young of Old Scone:** My question is the reverse of that. Mr Hawes, do you think the UK Government are doing enough to develop a vision that allows the United Kingdom to benefit and develop a leadership role in this area?

**Mike Hawes:** Yes, I think it is. It could always do more but if you look internationally, the framework that we have in place is facilitating the UK as a testbed, and that is part of that journey. We have tests in Greenwich and Milton Keynes. Volvo have announced that they will be testing autonomous vehicles in London next year. That shows that international companies have been looking at the UK as a potential test-bed. There is a framework in place where essentially all you need is the insurance. Going back to what Dr Meyer said earlier, because of a quirk of history, the UK never signed up to the Vienna Convention—I am never quite sure why. It was the late Sixties, early Seventies or something—and as a consequence some of those barriers are not there. The real challenges are making sure that the Government develop a strategy which brings all the sectors together: government, automotive, tech companies, telecoms companies. We talked about the importance of infrastructure; it is hard infrastructure on the roads, the virtual infrastructure of 5G, and so forth, and the coverage around the UK, because, as we said before, it is all very well testing the vehicles on the motorway—nice line, straight roads, everyone is going in the same direction, traffic is segregated—but as soon as you hit the off ramp, the level of complexity increases enormously, and that is where we can do nothing but further testing.

**The Chairman:** We have run out of time. Lord Oxburgh has kindly indicated to me that he does not wish to pursue his question. I have to say to our three witnesses that we are enormously grateful to them for having joined us today, and I know you have travelled quite a bit to get here. So to Claire Depré, Dr Hermann Meyer and Mike Hawes, very many thanks for your help today. Thank you very much.

## Five AI Inc – Written evidence (AUV0013)

### Impact and benefits

1. The largest applications will be in the transportation of people and goods:
  - a. Personal mobility-as-a-service (MaaS) delivered through a fleet, which may be heterogeneous in size, of autonomous electric vehicles as replacement for commuter and family cars
  - b. Automating the driving of trains, trams, light railways, underground systems, taxis and buses
  - c. Package delivery to the home or office
2. Benefits will be:
  - a. 50-75% reduction in commuter road traffic in urban environments and halving of journey times, since vehicle occupancy can easily be increased to between 2 to 6
  - b. Recovery of circa 460 hours per year per person (2 hours per working day) of time otherwise spent driving; individuals can be much more productive since vehicles will be equipped with broadband connectivity and charge points for tablets, phones and notebooks
  - c. Substantial reduction in mobility expenses per person, estimated at £2,100 per person per year. That money was previously spent on (mainly) imported vehicles, imported fuel, parking charges, insurance and servicing.
  - d. Subject to the technology, a reduction in accidents resulting in injury and death, since autonomous cars will not get distracted.
  - e. Release of substantial car parking spaces in our towns and cities for better economic use
  - f. Rapid switch-over from fossil fuel vehicles to all-electric vehicles, potentially assisting the UK in meeting Kyoto emission targets

Costs will be:

- a. There will be some winners and losers in the economic game, losers will include branded vehicle manufacturers supplying mass-market cars to the developed world (OEMs) and related component suppliers (tier 1s), body shop repair firms, downstream fossil fuel distributors, taxi companies
- b. Suitable vehicles might be assembled relatively quickly and cheaply by new 'no-name' OEMs, which could in theory be based anywhere: economics of battery technology supply, energy costs, labour costs, speed of product design, customizability of platforms, tariffs and other factors will determine winners and losers
- c. Insurance companies will continue to play a key role, but instead of actuarially determining the probability and cost of human cognitive failures giving rise to accidents, instead they will need to become expert in measuring the probabilities of artificial intelligence cognitive failures. That means they must build and become experts in highly sophisticated simulation environments of

the world and be able to assess AI software against a very wide range of test cases in that simulated world. Those who are slow and fail to develop this expertise will mis-price risk and ultimately fail.

3. Knowledge is being built in trials across the world, primarily in the US and Singapore. But it is straightforward to model traffic flows, impacts and economics. More difficult at this stage is assessing the point at which autonomous vehicles can be safely deployed in our complex urban environments since the quality of perception and planning systems depends on solving many unsolved problems in the fields of computer vision, behavioral prediction modeling and planning vehicle action in resulting entangled complex states.
4. No comment.
5. The global (and local) market opportunity, just on personal mobility alone, is huge. In 2015 the world manufactured and consumed around 87 million cars. McKinsey is one firm that has estimated the growth in the number of autonomous shared cars shipped by 2030, which they put at 10 million units that year, out of total shipments of 115 million by then. That would imply a global fleet of around 25 million autonomous cars by that date, but autonomous cars work much harder than owned cars, so they estimate autonomous cars could account for 32% of all journeys by that time.

Five AI believes this prediction is very conservative and the ramp will be much sooner and the numbers will be much bigger, more like 20 million autonomous unit sales by 2025 and a 40 million autonomous vehicle global fleet by that date.

If correct, this global fleet could offer capacity of 200 million seats. Assuming an average seat utilization of 50%, and 12 billable journeys a day per utilized seat, that would equate to 1.2 billion billable journeys each day. Assuming journeys would be priced the same as a bus ride (£4) the service opportunity alone equates to a £1,400 billion annual TAM. Our modeling suggests an operator gross margin of 25% is achievable at these fare levels, assuming appropriate levels of vehicle, insurance, cleaning, maintenance and energy input costs.

The supplies of those inputs also represent very significant global market opportunities themselves, aggregating to an estimated £1,050 billion. That figure includes:

- Vehicles: £400 billion
- Sensors and computational hardware platforms: £200 billion
- Software licenses and on-going support: £370 billion
- Insurance: £50 billion
- Energy: £100 billion
- Cloud/app IT services: £40 billion
- Support services (monitoring, maintenance, cleaning): £220 billion

## **Creating an Enabling Environment**

6. The UK is not (yet) a leader in autonomous vehicle technology development, despite the fact we have some of the top university research departments in the fundamental sciences of visual geometry, deep learning, artificial intelligence and control systems. In fact there are two serious attempts in the UK to build global players that can leverage these raw capabilities – Five AI and Orobotica. Both are tapping into key academic knowhow at the University of Oxford and to a lesser extent, Cambridge, Imperial and UCL.

Demonstration facilities are not really the issue, although a simulation and physical test track would have significant value for all developers.

7. US companies lead the field today, substantially because of DARPA funding in the mid-2000s and the Grand and Urban challenges they set and funded. All leading spin-outs from US universities that went on to create software companies for driverless cars were participants in the DARPA challenges – Berkeley’s team which became 510 Systems which was then acquired by Google to form the platform for their driverless car program, Carnegie-Mellon’s team now working for several companies most notably Uber, Stanford’s team now working for drive.ai, MIT’s team now working for Nutonomy, being examples.

Of course, the availability of huge pools of capital in technology companies – Google, Apple, Uber – and their ability to recruit and retain some of the world’s top talent in the fields of computer vision and machine learning due to this capital and the research-led working environments they created, represents a serious challenge to counter in the UK.

And US venture capital firms are more technologically-aware than their European counterparts and have access to larger pools of capital themselves – endowments and fund-of-funds – due to their better track records. That weight of capital outside the tech firms themselves also represents a challenge for companies in the UK taking on this challenge.

The UK government initiative to support driverless car technology development, especially the learning from the DARPA challenges, is exactly the right move to stimulate activity and focus in this area and should be applauded.

Beyond that, UK startups need to counter the gravitational pull of talent to large US technology firms by offering competitive salaries, significant stock options and greater access to resources beyond their existing reach. Much of that comes down to the caliber, experience and energy of the leaders of these companies and their investors, but the one role UK government should consider beyond the CCAV funding challenges would be the foundation of a specific venture firm operating in the UK market to invest alongside existing UK firms but with a remit to support this segment.

Such a firm should seek to attract top venture investor talent from the most prominent and successful technology venture firms operating in London – for example Accel, Index, Balderton, Atomico and some of the smaller deep tech investing firms, such as Amadeus, Mosaic, Notion and Kindred.

Beyond that, we are in the realm of industrial strategy and the politics of whether it is a good idea or not for governments to own or control businesses in emerging fields. In general, this has not worked well for Anglosphere companies, although there is more sign of success in some continental European countries, notably France.

8. CCAV has been extremely effective. An almost perfect start. Team is sensible, commercial and ambitious. We don't yet have any comment on Innovate UK.
9. The environment is enabling, with the first round of CCAV funding spread across a range of projects, clearly taking a somewhat experimental approach to begin with. In retrospect, possibly too much funding was offered to very small companies on peripheral areas of industrial research.

What is needed now, and CCAV recognizes, is to put more wood behind fewer larger arrows. The CCAV2 stream 1 large-scale challenge is an important step to take, since it should help enable UK firms to catch-up with and eventually overtake US (and German, Japanese, Swedish, Chinese) counterparts. That catch-up is possible because the science underpinning many of the necessary features is evolving quickly, and in our Universities, so intercepting that science now is advantageous compared to intercepting it in 2010, say.

10. Eventually, we will want to layer V2X (vehicle to infrastructure) communications over the cognitive capabilities of the vehicle itself, to further reduce accident rates and aid in planning. The specific technology to achieve this is being debated globally. But it is not essential to the launch and development of driverless cars. We humans do not have (or need) ubiquitous communications. And any systems that were to rely on the availability of such a communications network alone would be intrinsically unsafe.

We'd judge that for the time being existing physical infrastructure suitable for human drivers would be suitable for driverless cars too. In time, we may all agree improvements that would make recognition of road markings, signs, signals etc clearer but this should not be a factor for deployment in the next 5 years or so.

11. We see deployment in four phases:
  - a. Operation of a shared driverless car service across fixed routes in/out of an urban environment (eg suburb to city centre); those fixed routes are regulated and insured one-by-one, based on simulation, supervised operation and then insurance underwriting

- b. These routes cross at nodes and any vehicle can then convey passengers from any point to any point on an approved, insured part of that network – almost city-wide mobility but not quite
- c. Last mile can be added from home to route and from route to office; now vehicles can transport people up door-to-door
- d. Cities will then remove exclusions making every route available

12. No comment yet.

13. Yes, but others will be able to provide better comment than Five AI.

14. We think that to the extent the technology requires cognitive decision-making involving life or death situations, it should obey some important principles, for example:

- a. All human life is equal (so children worth the same as adults, pedestrians worth the same as passengers)
- b. Systems should measure and assure they do not get into a situation where decisions must be taken between options, all of which involve the risk of serious injury or death. Therefore measuring the extent to which this is achieved in all sorts of complex entangled situations in simulation will be an important ethical objective in the design of the software.

15. We need a legal framework that permits fully autonomous vehicles to operate on our streets without local on-board supervision and without being restricted to certain roads, speeds or behaviors. We need optionality on who takes the liability risk on accidents; one option should be that the liability can be taken by an insurer. That is needed since in a MaaS world, the vehicles could be supplied by a no-name company (man of straw) and another small firm could provide the software.

16. In the emerging fields of computer vision, machine learning, artificial intelligence, the University outputs of our top schools is as strong as anywhere in the world. Our challenge as a country is to keep those people in the country and to configure them into world-beating companies.

17. We think the strategy and work is wide enough.

18. We are seriously concerned that our universities will find it harder to attract talent to study for first and second degrees in the UK, due to the mood music change alongside Brexit. We are concerned that strong students will feel discouraged from remaining in the UK and contributing to companies here and that the visa process which is likely to be introduced will form an unnecessary and symbolic barrier that it would be best not to have. Visa-free travel and right to work for relevant people would be good. Since Europe's car industry is centered in Germany, the fact the UK is leaving the EU may also alter the level of trust that partners and customers for our technology are looking for. They may feel more aligned with German, French, Italian or Swedish companies. Membership of the EEA or equivalent could help.

*14 October 2016*

## **Forum of Insurance Lawyers (FOIL) – Written evidence (AUV0065)**

**FOIL** (The Forum of Insurance Lawyers) exists to provide a forum for communication and the exchange of information between lawyers acting predominantly or exclusively for insurance clients (except legal expenses insurers) within firms of solicitors, as barristers, or as in-house lawyers for insurers or self-insurers. FOIL is an active lobbying organisation on matters concerning insurance litigation.

**FOIL** represents over 8000 members. It is the only organisation which represents solicitors who act for defendants in civil proceedings.

This response has been prepared by the FOIL Motor Sector Focus Team: Peter Allchorne, Roger Mackle, Patrick McCarthy, Gary Beazleigh, Glyn Thompson, Phil Mann and Karen Fyffe.

### **Introduction**

FOIL member firms are involved in the handling of claims on behalf of insurers following road traffic accidents. Their expertise is therefore limited to some of the questions raised in the Call for Evidence and, as the Committee indicates is acceptable, it will limit its response to those issues:

### **Question 13: Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

A road traffic environment which includes autonomous vehicles will create much more complicated liability issues than at present. Under current law compulsory motor insurance obligations are placed on the user of the vehicle, with liability being established on the basis of negligence by that user. In the new environment responsibility for the accident could still rest with the user of the vehicle but may rest elsewhere:

- On a manufacturer – a vehicle with Advanced Driver Assist Systems (ADAS), which help a driver with some of the functions of driving, or a fully autonomous vehicle, may be defective as a result of a manufacturing fault.
- A supplier – a component may be defective.
- An importer – for a defective product under Section 1 of the Consumer Protection Act 1987.
- A repairer – FOIL notes that at a recent Roundtable event arranged by Insurance Post to discuss issues around the repair of automated vehicles it was recognised that recalibration of an ADAS system is a key issue. Most ADAS systems operate through sensors and cameras inside the windscreen, making windscreen replacement much more technically challenging than at present. As the report of the Roundtable event states, *“Even a 1° misalignment can cause the system to misjudge braking distances or where the edge of a motorway lane is, with potentially serious consequences for the driver and other road users.”*

- The registered keeper – adequate repair, including updating of software to both operate the vehicle and protect it from hackers, will potentially be of much greater significance in an ADAS or a fully autonomous vehicle than at present.
- A hacker – a vehicle may be the target of malicious interference.

Some of these complications already arise with conventional cars. Accidents can occur as a result of defective vehicles or defective repair. These circumstances are relatively rare: the Government has indicated that at present over 90% of road traffic collision are caused by human error. Richard Cuerden, chief scientist at the Transport Research Laboratory, has stated that 4% are linked to vehicle defects. In practice, FOIL members report that it is very unusual to have a situation where an insurer is considering seeking recovery of its losses from a negligent third party.

In future, accidents resulting from a cause other than driver negligence are likely to be much more common. As ADAS become more sophisticated and truly autonomous vehicles are introduced, the majority of accidents are likely to be the result of a problem with the vehicle, whether caused by a manufacturing defect, defective repair, or inadequate maintenance and updating.

It is essential that the insurance arrangements for automated vehicles are as simple and straightforward as possible, making it easy for those injured in an accident to bring a claim against an easily identified insurer. The situation, however, is complex. Even in an environment where all vehicles are fully automated, and where it might be thought that a manufacturer will be responsible for any accident, circumstances are likely to arise where a user programming the system; a registered keeper maintaining and updating the system; a garage charged with repairing and checking the vehicle; or a hacker, may in fact be responsible for causing the accident.

The Government proposed in its consultation paper, ‘Pathway to Driverless Cars’, that appropriate insurance arrangements can be put in place by simply adding into the Road Traffic Act 1988, an obligation on a user to have product liability cover in place to cover a manufacturing defect.

For FOIL, the proposal raises a number of issues:

#### *Product liability law*

Product liability under the Consumer Protection Act 1987 is subject to a strict statutory regime:

1. There is strict liability under the Act for a defective product, meaning that there is no need to prove that the manufacturer was negligent, although it is necessary to show that there was a “defect”, meaning that “*the safety of the product is not such as persons generally are entitled to expect*” - a definition that may prove difficult in a field that is as cutting edge and complex as autonomous vehicles.

2. The supplier of a component which proves to be defective will have a defence under Section 4 if the defect was “*wholly attributable to the design of the subsequent product or to compliance by the producer of the product in question with instructions given by the producer of the subsequent product*”
3. Under Section 5(2) of the 1987 Act, a producer is not liable for damage to the product itself, in this case, the vehicle.
4. Under the Limitation Act 1980, different rules apply to product liability claims. Non-personal injury claims must be brought within 10 years of the supply of the defective product; with personal injury claims required to be brought within three years, subject to a long stop of 10 years from date of supply. This would have the effect of preventing claims for accidents caused by vehicles more than 10 years old.

The effect of this statutory regime creates a liability very different from that which arises under a traditional motor policy. That very different regime, and the insurance products which have grown up to cover claims arising under it, make it difficult to see how product liability and motor liability can be bolted together under a single policy.

The need for dual cover will create complexities for motorists required to obtain cover under two policies. The limitations of product liability law and product liability insurance cover will not provide the same watertight coverage that exists under a motor policy, designed to meet the requirements of the compulsory motor insurance regime.

The decision of the European Court of Justice in *Vnuk v Zavarovalnica Triglav d.d. [2014] CJEU C-162/13* raises a further legal complication. In that case the Court held that a tractor being used for agricultural purposes on private land was still within the compulsory motor insurance requirements, ensuring compensation could be paid in the event of an accident. The case made it clear that the Motor Directives require a motor policy to be in place to cover “*any use of a vehicle that is consistent with the normal function of that vehicle*”. As the automated features will be the normal function of an ADAS or AVT vehicle, European law would appear to require that a motor policy is in place to cover the risk arising, not a product liability policy.

#### *Breadth of coverage*

As indicated above, there is the potential for a much wider range of potential defendants to arise in relation to the use of a vehicle with ADAS or fully autonomous vehicle. The potential liability of repairers is of particular concern. With the diagnosis of problems with ADAS and automated systems, and recalibration of the systems after an incident, likely to present challenges as the new technologies are introduced, will the law of negligence be adequate to establish liability, to enable an insurer to recover where appropriate?

#### *Insurance obtained by the user*

Under the proposals it would appear that the user of the vehicle will be responsible for buying cover which is most likely to be required to cover the product liability of a

manufacturer, or negligence of a repairer. If separate product liability cover is required, it will not be protecting against a claim which can arise against the user. Is it considered acceptable that a motorist will be required to buy cover which can only benefit a manufacturer?

**Question 15: What does the proposed Modern Transport Bill need to deliver?**

*Liability*

FOIL understands from the consultation paper, ‘Pathway to Driverless Cars’, that the Government is *“not currently proposing any significant change in our rules on liability in road traffic accidents to reflect the introduction of automated cars. We still think a fault based approach combined with existing product liability law, rather than a strict liability regime, is the best approach for our legal system. We think that the existing common law on negligence should largely be able to adapt to this new technology.”*

FOIL believes that the use of automated vehicles raises issues of liability that should be looked at afresh rather than the common law automatically being considered adequate. Complex issues arise around maintenance and the updating of software and in these circumstances it is unclear who is to be considered responsible: the driver, the registered keeper or the owner? It would be more appropriate for these issues to be considered and included within the Modern Transport Bill, rather than being left to be dealt with by litigation.

*Classification*

As the Government is proposing currently to adopt a gradual approach to insurance reform, introducing changes that will only apply to those buying automated vehicles, there is a need for a classification system for vehicles to enable purchasers, whether or new or second-hand cars, to be able to identify the automation within the car. This will have several benefits:

- Allowing insureds to buy the right type of insurance for their vehicle.
- Allowing insurers to assess risk appropriately.
- Ensuring that owners and registered keepers of vehicles can take account of the technology within the vehicle when undertaking repairs, for example, when windscreen replacement is required.

*A Standard Data Set*

It is inevitable that in incidents involving autonomous vehicles, data will be required to determine whether the driver or the vehicle was responsible for any collision, to provide evidence, for example, on who was in control at the time of the incident.

The format and the detail of the data should be subject to regulation, to enable it to be relied upon both in a criminal and a civil context.

It would be useful to consider whether Sections 170 and 172 of the Road Traffic Act 1988 should be amended, to require the disclosure of data to any person having reasonable grounds; and to allow for the request of details of whether the driver was in full control of the vehicle at the time of the incident.

*26 October 2016*

## **GATEway (Greenwich Automated Transport Environment), Bristol driverless cars project and Milton Keynes Council – Oral evidence (QQ 31-39)**

Tuesday 8 November 2016

### [Watch the meeting](#)

Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Fox; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Morgan of Huyton; Baroness Neville-Jones; Lord Oxburgh; Viscount Ridley; Lord Vallance of Tummel; and Baroness Young of Old Sccone.

Evidence Session No. 4

Heard in Public

Questions 31 - 39

### Examination of witnesses

Professor Nick Reed, Academy Director at TRL, on behalf of GATEway (Greenwich Automated Transport Environment); John McCarthy, Technical Director at Atkins' Intelligent Mobility, on behalf of the Bristol driverless cars project; and Brian Matthews, Head of Transport Innovation, Milton Keynes Council.

**Q31 The Chairman:** Could I invite the Committee to reconvene and welcome our three witnesses in this session, Professor Nick Reed, John McCarthy and Brian Matthews? Perhaps as we are being broadcast it is necessary for the record for you to introduce yourselves, and if you would like to make an opening statement, please feel free to do so. Perhaps we could start with Professor Nick Reed.

**Professor Nick Reed:** Thank you, and thank you for the opportunity to speak to the Committee today. My name is Nick Reed, I am the director of the Academy at TRL, the UK's Transport Research Laboratory. I am responsible for co-ordinating research and innovation at the lab. I lead on vehicle automation and I am technical lead of the GATEway project that I am representing here today. TRL is the UK's Transport Research Laboratory, an independent, non-profit, distributing centre of excellence for research into all forms of surface transport and it has had self-driving cars for more than 50 years. The GATEway project is a collaborative R&D study, part-funded by Innovate UK and by the commercial partners involved, in which we will be testing a range of different automated vehicles in Greenwich. The Royal Borough of Greenwich is playing host to a number of connected and automated vehicle studies, so we have taken the opportunity to brand the Borough of Greenwich as the UK Smart Mobility Living Lab.

I am also pleased to declare that Lord Borwick is the chair of the cross-sector advisory group.

**The Chairman:** We have sussed that out.

**Professor Nick Reed:** I am sure you have. We have very helpful input from him.

**John McCarthy:** Good morning, all. Thank you for inviting me here. I am John McCarthy. I am technical director with Atkins consultancy. I am also technical director for the VENTURER project based in Bristol and south Gloucestershire. Atkins is a global engineering consultancy with roughly 20,000 employees. The VENTURER project that we are leading looks to create an independent test site on the Bristol and south Gloucestershire roads for the deployment, testing and validating of autonomous vehicles on real urban roads.

**Brian Matthews:** Good morning. My name is Brian Matthews. I am head of transport innovation at Milton Keynes Council. Milton Keynes is a unitary authority based in the south Midlands with a population of 260,000. My role in this topic area is to lead for the council the UK Autodrive programme, specifically looking at the research elements of the programme. Over the next year the city will be hosting demonstrations of saloon cars driving autonomously and the deployment of 40 individual pods as a public transport system.

- Q32** **The Chairman:** Thank you very much. I am going to open the questioning with a rather general question. You will have noted in the earlier session—I apologise that we have kept you waiting a while—that we ran out of time, so when I ask you to respond briefly, you will understand why. It would be helpful if you could give us in a nutshell a description of the trials you are carrying out, and tell us whether this is demonstrating a scientific and engineering process or testing elements of a system to be deployed, and to what extent you are looking at the social and behavioural issues which will arise from the introduction of this technology. Perhaps I could start again with Nick Reed.

**Professor Nick Reed:** There are three main trials in the GATEway project. The first is testing seven six-seater pods as an automated transport service on the Greenwich peninsula. The second trial is looking at how automated vehicles can be adapted to suit the needs of mobility-impaired, visually impaired and deaf transport users. The third trial is looking at the use of an automated delivery vehicle, so the extent to which it will be possible for deliveries in the city to be made by a quiet, automated, zero-emission vehicle. We are also looking at driver behaviour in the presence of automated vehicles, so using our driving simulator to see how drivers of manually driven vehicles change their behaviour when they are in the presence of automated vehicles. We also have a trial looking at remote vehicle operation, whether it is possible to take control of an automated vehicle from a control centre for vehicle management.

**John McCarthy:** VENTURER is looking to focus on the individuals, on understanding the behaviours and the relationship between people and autonomous vehicles, while not neglecting the need to understand the technology aspect of it. Through the consortium we have members from the insurance industry, academia, the private sector, and we are looking at understanding the relationships that these different elements can bring together to have a real and scale-able test site to address some of the issues raised in the earlier session. We have just completed trial one, which is looking at a handover mechanism, going from a situation there the

vehicle is driving itself to where the driver has to take control. We are engaging through simulation and on road deployments in looking at creating scenarios where we can test offline, take that learning and deploy it in the real world. For trial two, which is taking place later next year, we are looking at the engagement of the autonomous vehicle with other road users, looking ahead at junctions and engaging with other drivers to understand user need and the technology requirements that underpin a smooth transition to autonomy.

**Brian Matthews:** The Autodrive project is a collaboration between 16 partners, made up of OEMs Jaguar, Land Rover, Ford, Tata Motors; SMEs, RDM, who make our pods; and the university sector, Cambridge and Oxford Universities, and locally the Open University, so it is a wide-ranging consortium. The three activities within the demonstration, as I mentioned earlier, are to demonstrate on the public roads of Milton Keynes and Coventry M1 saloon cars operating in live conditions, and those trials will take place towards the start of 2018. The second element is to deploy a fleet of 40 autonomous pods within the pavement areas of Milton Keynes, operating as a public transport system, a last-mile solution. One of the trials will be to integrate the connected cars, the M1 saloons, with the pod journeys to demonstrate they can connect. The third element is a cities research programme, as we term it, which looks at some of the social factors around the public attitude towards autonomous vehicles and whether it changes within the life of the programme; the business case development of a last-mile public transport solution, specifically looking at the capacity benefits that may be unlocked by autonomous controls on the highway; and a future horizon scan of how the technology may develop in the short to medium term.

**The Chairman:** Coming back on that, one of the interesting issues which came out in the earlier session is the social issue—how people will react as they share their roads with assistive vehicles and eventually autonomous vehicles. There are clearly some interesting issues to explore on human behaviour: how people will react, whether we are talking about the person who is a driver, who is moving to a situation where they have less and less participation but remain in ultimate control, or a situation—and we are told it is some time ahead—where you eventually move to autonomous; also how third parties are likely to react. At some level will they play chicken and see whether the autonomous vehicle stops; or will there be concern in wider society at what appears to be a vehicle not obviously being controlled? Are these issues of human behaviour part of your project?

**Brian Matthews:** Certainly, yes. We are looking to explore current attitudes towards driverless technology, which is very new to the UK, and see what the acceptability is, without it really being demonstrated as it is in its infancy, and whether that changes through the life of the programme. We are comparing Milton Keynes, where there is a little bit more exposure to autonomy, to other areas, and we are also taking the survey out into international areas to test the areas, but the aspects you mentioned are all covered in the detailed survey. Certainly the chicken aspect we have noticed very readily: all the journalists want to jump in front of it and make sure it stops, and it does.

**John McCarthy:** For us, within the conversation around autonomy there are a huge number of questions. We are all struggling to understand what the answers might be in the near term. A lot of conversations are focused around technology—how technology can be deployed and how it can be validated. For us, putting the user at the centre of the conversation is the prime aspect of VENTURER, building the technology around that, building the integration with the road network, understanding the needs of the individual relating to the technology, the dependencies between the infrastructure, the vehicle and the human, and how they can all relate to each other within a new way of travelling.

We are of the mind that transport is changing to a mobility-type solution and how the individual can be part of that, which raises lots more questions around data protection, the security of the individual, the security of the system, the testing and the validating, which is driving us to create this independent test site to capture the behavioural aspects and the technology in a unified way.

**Professor Nick Reed:** The call under which these three projects were funded was explicit in saying it was not about the development of new technology but about testing those technologies and learning about how the public come to trust and accept these vehicles as part of an urban mobility environment. It gives us the opportunity to engage directly with people, give them an experience of the use of automated vehicles, and then come to a conclusion about whether they would like to pay for transport using such vehicles. There have been a number of frankly unhelpful surveys which asked members of the public whether they think they would like a driverless car. It is very difficult to make a judgment on that when you have not experienced one. In our early demonstrations we have all seen that there is a lot of interest, excitement and ready acceptance of automated vehicles, so let us get out there, do the trials, and find out people's genuine opinions when they have used an automated vehicle.

**The Chairman:** Was Lord Maxton trying to catch my eye earlier?

**Lord Maxton:** Yes, it is a question on that subject: quite simply, you try and get people to drive an automatic car and they want gears—in America they do not but in this country they do. How do you react to that?

**John McCarthy:** I think the question really is: what do people want and why do they want it? The oft-quoted figure, and we heard it earlier, is that 90% of accidents are caused by human error, so if you are asking whether people want a safer way of going from A to B, people potentially will say yes. If you ask if they want an alternative technology which puts them in a new environment they might not be comfortable with, the answer might be no. We have to understand the full range of needs and user requirements to answer what people want rather than pushing a technology that is not what they are looking for.

**Lord Maxton:** I would not drive anything else but an automatic.

**Lord Hennessy of Nympsfield:** Are imaginations aflame in Greenwich, Milton Keynes and south Gloucestershire among the people who have experienced this? Can you peg it up a bit? There is no poetry in all this, is there? I have a vision—and I do not like the word “vision”; I think it should be left to mystics, but everybody has to have

a vision these days—of being stuck in a driverless car on the A43, going to the immensely boring British driverless Grand Prix at Silverstone. Is there any poetry you can offer us or, for the people that experience it, does it take care of itself as a problem of imagination?

**Professor Nick Reed:** If we are giving people an exciting experience, we have done our jobs incorrectly.

**Lord Hennessy of Nympsfield:** But do you?

**Professor Nick Reed:** As John has said, if we want to offer people new ways of achieving mobility and regaining time, you may be able to access the time spent on the A43 in a traffic jam and use it productively or for relaxation. We want to improve safety. Human error is a contributory factor in the majority of collisions. We are directly addressing that through automation of the driving task. Safer, cleaner, more enjoyable journeys—it is not poetic but I think it is a good ambition to have.

**Lord Hennessy of Nympsfield:** Poetry in Bristol?

**John McCarthy:** We are very poetic in our thinking, landed in the reality of everyday concerns. We think about this as not replacing a new technology with an old type of solution. It is not a new way of going about our journeys; it is looking at unearthing new ways of engaging with how we live our lives, connectivity, autonomy, how you save time, create new services, and those services can be as fast and as wide as you might want them to be. Now we can pause TV—did we imagine something like that 10 years ago? That is one example of technology providing a benefit for people in ways that we cannot imagine right now. I think it is tremendously exciting, and the services that can be enabled from an autonomous future in the short term are for us to determine. Fundamentally, the non-poetic side of it is that we have to understand what people want and deliver a solution that is absolutely safe.

**Brian Matthews:** I liken it to the example where we all understand the risks or potential risks of using our credit card on the internet, but we still do it because the benefits are greater than the risks, because we like shopping. I see that as being the evolution of driverless cars in the UK: yes, we like driving, we like changing gear, but we might like using our phone a little bit more than doing that. I think that is how we see them developing, that the public will come to accept this technology because the benefits are greater than what they enjoy in the current offer.

As for how we see it in the city of Milton Keynes, for those who have been there, it tends to be dominated by the car; it is car-centric. We recognise it has a role to play but we also have ambitions for the city developing and growing and being more successful, and if we can start to remove the reliance on the car through a range of measures which includes autonomy and the last-mile solution, perhaps we can be more poetic with our city and develop a city example that our residents like better than the current model of cars everywhere, and parking everywhere.

- Q33** **Lord Mair:** You heard in the previous session a bit about trials and testbeds, and the three trials that you describe are obviously of great interest, but it is still early days; there is clearly a lot more needed. Could you say something about how much more we are going to have to do in the way of trials? What do you envisage as the next

generation of trials, to get public confidence, testing technology in difficult conditions, potholes, driving in foggy, rainy conditions, all these kinds of things? What do you think are the next kinds of trials that will have to take place?

**Professor Nick Reed:** All of the three projects here are research projects for the urban environment, so we are geographically constrained. We need to think about what automation would look like in rural and inter-urban environments. None of us is seeking payment for the use of our automated vehicles. We need to understand what people would be willing to pay for these vehicles as a service. Event data recorders were talked about in the last session and what data those need to collect, at what level of accuracy, across what scope, how access is managed to that data to understand liability, and the interaction between manually driven, partially, highly and eventually fully automated vehicles, how the social interaction between a heterogeneous fleet would be achieved safely.

**John McCarthy:** From our side, from the VENTURER project and from an Atkins perspective as well, we are one year in. We have delivered one trial looking at the handover mechanism. That is one part of a huge jigsaw for autonomous vehicles. The second part is manoeuvring across the white line in certain circumstances, turning left and right at junctions. What we talk about is building up a series of increasingly complex scenarios. This is what we all look to achieve across all three projects, to build up that scenario where we have a list and an understanding of these different events.

We are only at the starting point of the testing environment. We need to understand the impact on infrastructure. We have yet to understand the full impact on the technology and the resilience that is put in place; looking at what the car industry is looking at, the individual within the vehicle itself, what it is that they look to engage with, whether it is or is not a steering wheel. These raise questions of how we create an environment that is realistic. Across the world we have lots of different test environments that are not necessarily on real urban roads, that do not complement the simulated world with the physical world, and that needs to be looked at.

I think there is a capability issue here. The UK as a whole can sell capability to the rest of the world. We have a number of test sites and we have a number of research projects under way. There are other research projects, and we should definitely bring that together in a unified offering to the rest of the world, because it gives us what we call a USP, a unique selling point.

**The Chairman:** Did you want to add anything, Mr Matthews?

**Brian Matthews:** Very quickly, I think we are all a year into our projects. Ours is a three-year project but results are emerging, and they have fed into CCAV and Government to give them sufficient confidence to set the bar higher for the next level of trials and demonstrations. As you are probably aware, there is a competition at the moment which seeks the next level, which will increase the complexity. It is an important role we are playing in setting the foundation for increasing complexity and more ambitious trials in the UK.

**Lord Mair:** Can I follow up? What do you therefore envisage? Do you think there are going to have to be trials for another five years, another 10 years? All three of you have explained very clearly that these are very initial trials and there is an awful lot more that needs to be done. We are trying to get a feel for what that involves. How many years of trials do you think will be needed before we can say this is going to be all right?

**John McCarthy:** I think the technology is probably there right now within car companies to do some level of automation. The question was asked in the earlier session about when it will exist. I think testing is a regime that will have to be in place in parallel with the technology to make sure that, as when new software comes out, when it has to be issued, you make sure that you validate it. We look to get to a state where we have a benchmarking around critical performance situations where we know what the technology would need to do, but I think testing, as happens right now with ordinary vehicles, in that new vehicles come to the market and undergo rigorous test regimes, will continue for the world of connected and autonomy.

- Q34** **Lord Hunt of Chesterton:** I was going to ask about the current trial you are planning in Milton Keynes and elsewhere. Presumably, you can programme an autonomous vehicle, if I may say so, to drive excitingly but within the law, stopping and starting like some vehicles, or very slowly. There is historical evidence about this. In Cambridge in 1910 there was the question of buses versus trams. The Conservatives were in favour of this new, nippy thing called a bus and the Liberals were in favour of trams, and the trams of course all went along tramlines. I was warned about this when I was a city councillor in the Sixties. Seriously, it is interesting. Presumably you can get some data and vary how people behave in autonomous vehicles, and that can answer or help decide whether a level of excitability of driving autonomous vehicle makes it more or less acceptable to the general public.

**John McCarthy:** There is a follow-on project in Greenwich called MOVE-UK, which is led by Bosch, and TRL, Direct Line insurance, and Jaguar Land Rover are partners in that project, and that is fitting a fleet of vehicles with automation systems. They do not act on the vehicle in any way, but they are there monitoring and recording what they would have done in the situations that the drivers encounter, so they are always human-driven but the automation systems are present. We will build up a big database comparing what the human drivers do and what the automation systems would have done, and, where there are differences, come to judgments about who was correct in that situation, to understand and improve the way in which we develop the algorithms that control an automated vehicle, and understand that variability in human driver behaviour.

**Viscount Ridley:** I am a notorious optimist. I think we harp on about the risks of new technologies too much and the benefits too little, but in this case there will be disadvantages as well as advantages. We all know the problem of the accident-prone but hyper-cautious autonomous vehicle that is going to mess up and congest the streets. How do we maximise the benefits and minimise the drawbacks, and is there a risk that at an early stage of the introduction of this technology, when, say,

15% of the vehicles on the road are autonomous, we are going to see all the disadvantages and not enough of the advantages?

**John McCarthy:** I think that is a very pertinent question. What we are looking to do within VENTURER is to look for the second trial to understand the engagement between autonomous and non-autonomous vehicles. You identified a scenario where a vehicle may not be, to use the word, “aggressive” enough in certain situations, where it is always waiting for a gap that will just not appear, which would cause congestion and tailback. It goes back to creating an intellectual awareness within the vehicle itself and within the control systems of the best performance in the best situation. I do not think an autonomous vehicle will always behave in exactly the same way in all situations, depending on the different parameters in place. If a vehicle is approaching at 10 or 15 or 20 mph, the vehicle has to be intelligent enough to make the call. That is part of the research, and part of what Nick alluded to there, the algorithm creating that intelligence that sits within the vehicle. It is also important from the traffic management perspective that the vehicle does not exist in isolation; it has to be linked into how we manage the traffic at a local level, at a centralised level, and receiving information that makes the best decision, because ideally, based on that optimism—and I am a fantastic optimist as well—it is receiving information from all these different moving parts and allowing the whole city to perform more efficiently. That is what we are looking to achieve ultimately from this, while giving the excitement to the user.

**Baroness Morgan of Huyton:** Can I add to what Lord Ridley asked? I am interested in what you have found out so far about whether there are any—I was going to say quick wins—quicker wins where you think the public may be more instinctively interested and supportive of this new technology. I need to declare an interest. I am a member of King’s College Council. I was not here last week.

**John McCarthy:** The first part of our work on the behavioural aspect of it will be released later this year. At the moment we are aggregating all the results. I think what comes out of the work that we have done so far is a little bit of fear linked into a little bit of novelty, linking intellect to the question of what I can get out of this. It is linking into the mindsets that people have traditionally around their transport choices, and seeing them re-imagining a future where something is going to be different, and connected and autonomous vehicles are part of that. The quick wins in this world are around the connected part of this CAV conversation, connected and autonomous vehicles—connectivity exists in a relatively stable way right now—and understanding what services we can offer to the individuals, to the traffic manager, to the different elements of supply chain that we can try and monetise that value. I think connectivity—and some of the panel members earlier mentioned this—co-operative ITS is part of the quick win. Also, looking at linking up the capabilities across all the different sectors that are involved within the UK would need to happen fairly quickly to allow the UK to be a leader in this emerging space.

**Lord Vallance of Tummel:** Some of these algorithms will be faced with moral questions, perhaps even life and death questions, or certainly questions of what makes people more or less happy. Who will make those judgments? Is it the

engineers who do the algorithms? What criteria will be used? Or does somebody else make the judgment?

**Professor Nick Reed:** This debate on the ethics of decision-making by an automated vehicle is an interesting thought experiment, and it will be a practical challenge. Personally, my view is that there are two factors that mitigate the concerns I have about ethical decisions by automated vehicles: first, that the vehicles will be risk-averse and have a better understanding of the risk that exists in the driving situation, so they will be much less likely to encounter a situation where a collision is unavoidable; secondly, that the vehicles will be recording all the conditions that existed in any collision situation and we'll be able to audit the process that the vehicle went through that resulted in any collision. The courts will decide who is liable and whether the vehicle behaved in a way that was acceptable or not. If it was unacceptable, it will be possible for all vehicles running that system to be updated, based on the decision-making around what is acceptable and not.

**Lord Vallance of Tummel:** Yes, but before the courts get at it, somebody has to write the algorithm. Who keeps a watching eye over the ethics of the algorithm?

**Professor Nick Reed:** The testing of automated vehicles will be different. It will have to be. We cannot just accept that a vehicle is tested on a sterile test track environment and then released into the wild. That was the logic behind setting up the living lab: we need test environments where you can address some of the complexity involved in driving in the real world. Having complex test environments will be important, and the ability to test the algorithms in a validated virtual setting. That is a big task: to create a validated virtual environment where you could present automated systems from supplier X and Y and compare whether one does better in foggy conditions or icy conditions. That is where we need to be heading.

**The Chairman:** I think we all understand that this will be safer—we expect it to be safer anyway. That is a reasonable expectation. We accept also that you can learn by experience, and if something goes wrong, any machine on that programme can ultimately be recalibrated, reworked, in order to take that into account. Nevertheless, we start with this ethical issue that there will be situations in which a choice has to be made between the safety of the passenger, for example, and the safety of a third party, and the question is: is society justified in asking somebody to write a programme which has ultimately to address that issue? That is not to say that it will not be an advantage, but have we the right to make people determine that decision, ultimately perhaps to be determined as to whether they got it right or wrong by a court?

**Lord Cameron of Dillington:** Or can society trust the motor manufacturers to take the right decisions, bearing in mind the post-Volkswagen fracas?

**John McCarthy:** I think “trust” is the key word here, and understanding how the system performs in different scenarios and situations. Linked to that, we face ethical questions right now as we drive as to what decisions we make and the consequences of our actions from our own individual perspective, not balanced against the perspectives of the other road users. We face ethical consequences of

our actions as we drive today. This links back to safety, and we all expect and hope we will have a safer future on the road.

Underpinning all of this is a scenario called the trolley test—I do not know why it is called the trolley test but it is asking the question: do you kill the old person or do you kill the child? What we look to do, reflecting upon that real question, is understand what the individual will do now, as a driver facing those situations, and the consequences of that, and see whether we can create a system with the capability of making the decisions in advance of that scenario arising. That looks at predictive capability, aggregating the data, trying to reduce the chances of it happening, and when you are faced by that choice, that the vehicle is not going to make a situation—and we cannot walk away from the statistics—of five people dying every day in the UK.

**Lord Cameron of Dillington:** Still, an individual will be writing this algorithm, so that responsibility will rest as it stands, with an individual. If you look at the parallel with the medical side of things, with the National Institute for Health and Care Excellence, for example, there are ways of doing cost-benefit analysis which deal with ethical issues. You will have another set of ethical issues here, and I wonder whether there should not be rather more than leaving it to the guy writing the algorithm.

**John McCarthy:** I think that is a doomsday scenario, where one individual is dictating the choices of the car in all situations. Part of what we are doing now is starting the journey around connected and autonomous vehicles, particularly autonomous vehicles, to understand what the requirements would be for the creation of this algorithm, for the creation of the software, who validates the person's code, who validates the system's response, who takes a collective approach, and what that means from a legislative and regulatory perspective as well. That is all part of the conversation that is unfolding now.

- Q35** **Lord Fox:** What timeframe do you think you are working to for the deployment of a level 5 automated vehicle, and what could speed up, or indeed, perhaps more pertinent, slow down that deployment?

**Brian Matthews:** In Milton Keynes we are looking to deploy the level 3/level 4 within the timeframe of the current programme, so within two years, and we are making good progress to deliver that. As mentioned, the next set of trials specifically asks for a level 4 capability to be deployed within the next two to two and a half years in all weather conditions on most highway types. The advances are coming very quickly. I heard the answer to the last question, and my view is that we will be at that level within five years.

**Lord Fox:** At what level?

**Brian Matthews:** Level 4.

**Lord Vallance of Tummel:** At what point during the trialling is somebody going to trial the vehicle-to-infrastructure telecommunications?

**Brian Matthews:** The trials in Milton Keynes through the connected vehicles do a little of that, in the connected vehicles to the connected infrastructure.

**Lord Vallance of Tummel:** Using what technology?

**Brian Matthews:** I am not a technologist by background but it is within the control system of the short range—my colleagues may be able to help—radio frequency between the vehicle and the control systems and the traffic signals of the road infrastructure.

**John McCarthy:** Typically, the technology that is used and that we would be looking to use is 802.11p, part of discrete short-range communications, called WAVE in other worlds. People see an advantage in this relating to the latency of the communications of the data and its resilience in certain circumstances, or in all circumstances. That has to be borne out from testing. The previous speakers talked about 5G and ITS-G5; 802.11p is complementary to ITS-G5 as part of that spectrum of engagement on V2I, vehicle to infrastructure, and vehicle to vehicle.

**Lord Fox:** Can I come back to the question I asked, because I obviously got the Milton Keynes view. Is that view shared in the other two tests of level 4 in about five years' time and presumably 5 some time in the far distant future?

**John McCarthy:** I think, again, like Brian in Bristol and South Gloucestershire, we are looking at level 3, level 4 within the remit of this project. If you are asking when people will be safely using and at a high level of use, within the real world, I think you are looking within the next five to 10 years. I think by 2030 is the ideal to have level 5 automation. The challenge—I think you asked what would stop it taking place—is lack of trust and lack of benefit. The trust is with regard to cybersecurity, what the vehicle decides to do in certain situations, and I think that trust is really important in getting a customer-centric value associated with autonomous vehicles so we are not stuck in congestion and that the vehicle is offering us something different.

**Professor Nick Reed:** Similarly, we are looking at level 4 vehicles in Greenwich. It is really important to understand the distinction between the different levels of automation. A level 5 vehicle is the vehicle that does all the driving all the time, and is capable of doing any driving that a human driver is capable of. A level 4 vehicle can do the complete driving task but only under certain boundary conditions. Google, for example, is creating a level 4 vehicle because its vehicle will operate only where it has done sufficient mapping. If you wanted to take a Google car from California to New York, it would not be capable of doing it because the massive part in the middle has not been mapped by Google to the sufficient level of accuracy. Level 4 vehicles can happen in the timeframes that have been described, five to 10 years; level 5 is a much more challenging task and will be some time beyond that.

**Lord Hunt of Chesterton:** Can I ask Mr Matthews: you are going to do these tests; will all the cars have the same programme? As we said earlier, you can have more or less exciting or risky behaviour, so will there be different parts of Milton Keynes run on different programmes, let us say the kind of excitement of people over there, or the very geriatric people over there?

**Brian Matthews:** One of the features of the programmes we are all involved in is collaboration, and that is a condition of taking these forward. The motor manufacturers, the OEMs, in Milton Keynes, which are Ford Jaguar Land Rover and

Tata, are all collaborating and the vehicles talk to each other. Our trials in Coventry and Milton Keynes will see, I think, six vehicles over 12 days operating on the network.

**Lord Hunt of Chesterton:** Always in the same framework?

**Brian Matthews:** Yes, in the same framework, the same routes; we have to specify routes, and we have picked challenging cross-city routes in both locations. The vehicles will demonstrate their level 4 capabilities, with a driver ready to take over should anything happen—a safety man, so yes, there is good co-operation between the motor manufacturers in this project, and I believe it is the same in the others.

- Q36 Baroness Morgan of Huyton:** Can I ask you a little bit more about what you have found out yet about what new infrastructure and investment you think will be needed? Obviously, you are all involved in practical testing at the moment. What is already there and what will definitely be needed? In our previous session obviously we heard about 5G, and since a lot of the country does not even have 4G, I wonder what areas we ought to be focusing on? Or 3G or any G.

**Lord Maxton:** No G.

**Professor Nick Reed:** My view is that automated vehicles will happen, regardless of the level of investment in infrastructure, but the pace of deployment can be enhanced by having an infrastructure that is adapted to their presence. I think it comes down to what kind of mobility we want to achieve. Particularly thinking about the city environment, we are very conscious in our trials that we do not want the development of an automated vehicle service to detract from the work that has been done to encourage active travel; we do not want a convenient automated service to replace journeys where people might have chosen to walk or cycle. Making sure the infrastructure complements the way in which we want mobility to be achieved, certainly in the urban environment, is what we are focused on.

**John McCarthy:** To build on that, there are two threads within the autonomous world; one is that there will be no dependency on infrastructure and one is that there will be a very strong dependency on infrastructure. I think those two worlds are still emerging as to what the impact will be. From an infrastructure perspective though, the UK's recent work on how we rate relative to the rest of the world and the need for investment within infrastructure, currently we are ranked 24th. That is the figure that was mentioned. It seems to me that if we want to be a leader in autonomous vehicles, if we want to be a world best, we have to have infrastructure that is world's best. What that infrastructure will be is yet to be determined.

**Baroness Neville-Jones:** What is your best guess about what kind of infrastructure you think people would go for?

**Professor Nick Reed:** I think it needs to be consistent. That makes it easier for the vehicle manufacturers or the system designers.

**Baroness Neville-Jones:** It has to be interactive possibly?

**Professor Nick Reed:** I do not think necessarily.

**Baroness Neville-Jones:** Not necessarily.

**Professor Nick Reed:** Not necessarily. There is benefit to management of traffic if there can be communication between vehicles and with infrastructure, and you would focus investment on the busiest routes to make that possible.

**Baroness Neville-Jones:** When you say it has to be consistent, are you saying that is so that the vehicle can recognise it, know what it is?

**Professor Nick Reed:** Yes, so that it can localise and understand the environment in which it is.

**Baroness Neville-Jones:** So you have to have standardisation of shapes and models of road furniture?

**Professor Nick Reed:** They are pretty well standardised already.

**Baroness Neville-Jones:** Is it?

**Professor Nick Reed:** Yes. Road designs are—

**Baroness Neville-Jones:** There are tons of things on the roadside that are not standard: crash barriers, et cetera.

**Professor Nick Reed:** A vehicle that has a digital map, so it understands its environment digitally, does not need any infrastructure; it does not need signs to tell it that it is a 30 mph limit; it knows from its location that it should be operating at a certain speed, and that applies to lane markings as well.

**John McCarthy:** On that point, I think typically when we talk about infrastructure we think about the physical, but in the world of autonomy and autonomous vehicles we have to think about the physical infrastructure and the virtual infrastructure, which is around the data side and the communications, and how we harness that data. From the physical perspective, it is whether road layouts that exist now are fit for purpose for the future, what exists and what might not be needed. I think the intelligence can be built into the infrastructure to allow conversations to take place as and when needs be, so that, particularly in safety-critical situations, the assets, the vehicle, the individual and the infrastructure can communicate with each other. From the virtual side, we need the ability to harness all this data and make sense of it, because we are migrating into an unbelievably data-rich world, and what we use it for and how we get benefit out of it is for us to try and understand in partnership with everybody else.

**Brian Matthews:** If I could add on the infrastructure point, with the low-speed pods we are operating in Milton Keynes, we are very confident and we have demonstrated they can operate with no infrastructure, but we recognise—and it is a point Nick made—that we have to support the needs of other travellers, so the infrastructure we are looking for is to support the cyclists, pedestrians, and other road users so these two systems can co-exist. A separate piece of work working with European partners is a project called Co-Exist, to try to understand what infrastructure requirements there are in the short term to allow the transition from the fleet as it is now to the fleet in the future, and provide some guidance and toolkit for highway design teams to understand what is needed in the short, medium and long term.

**Lord Oxburgh:** These are electric cars, are they?

**Brian Matthews:** The pods in Milton Keynes are powered by electricity, yes, but the cars are standard cars.

**Baroness Neville-Jones:** Does the speed at which a vehicle is travelling affect the calculus at all? Do you need more interactivity if you are going at greater speed to get more advance information, or do you not think that is a relevant consideration?

**Professor Nick Reed:** The speed has more of an influence on the quality of the sensors and the speed of processing of the data that it is able to collect rather than connectivity.

**Q37 Lord Hunt of Chesterton:** Have your trials been assisted or impeded by the current regulatory regime? Are you making recommendations for it to be changed?

**Professor Nick Reed:** The code of practice for testing automated vehicles that the Department for Transport introduced post-dated the award of the projects, so we all had the opportunity to influence the creation of that code of practice. We were thinking very much about how the code of practice would support the implementation of the GATEway project and the 10 other research projects we felt were important to be undertaken in the next three to five years. The regulatory environment has been supportive and we have been in regular dialogue with CCAV on how results from our trials can influence the changes to that regulatory world.

**Lord Hunt of Chesterton:** Is it quite similar to what they are doing in other European countries?

**Professor Nick Reed:** The point was made in the previous session about the differences in approach to the Vienna Convention on Road Traffic. That other European countries are doing everything they can to enable testing of automated vehicles in their own territories is bound to be happening, and certainly the Netherlands, Germany and Finland, I would say, are very active in the testing and development of automated vehicles.

**John McCarthy:** As part of the work within VENTURER, our team is made up of AXA insurance, complemented by Burges Salmon looking at the impact of autonomous vehicles in a regulatory way, understanding what the impact might be from a policy perspective. It is an ongoing engagement to understand what those impacts might be and how it relates to questions which have been raised here in different ways. I think the regulatory framework as it exists right now allows for testing. You must understand what can be possible for true deployment, ongoing engagement and full usage within the real world. That is part of the work we are looking to do across the three different trials, to understand from the technology perspective it is a complex scenario, but from an insurance perspective—and we talked about product liability rather than individual liability—the impact from a regulatory framework. That is what we look to do across trials two and three.

**Lord Hunt of Chesterton:** Does the fact that we are already number 25 in this list of countries in the world with infrastructure, as opposed to number one, make a difference to how you are developing these regulations? I can imagine in a country on average with poor infrastructure you would do things differently.

**John McCarthy:** I think they are linked. I do not believe they are intrinsically linked with regard to the regulatory aspect. The performance requirements and possibilities associated with autonomous vehicles having the right infrastructure—and we have to debate what that is—is a conversation that will take place anyway.

**Lord Cameron of Dillington:** Are we leaders in this field? Could we become leaders in the field, and what do we need to become leaders in the field? To what extent is information globally available between you and trials going on in other countries?

**John McCarthy:** We approach connected and autonomous vehicles as part of the bigger conversation, and that is around intelligent mobility; it is about engaging people, places and goods and re-imagining infrastructure. Are we leaders in the overall field of connected and autonomous vehicles? Within elements of it we probably are. The supply chain and the different parts that make up the conversation are huge. What we look to do within this piece is take a leading step within the understanding of user requirements, of the behavioural aspects, certainly from a VENTURER perspective, and from complementary works we have done, so a separate project, Flourish, looking at connected vehicles and the impact on the city, and the needs of the older population through the use of new technologies. I think we can lead in certain aspects, and it has to come back to the capabilities of the UK.

Connected and autonomous vehicles is a massive cake; I do not think we can eat all of it. I think we should look to have the vital ingredients, to use that analogy, to make sure that people will want to come to us. I think the testing environment allows that to happen because, first of all, it is real; secondly, the testing environment itself is real; thirdly, the innovation this country offers is respected globally and we should build upon that. That is what we are all looking to do within our three projects and the others that are mentioned.

- Q38 Baroness Young of Old Scone:** I think you have already partially answered the question about whether the testing regulation can be UK or needs to be European or international, but on operation for the future, do you think we can develop any of our regulation alone or does it have to be a global system?

**Brian Matthews:** We are certainly starting to talk to international partners on these topics. We have recently undertaken a roundtable discussion with cities in the US, Australia, Singapore, and Sweden around these issues, and the feeling around the table is that it has to be collaboration. That is not to say they were recognising that the UK in many of these fields is ahead of the game, and there is as much to learn from us as we can learn from them, but I believe it needs collaboration and we are taking steps to bring that forward.

- Q39 The Chairman:** You have described to us the three projects that you are involved in, and indeed there is a fourth soon to start. To what extent do you pool the evidence that you have accumulated and to what extent do you help each other out?

**Professor Nick Reed:** In the three projects we were competitors for the funding at the start but, having been awarded funding, we collaborate. I would say to date it has been more about getting our trials up and running. We have been busy making sure we are hitting our timescales for technical delivery, but now that we are

starting to deliver our trials, there will be more opportunities for us to collaborate and share data that is emerging. There is also a DfT-funded project to collect the social and behavioural outcomes from the three projects, integrate that and look at the emerging patterns from the three trials.

**John McCarthy:** In early December there is a further event organised, where all the winners within the space sit down and engage with each other, because the worst-case scenario is that we create silos of excellence. The benefit is across all of these areas and, as Nick said, we were competitors but now we are building on the capabilities, and with the separate project and the event in December, now that we have gained traction within our projects, we are probably at a level where we have something concrete to begin talking about and sharing our learnings and knowledge.

**Brian Matthews:** That certainly is a good point. When we started the projects everybody was very excited and wanted to see an autonomous vehicle the next day; the reality was they are not appearing for another six months or so. It seemed as if we all went into our shells but, as has been said, we are collaborating more openly now. Within the Autodrive project there is a work package for dissemination of the results, and that is key for us to get out there what our learnings are and share the results.

**The Chairman:** Unless anyone has a burning question they wish to put, we have probably run out of time, as usual. It has been a most instructive session and we could have continued at great length, particularly hearing more about tests around the world and to what extent they complement your activity. Time is against us. Thank you very much for helping us this morning. There will be a record of the deliberations circulated to you, and please make any amendments if the record is inaccurate. On behalf of the Committee, can I thank Professor Nick Reed, John McCarthy and Brian Matthews for joining us today? Thank you very much.

## **Government – Department for Transport (DfT) and the Department for Business, Energy and Industrial Strategy (BEIS) – Written evidence (AUV0084)**

### **Introduction**

1. The Government welcomes the opportunity to contribute to this Inquiry.
2. Connected and autonomous vehicles have the potential to affect many aspects of our lives. The Government is keen to ensure we make the most of the opportunities they offer, and has established the Centre for Connected and Autonomous Vehicles (CCAV) to keep the UK at the forefront of the development and deployment of this technology.
3. The Government’s approach to the regulation, research, development, and demonstration of connected and autonomous vehicles is differentiated by operating in a more collaborative and transparent fashion than almost any other country. We are taking forward measures, including through the forthcoming Modern Transport Bill to enable their safe development and introduction.

### **Impacts and benefits**

#### **1. What are the potential applications for autonomous vehicles?**

4. The Government’s focus to date has been on road vehicles, where automating the driving task could improve safety and open up new mobility options. In this sector “connected and autonomous vehicles” is an umbrella term for a number of distinct technologies; all enabled by developments in underpinning capability in computing power, sensing technology and data analytics.
5. Key aims of this technology are to automate the driving task (either to support or allow the driver to disengage from the driving task entirely) and to connect vehicles to other vehicles or to infrastructure (either to provide services to the driver, or to allow vehicles and roads to operate as a network to improve safety and efficiency). Many commentators believe these technologies will converge over time, though predictions for when and how this will happen differ.
6. Those developing automation technology are following two parallel tracks of development. Some are seeking to add automation to existing vehicles incrementally over time, building on existing Advanced Driver Assistance Systems (ADAS) such as Automated Emergency Braking (AEB). Others are seeking to leapfrog this approach and focus on fully automated vehicles that do not need a driver, with activity focused on urban or motorway driving.

7. Similarly, in connectivity, there are different tracks of development. Some manufacturers are focused on introducing new features for drivers such as navigation information and infotainment (in-vehicle information and entertainment not related to the driving task), using existing networks. These features are already available in vehicles for sale, with some estimates suggesting there are one million vehicles with this type of connectivity on UK roads. Other manufacturers are keen to introduce new technology to allow vehicles to speak to each other and to infrastructure. Much of the potential safety benefit from connectivity could come from networking in this way, either over the cellular network or via other technologies.
8. In addition to road vehicles, there are also a significant range of wider potential applications of automated vehicle technology, such as in ports and warehouses, hazardous environments (removing people from operating in dangerous conditions such as nuclear decommissioning, natural disasters), as well as a range of security and military use cases. More information can be found in the UK's 2020 Robotics and Autonomous Systems (RAS) Strategy published in 2014 on behalf of the industry-led, RAS Special Interest Group<sup>132</sup>.
9. Connected and automated vehicles are also expected to form part of the smart city ecosystem; both in transforming urban mobility and generating new sources of data that can help city authorities plan and manage infrastructure and service delivery in a more effective and integrated way.
10. Exactly what development path these technologies will take is still unclear. By adopting an outcomes-focused approach to the R&D and policy development, the Government intends to keep the UK at the forefront of the latest developments and well-positioned to secure sustainable, long-term economic value from their deployment.

## **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

11. Connected and autonomous vehicle technologies provide the opportunity for the UK to unlock and secure significant social and economic benefits and to demonstrate how it will use innovation to thrive in the world. Some early areas of focus are listed below. The Government plans further research to understand the benefits and disadvantages.
12. **Safety** – In the UK we have some of the safest roads in the world. Nevertheless over 1700 people are killed on UK roads every year, with many more being seriously injured. Human error is a factor in up to 94% per cent of all recorded road injury collisions in Great Britain (Department for Transport, 2015); automating the driving task has the potential to deliver significant improvements.

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<sup>132</sup> <https://connect.innovateuk.org/documents/2903012/16074728/RAS%20UK%20Strategy?version=1.0>

13. **Mobility** – Automating the driving task could improve mobility options for those currently unable to drive, whether due to financial, physical, sensory, or cognitive reasons. Extending inclusion will have social and economic benefits.
14. **Network efficiency** – Connecting vehicles to each other and to infrastructure could enable more efficient use of our roads by creating networks of vehicles that can interact with traffic signals and network operators. INRIX research has found that in 2014, English drivers spent on average 30 hours a year stuck in congestion, rising to 96 hours a year in the London commuting belt, in addition to regular commuting times<sup>133</sup>.
15. **Productivity** – In England, drivers currently spend on average over three working weeks each year driving. If drivers are safely freed from the driving task it may be possible in future for journeys to become more productive.
16. **Jobs and growth** – Industry estimates that these technologies could provide up to £51 billion benefit annually to the UK economy, creating over 300,000 jobs by 2030<sup>134</sup>.
17. Consolidating our early leadership in connected and autonomous vehicle technologies could spearhead our innovation-led industrial strategy, supporting regional growth and new job creation by combining our world class research base and global, cross-sectoral centres of excellence with our resurgent automotive industry and one of Europe's most productive workforces.
18. The Government believes these potential benefits are a strong justification for pursuing a leading role for the UK in the development of these technologies. At the same time there will be important risks to manage:
  - a. Connecting vehicles to networks and to each other will mean they will require a high degree of network security. It will therefore be important for the technologies to be safe and secure by design, and handle data appropriately.
  - b. Connected and autonomous vehicles could have an impact on the way our wider transport system operates, and on those who are employed within it. While some international studies suggest that certain jobs may be reduced by robotics and automation others maintain that many more jobs will also be created. For instance, it is estimated that, in the UK, connected and autonomous vehicles will create up to 320,000 jobs in the wider supply chain by 2030<sup>135</sup>. We need to understand these risks and act to shape the way the

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<sup>133</sup> <http://inrix.com/press/scorecard-report-united-kingdom/>

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[http://www.kpmg.com/UK/en/IssuesAndInsights/ArticlesPublications/Documents/PDF/Market%20Sector/Auto\\_motive/connected-and-autonomous-vehicles.pdf](http://www.kpmg.com/UK/en/IssuesAndInsights/ArticlesPublications/Documents/PDF/Market%20Sector/Auto_motive/connected-and-autonomous-vehicles.pdf)

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[http://www.kpmg.com/UK/en/IssuesAndInsights/ArticlesPublications/Documents/PDF/Market%20Sector/Auto\\_motive/connected-and-autonomous-vehicles.pdf](http://www.kpmg.com/UK/en/IssuesAndInsights/ArticlesPublications/Documents/PDF/Market%20Sector/Auto_motive/connected-and-autonomous-vehicles.pdf)

technology emerges to ensure that it delivers benefits for the widest group of people.

- c. To make progress, part of the development of the technology will need to take place in the real world. It is essential for the technology to be developed in a transparent and safe way, to allow members of the public to engage and shape the way it emerges, and to feel comfortable with it.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

19. Connected and autonomous vehicles have the potential to radically transform current mobility paradigms. In the long term this could mean transformative impacts on the nature, patterns and volume of travel, with wider impacts on spatial planning and other areas of policy. However, there is significant uncertainty over how the market will develop and what these impacts will be.
20. Overall, the need remains to continue to address the historic backlog of investment to keep the country moving and get our networks ready for the future. The background increases in transport demand will continue to be driven by population increases, urbanisation, and ageing.
21. Government is continuing to develop the evidence base around the complex and wide ranging potential impacts of CAV technology, to inform long-term infrastructure and policy decisions to ensure we are planning ahead and preparing for a range of alternative futures, and to ensure we can maximise the social and economic benefits of these technologies along the way.
22. Cars, rail, and public transport all serve different needs. For example, our cities have limited road space and public transport is essential to keep people and businesses moving. The speed and convenience of city-to-city rail travel is unlikely to change. If we see transport as a tool of economic policy, as well as personal mobility, then the power of rail to support sectors such as business services and finance is clear. More generally, new, high-quality transport assets have the power to reshape our economic geography.
23. We plan further research to help us understand the impact of connected and autonomous vehicle technology - including projects funded through the £100 million Intelligent Mobility R&D Fund, academic research, as well as modelling and scenario development.

### **4. How much is known about public attitudes to autonomous vehicles?**

24. Engaging the public in the development and demonstration of connected and autonomous vehicle technologies and maintaining their trust in its safety and security is vital. It is important for those developing the technology to engage with the public about the benefits and costs of these technologies openly and honestly.

25. The Four Cities Driverless Car Trials will involve testing of automated vehicles in real-world environments in Bristol, Greenwich, and Coventry and Milton Keynes. This will enable the public to see the vehicles up close, and build understanding of how the vehicles will fit into everyday life. Each of the trials has a discrete public engagement workstream to gather data on public attitudes to connected and autonomous vehicles, through surveys, workshops, and interaction with the vehicles. This will help to inform the focus of future research competitions and future policy development.
26. To increase our understanding of these issues, the Department for Transport will be launching a three year social and behavioural research programme to build our understanding of the attitudes, behaviours and wider acceptability of connected and autonomous vehicles for drivers, road users, transport stakeholders and wider society. This will build on other work, such as an HGV platooning trial, currently being commissioned by the Department for Transport and Highways England. Part of this work will consider the behaviour and attitudes of platoon drivers and other road users.
27. In addition, in the Traveller Needs and Capability Study (jointly funded by BEIS, DfT and Innovate UK), the Transport Systems Catapult surveyed over 10,000 people and from this have identified the key drivers for travellers, and how the development of connected and autonomous vehicle technologies can assist in meeting their future needs across an increasingly connected and autonomous transport system. It also addresses how the key “pain points” experienced during an everyday journey can be ameliorated or solved.

## **5. What is the scale of the market opportunity for autonomous vehicles?**

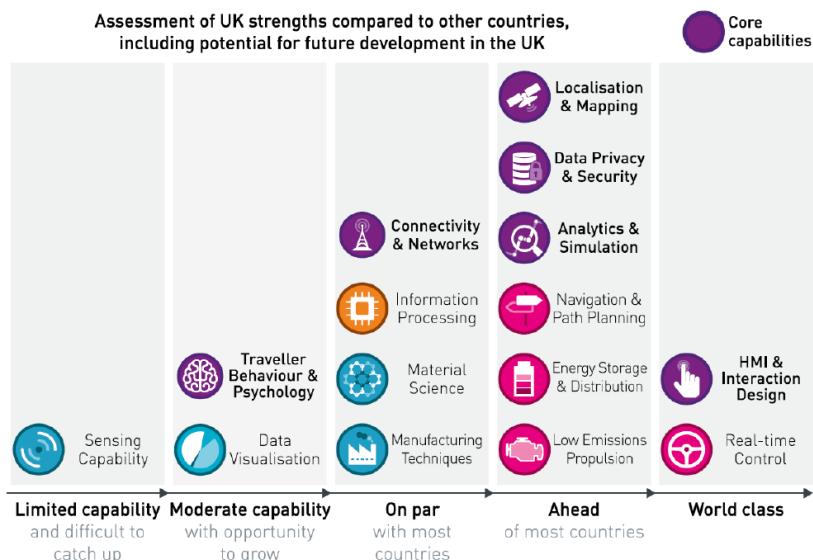
28. Connected and autonomous vehicle technologies are still at a relatively early stage of development. There is great uncertainty around deployment and market penetration rates. However, many leading figures in the automotive industry believe the impact is likely to be as great as anything that the sector has ever experienced. General Motors’ CEO, Mary Barra, has suggested that the sector will, over the next ten years, experience greater disruption than over the past fifty years. Significant investment in these technologies is taking place among vehicle manufacturers, automotive industry suppliers, and new entrants to the market.
29. Early estimates from industry suggest that if the UK can consolidate its early leadership position, success could be worth up to £51bn annually in socio-economic benefits to the UK by 2030. The Transport Systems Catapult believes the (more broadly defined) global “intelligent mobility” could be worth up to £900bn by 2025<sup>136</sup>.

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<http://www.kpmg.com/UK/en/IssuesAndInsights/ArticlesPublications/Documents/PDF/Market%20Sector/Auto-motive/connected-and-autonomous-vehicles.pdf> and <https://ts.catapult.org.uk/intelligent-mobility/market-breakdown/>

30. The Government plans to take forward further research on the connected and autonomous vehicle supply and value chains with the Transport Systems Catapult and Innovate UK to determine where the UK should best focus its resources to achieve sustainable, long-term economic growth and high quality job creation. The Traveller Needs and Capability Study (referenced above) produced the initial assessment of where the UK strengths lie (below).



Relative global capability of UK technology in intelligent mobility, including CAVs (Transport Systems Catapult)

## Creating an enabling environment

### *Research and development*

#### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

31. The UK has a world class research base and global centres of excellence in automotive, software development, as well as world centres of law, insurance, finance, computer games, and telecoms. Two of the world's best vehicle test tracks – Horiba MIRA and Millbrook – are located in the UK.
32. In addition, we have one of the most open regulatory frameworks for testing of connected and autonomous vehicles in the world, set out in July 2015 in the guidance document "A Pathway to Driverless Cars: A Code of Practice for Testing". A key feature of this framework is that trials are possible on any road in the UK.
33. These strengths enabled the current UK trials of automated vehicle technology, each interdisciplinary project involving many collaborators such as global corporates, telecoms, insurers, local authorities, universities, and SMEs. They have also prompted

the establishment of new testing environments in Coventry, Milton Keynes, Greenwich, Culham Science Park, Cranfield University and elsewhere.

34. While these facilities are world class, competition for global leadership in this field is fierce, and the Government believes that we will need to do more in future to continue to be able to compete.
35. Over the summer the Government issued a call for evidence to industry to identify how to improve the UK's test environment for connected and autonomous vehicles. In particular, it asked whether there is a case for a new flagship test bed to provide a focus for this activity. Responses to this consultation are now being considered and a response will be issued in due course.
36. In addition, the Government is investing significant funds into R&D which we believe will create a pipeline of high quality UK R&D projects to lock in and maximise the value to the economy. This is discussed in more detail below.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

37. Government has acted quickly to secure an early leadership position in the research, development, and demonstration of connected and autonomous vehicle technologies. We have done this by establishing a world-leading regulatory environment and by investing significant funds in R&D.
38. Building on the £19 million four cities driverless car trial announced in 2014, the then Chancellor announced a further £100million at Budget 2015 for an Intelligent Mobility Fund for research in this area, to be match-funded by industry.
39. The winners of the first, £20 million, competition were announced in February 2016, with eight collaborative R&D projects and 13 feasibility studies receiving funding. This has resulted in total project costs of around £30 million with an additional £10 million being injected into the UK's research base. A second, £35 million, competition is currently open. This competition includes a ground-breaking challenge prize of up to £15 million to demonstrate a highly automated vehicle in a range of environments. There is currently no other challenge quite like this.
40. The Centre for Connected and Autonomous Vehicles is working with Innovate UK, industry and the research community to better align UK research and development efforts and ensure that investment in supporting the development of connected and autonomous vehicles technologies is effective, targeted and derives maximum value. As part of this, we will work with key groups such as the Automotive Council to enable development of suitable roadmaps and ensuring that government funded research activity is effectively disseminated and helps to inform wider research efforts in industry and academia.

## **8. How effective are Innovate UK and the CCAV in this area?**

41. The Government believes it has the right plans in place to succeed in this area.

## **9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

42. In such a fast moving field it is important to make it as easy as possible for UK SMEs to get involved in the development of the technology.

43. UK SMEs have seen some success and are involved in many of the R&D projects taking place across the UK. Oxbotica, a spin out from the University of Oxford, has publicly launched Selenium – an autonomous control system. FiveAI – a Cambridge/Bristol based Artificial Intelligence startup is now working on an autonomous vehicle control system.

44. However, more needs to be done for SMEs to gain access to the facilities and kit they need for testing. Government will continue to discuss and engage with SMEs to understand how best to support their involvement in this sector, removing barriers to entry, enabling testing at various scales and in different environments, and providing routes to market. These were persistent themes in the Call for Evidence on the UK testing environment mentioned above.

### ***Real world operation***

## **10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

45. As connected and autonomous vehicle technology is still in an early stage of development it is not possible to identify precisely what infrastructure changes will be necessary to enable them. Views in industry differ about what will be needed to operate their systems. Some operators have said, for example, that clearly defined white road markings are integral, other operators have said that wide spread connectivity is more important to allow for the automated vehicles to download road information as they are travelling.

46. To help us determine the appropriate policy response we will continue to engage with industry and with international partners to understand the implications of different scenarios. Projects such as the UK's A2-M2 Connected Vehicle Corridor will be testing different communication requirements, and the associated infrastructure, for broadcasting traffic information into road vehicles. Alongside this work we will continue to build our evidence base and business case for future deployment.

47. As the technology is still in its infancy it is important we remain flexible and consider how the technology will develop to avoid locking in to systems which become obsolete in the long run.

## **11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

48. The move to automated vehicle technology will require close working between government, industry and academia to create the right regulatory and insurance frameworks and to provide the public with assurance that the technology is being developed safely and will improve their lives.
49. In 2015 the Government published “The Pathway to Driverless Cars”, a regulatory review of what will be necessary to enable the testing and development of automated vehicle technology. The publication of the “Code of Practice for the Testing of Automated Vehicle Technologies” later that year was a key milestone on the pathway. It provided guidance on organising tests for automated vehicle technologies on public roads and in public places whilst maintaining safety.
50. Consultation with industry since the publication of these documents has identified insurance as a priority area for reform to enable the development of the technology. Our current motor vehicle system requires that the driver is insured, and when drivers disengage from the driving task entirely, and hand control and responsibility to their vehicle it is possible that gaps will start to emerge. These gaps, such as no clear route to compensation in the event of a collision involving an automated vehicle, could hinder innocent victims from getting compensation quickly and easily – a cornerstone of our insurance practices. For that reason, the Government has consulted on the issue<sup>137</sup> over the summer, and will bring forward measures in the Modern Transport Bill to update our motor insurance framework so that it is ready for the introduction of automated vehicle technology.
51. We will continue to engage widely as the technology develops to ensure our framework remains appropriate to safely enable people to enjoy the benefits of the technology. Given the uncertainties in how the technology will develop, it is important for Government to create as open as possible a framework to avoid stifling any particular technological pathway.

## **12. Does the Government have an effective approach on data and cybersecurity in this sector?**

52. We believe that these technologies must be secure by design and handle data appropriately. We are working closely with the security community and the UK’s leading cyber-security sector (which is in the top three worldwide), together with industry, other countries and international standard-setting bodies to promote a vision for a secure connected and autonomous vehicle ecosystem that articulates the social, economic and commercial case for security by design and appropriate data protection.

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<sup>137</sup> <https://www.gov.uk/government/consultations/advanced-driver-assistance-systems-and-automated-vehicle-technologies-supporting-their-use-in-the-uk>

53. We are developing guidance on cyber security which we intend to publish. We are also pressing for international coordination and investigating other options for government intervention including standards, regulation and consumer information.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

54. As referenced above “The Pathway to Driverless Cars” regulatory review set out key changes that will be needed to enable the development of automated vehicle technology. The Government has taken forward many of the actions identified in that review, including issuing guidance for automated vehicle testing, and plans to continue to work with the automotive and the insurance industry to address others.

55. This is a sector which is developing at pace but we are still at an early stage in the development of the technology, and there are still some tough technical challenges to overcome. As the focus of industry is likely to adapt to developments in their research programmes, it will be important for Government to remain flexible and we will need to adjust our approach to focus on the current state of play at any given time

56. In addition, some aspects of road vehicle regulation are handled internationally to facilitate the export for sale and cross border use of vehicles. We expect, for example, that the sale of automated vehicles will be underpinned by technical standards set in Geneva by the UN Economic Commission for Europe. The UK wields significant influence in this forum, and chairs the global experts committee designing the standards for automated functions in road vehicles.

57. Given this, we have necessarily had to choose where to focus our efforts and design a rolling programme, with waves of reform. In doing so we have been guided by the following principles:

- a. Ensure safety is at the heart of the approach. When the technology is perfected it will save many lives, but people in the UK will also expect the development process to be safe and secure too.
- b. Keep the UK in the lead. If another country has found a freedom that does not exist here then we look for ways to address that.
- c. Focus on the problems that are most pressing. We have been led by intelligence from the UNECE process on which technologies are closest to market and our assessment of which elements of the regulatory framework need to change to ensure we provide the right testing landscape for industry to make progress.

58. As referenced above, over the summer the Government consulted on the first wave of reform, some of which will be taken forward as part of the Modern Transport Bill.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

59. Connected and autonomous vehicle technologies offer significant social and economic benefits but there are a number of potential ethical, legal, and wider social issues linked with some uses. Government has a role to play in managing and mitigating any risks that might arise.
60. It is important to strike a balance within the regulatory framework to ensure that laws are in place to prevent harm to humans, while at the same time ensuring that innovation is not stifled and any barriers to the development of these technologies are removed where possible. For example, Government has undertaken a regulatory review (explained elsewhere in this submission) for connected and autonomous vehicle applications in order to inform future regulation and research.

***Wider governance***

**15. What does the proposed Modern Transport Bill need to deliver?**

61. The Government plans to take forward measures to update our legal framework for motor insurance to prepare for automated vehicle technology (as set out above). The Government consulted over the summer on these measures and will respond to the consultation in due course. The insurance industry will need time to prepare for the changes that the introduction of automated vehicles will bring, and by making changes to the way that motor vehicle insurance legislation now, we will provide the insurance industry with that time.
62. It is important to remember that much of the technology which will require regulatory change to use safely is still being developed. And, until the technology is more mature, it is not sensible to change regulations now. So, we will use our rolling programme of regulatory reviews and, where necessary, reform, to make the required changes to primary and secondary legislation, and guidance, when we have a better understanding of how the technology works. That way, we can make sure that our regulations, and guidance, will help people and businesses to safely use, and thus, benefit from connected and autonomous vehicles.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

63. The UK is operating from a position of some strength but the rapid growth of the sector presents a challenge now and in the future with increasing competition for vital – but readily transferable – talent from across sectors i.e. the financial technology sector and from other parts of the world, i.e. Silicon Valley.
64. In October 2016, the Transport Systems Catapult published a “Intelligent mobility skills strategy: Growing new markets in smarter transport”. That report concluded that, in the wider Intelligent Mobility sector which encompasses connected and autonomous vehicle technologies, the UK faces a potential skills gap of 742,000

people by 2025. Using a wider skills approach they identified that around 1.159 million individuals will be needed against an estimated supply of 417,000.

65. The Science and Technology Committee Report on Robotics and Artificial Intelligence published in October 2016 echoed the findings of the Transport Systems Catapult but suggested that there has been a shift in graduate career choices.
66. The Government will be considering this alongside other work to identify the skills we need to succeed in future.
67. Alongside this, the DfT has launched its Transport Infrastructure Skills Strategy, which makes a commitment to 30 000 apprenticeships by the end of the parliament – this is across roads and rail sectors and down supply chain. CEOs (or equivalent) of Network Rail, Highways England, Crossrail, HS2 Ltd. TfL, all signed up to this commitment. The Strategic Transport Apprenticeship Taskforce (STAT), is the primary delivery vehicle for the strategy and was launched in April this year. The STAT will report on progress annually. The first report is due in the spring of 2017.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

68. Connected and autonomous vehicles are seen as the first robots that the general public will encounter day-to-day but, as referenced above, there are a significant range of other applications.
69. British-Australian mining company, Rio Tinto, is currently running 69 driverless trucks in its Australian iron ore mines in Pilbara and operated from Perth, 1,200 kilometres away. The trucks run 24 hours a day and remove the human driver from a dangerous occupation. The trucks move about 20 million tonnes of material a month and have travelled more than 3.9 million kilometres since they were deployed in 2012.
70. As part of the UK Atomic Energy Authority, the RACE (Remote Applications in Challenging Environments) facility in Culham, Oxfordshire, is conducting R&D and commercial activities in the field of Robotics and Autonomous Systems (RAS), again exploring how to remove people from dangerous environments, such as nuclear decommissioning. (Automated vehicle testing is also taking place in Culham as Oxtbotica has recently made the facility its testing site.)

71. In Agriculture

- a. Ordnance Survey recently announced a partnership with American agricultural machinery manufacturer, CNH Industrial, to test driverless tractors near OS's headquarters in Southampton.
- b. The 2013 AgriTech strategy set out the establishment of four Centres for Agricultural Innovation with £68m funding from the Department for Business,

Energy and Industrial Strategy (BEIS), (matched by industry). The first of these centres, Agrimetrics, a world class big data centre was launched by ministers in October 2015; the other three will be launched this autumn. One, the Agricultural Engineering Precision Innovation Centre (Agri-EPI; £18 million over four years) will help the UK's agri-food sector develop advanced technologies that will increase productivity and sustainability in UK agriculture. It will explore, among other things, research projects examining robotics for planting, monitoring and harvesting crops.

72. The UK is recognised as a world leader in robotics, autonomous systems and artificial intelligence. BEIS will work with industry and academia to explore the full range of opportunities presented by Robotics and Autonomous systems and considering its potential within the wider industrial strategy

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

73. We understand the concerns of industry and it will be a priority of our negotiations to support UK car manufacturers and ensure that their ability to export to and from the EU is not adversely affected by the UK's future relationship with the EU. However our automotive sector is strong. Car production hit a 10-year high in 2015, increasing nearly 4% from the year before. 163,000 people are directly employed by the sector and another 330,000 in the supply chain.
74. The UK is a world-leading location and welcoming partner for the research and development of new automotive technologies required in all global markets in the coming decades, from zero emissions to connected and autonomous technologies. We are also a leading market for the testing and deployment of those technologies.
75. Securing our world-leading position in the research and development of these technologies, along with our rolling programme of reform to keep our regulations up to date, will help the UK continue to support regional growth, high value job creation, and our resurgent automotive sector.
76. There is a real opportunity for this to become a success story, demonstrating how the UK can and will retain global influence and thrive post-Brexit. For research, development, and demonstration of these technologies, the funding and most of the regulations are within our control.
77. The UK programme is differentiated by operating in a more collaborative and transparent fashion than almost any other country. This approach is already having an impact. Recently both Volvo and Jaguar Land Rover have separately announced high profile research programmes of around 100 highly automated vehicles in the UK. The former demonstrates that the UK is attractive for globally mobile investment; the latter that we are growing world-leading capability in the sector.

*28 October 2016*

Government – Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), and Ian Yarnold, Head of International Vehicle Standards Division Department for Transport (DfT) – Oral evidence (QQ 1-10)

**Government – Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), and Ian Yarnold, Head of International Vehicle Standards Division Department for Transport (DfT) – Oral evidence (QQ 1-10)**

[Transcript to be found under Government – Ian Yarnold, Head of International Vehicle Standards Division, Department for Transport \(DfT\)](#)

Government – Rt Hon John Hayes CBE MP, Minister of State, Department for Transport (DfT) and Nick Hurd MP, Minister of State for Climate Change and Industry, Department for Business, Energy and Industrial Strategy (BEIS) – Oral evidence (QQ 63-74)

**Government – Rt Hon John Hayes CBE MP, Minister of State, Department for Transport (DfT) and Nick Hurd MP, Minister of State for Climate Change and Industry, Department for Business, Energy and Industrial Strategy (BEIS) – Oral evidence (QQ 63-74)**

Tuesday 22 November 2016

[Watch the meeting](#)

Members present: Earl of Selborne (Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Hennessey of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Neville-Jones; Lord Oxburgh; and Baroness Young of Old Scone.

Evidence Session No. 8

Heard in Public

Questions 63 - 74

**Examination of witnesses**

Rt Hon John Hayes CBE MP, Minister of State, Department for Transport (DfT) and Nick Hurd MP, Minister of State for Climate Change and Industry, Department for Business, Energy and Industrial Strategy (BEIS).

**Q63 The Chairman:** We are most grateful to you for joining us this morning. This is our last oral session of evidence in our inquiry on autonomous vehicles, for which I think we should say “connected and autonomous vehicles”. We are being broadcast, so I will ask if you would like to introduce yourselves, and if you would like to make an opening statement before we go into the questions do feel free to do so. Would Mr Hayes like to start?

**John Hayes:** I am John Hayes and I am Minister of State at the Department for Transport.

**Nick Hurd:** I am Nick Hurd and I am Minister of State at the Department for Business, Energy and Industrial Strategy.

**The Chairman:** You do not want to make an opening statement?

**John Hayes:** I would be delighted to do so.

**The Chairman:** I am giving you the choice.

**John Hayes:** Schumacher said in his seminal book *Small Is Beautiful* that “the system of nature of which man is a part tends to be self-balancing, self-adjusting, self-cleansing; not so with technology”. There are two things I will say at the outset.

There is a kind of Whiggish assumption that all change means progress, which I completely refute. Of course, the truth is that in each and in all of our lives many things change, some for the better and some for the worse. Part of the job of Government is to try to anticipate those changes and the effect they might have on communal well-being, personal opportunity and fulfilment.

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The second is that, sadly, in that spirit and context, governments are notoriously bad at thinking both laterally and long term. This is not a reflection on this Government or the previous one, it is a comment on governments generally. This is for two reasons, in essence, Chairman, as you know. First, to think laterally requires them spanning all kinds of responsibilities and departments and ministers' work, and to think long-term in a democratic polity means freeing oneself from the inevitable consideration of the five-year electoral cycle. To predict and think long-term is risky for government, risky for the officials who advise ministers and risky for ministers themselves.

Bearing in mind my two hypotheses, where does that leave us in respect of autonomous vehicles? We have to do, it seems to me, two fundamental things. The first is to try to establish a regulatory framework sufficient to allow us to take advantage of the opportunities these vehicles offer whilst not assuming that those who develop the technology and those who market it will be motivated in the first instance by virtue. When I was a businessman, I was interested in the commercial success of my business and nothing much more than that. We should not expect, and it is not reasonable to expect, the technologists and the businesses associated with this to take that bigger, societal, communal view.

The second is that we need to measure across government what the consequences and ramifications of these changes might mean. They have implications for all kinds of things, as your inquiry has no doubt already identified, Chairman, in all kinds of aspects of government: employment, urban planning, the very concept of ownership, accessibility, safety, and so forth. They cross a series of ministerial portfolios and touch on a series of departmental areas of concern. I am mindful that your inquiry will be exploring all those things, but it is important that this important Committee knows that we understand those things too. This is not a straightforward matter, Chairman, and no one would pretend it is, but we are determined to try to think, as much as governments ever do, widely and in the long term.

**The Chairman:** Thank you very much.

**Nick Hurd:** Chairman, could I complement that, and I will be considerably more prosaic and much less interesting than my friend John?

I represent the Department for Business, Energy and Industrial Strategy, so our primary interest is in the industrial opportunity that, in theory, underpins this area. We are delighted by the interest of the Committee in it, but obviously the immediate context is our preparation of an industrial strategy. The primary driver of that is tackling the imbalances of prosperity and productivity across the country and getting a clearer view on where the decent jobs and decent wages will come from in the future.

Part of the reason why a strategy is required is that it is very clear that many key sectors of our economy face huge levels of change and, arguably, none more so than the auto sector, which is very important to the economy. That is why we have been very keen for some time to try to position the UK as a go-to destination for the research and testing of connected and autonomous vehicles because we are clear that, in theory, there exists a substantial industrial opportunity for the UK going

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forward, so we have set up what seems to be a competitive stall in terms of research and development, the regulatory environment and the testing environment. I would expect this to be an important feature of the industrial strategy going forward in the context of the future of the auto sector and the very fundamental discussion about the future of mobility.

**The Chairman:** Thank you very much.

- Q64** **Lord Hennessy of Nympsfield:** I really appreciated the width of your opening statement; I found it very interesting. I note that you stress that it is a very risky thing for any government to think long-term, but can I ask you, therefore, to take a bit of a risk, to take a walk on the wild side and start us off, Mr Hurd too, with a bit of horizon-scanning. What do you think are the risks and the drawbacks in the assessment you can already make from what you know of this move to autonomous vehicles and other sectors of the economy which will be automated? Can you take a very non-Whiggish, practical view of the social and human aspects of all this, because I am one of those people who thinks we will have to change human nature if this is going to work, a bit of a sceptic? With all those caveats in mind, which you have expressed so eloquently, take a walk on the wild side into the future. Have you seen the future and is it going to work?

**John Hayes:** Like Lou Reed?

**Lord Hennessy of Nympsfield:** Exactly.

**John Hayes:** I have written to the chief scientist today to support a piece of work that my officials have already been persuading him to take on the future of mobility generally, because you have to put this in that context. This is about the future of mobility, about, in a sense, why people travel, where they travel and how they travel. Whilst it is important to be specific about autonomous vehicles, and I will be in a second, it is important also to understand what you have implied, that there is a very significant, bigger thing happening in respect of technological change which challenges some of our core assumptions about why, where and how people travel. I am hoping that we will get that piece of foresight work of the depth and character that you wish and I wish too.

**Lord Hennessy of Nympsfield:** Can you make sure the Committee gets sight of that?

**John Hayes:** I will give the Committee sight of my letter. Assuming we are successful in getting the chief scientist to agree to engage in this work, clearly it will be very important that the Committee gets, at the earliest opportunity, the modus operandi of that, the terms of reference of the work that I am describing, so I am happy to provide that, of course.

The second thing is on the specifics. We have already engaged in pieces of scoping work to look at a range of issues. One is around insurance, and of course we have the modern transport Bill, which will be published next year, which is an opportunity to give some of that statutory life, so insurance is important, and liability. It changes, of course, a lot of what we currently know about liability, so the insurance aspects of this are important. Clearly, the safety aspects are very important. This could provide a significant advantage in terms of safety and could make driving safer, providing we

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do the diligence in respect of the technology itself and that the technology is sound, because it will eliminate human error; human error is the principal cause of most road traffic accidents, of course.

Third, I think it might be beneficial in respect of accessibility. There are all kinds of people who do not drive because they cannot drive, which might be due to infirmity, disability, age, et cetera, and those people might now be able to have access to travel which they do not have currently, so there is a significant societal implication.

Finally, and I could go on and on, Chairman, on the positives, it may lead to more car-sharing and a different perspective on the ownership of vehicles. Essentially, people will acquire a car when they need it, rather like they might book a taxi now when they need it, rather than having a car sitting in the drive for long periods of time or sitting in a car park for a very long period of time, so that could be beneficial in terms of the numbers of cars on the road with the knock-on effect on congestion, emissions and so on. Those are some of the ups.

On some of the downs, let me just flirt with those for a moment rather more briefly. I think the principal down is in my opening remarks in assuming that somehow the market will regulate this and that it will all work out okay in the end. If we were to go down that road and assume that somehow this technology will regulate itself and will all work out okay, without doing all the diligence on some of the things I have described, we might find ourselves in very deep waters. Part of the downside is in not identifying and qualifying the potential of the upsides.

**Lord Hennessy of Nympsfield:** Does Mr Hurd have a vision?

**Nick Hurd:** My powers of imagination are significantly more limited than my friend's, but I am the Minister for Climate Change as well as industry, so what I can see is that what we drive will change profoundly over the next 10 years, both in terms of not just the carbon imperative but the clean air imperative as well; that is clear to me.

I can see how the technology in-car is changing so fast that the efficiency with which we drive will be evolutionary and, I think, radical. Whether that leads us to a future where we do not drive I am not sure, but it is clear that clear thinkers and leaders in the auto sector think that is the future.

What is clear to me is that our attitude towards the car is changing. I have six children, four of whom are of the age when they could drive, but only one does. Their attitude to car ownership is completely different from mine when I was growing up, so there is profound change going on inside the sector which matters a great deal to our industry, and I come back to that point.

The Government have to be alive to the industrial opportunity that underpins this, and clever people have produced, inevitably, reports that go with every transformative technology pointing to billions of pounds of upside and hundreds of thousands of jobs. Who knows, but there clearly is the potential for a big industrial opportunity and, therefore, the Government have to be alive to it and on it.

- Q65** **The Chairman:** I want to move on to the problems of operating a mixed fleet. It is clear that there is a role for fully automated transport systems. We know they are already in mind. For example, in Western Australia, there are fully automated

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vehicles running, there is the London Docklands Light Railway, a different kind of transport system, forklift trucks, farm machines, all these fully automated with no great problem, I suspect, in advancing them safely. When it comes to operating a mixed fleet on our existing roads, it is very different. What research have you done on the practical issues of managing a mixed fleet on the UK networks?

**John Hayes:** There are several things. The first is that we have developed a code of practice which sets out simple recommendations for how we test these vehicles anywhere in the UK. As well as some of the things I have described, roadworthiness, insurance and the ability of someone to take over, should they need to do so, but not necessarily in the car, part of that will, of course, be the interface between these vehicles and other vehicles in the mixed way you describe. We are ahead of our competitors, by the way, as Nick will know, in these terms.

The second, of course, is that, because we are keen to test these things in the real world, we are working, as you will also know, with four projects in four cities across the country—Milton Keynes, Coventry, Greenwich and Bristol—and there will be further projects. The Government have funded this, as you know. We are looking here, in part, to develop and demonstrate a highly autonomous vehicle in a mix of challenging environments. The purpose of that is to look at real road experience, part of which is how these vehicles fit into an existing driving landscape, which is precisely what your question is about. There is a challenge here in supporting the R&D, which we are clearly doing, which is designed to make sure the innovation happens here, and then in getting the rollout into real places where we can test these vehicles on the road. Both matter and the Government are backing both.

**The Chairman:** In your written evidence, which the two departments kindly submitted, you gave us a chart which shows our relative capacity in rolling out intelligent mobility. We are doing pretty well on that and are ahead of the game in, I think, eight, average in three and we are below on sensing capability, traveller behaviour and psychology, and data visualisation. If we are to lead the world in intelligent mobility, as is the Government's intention, will we try to catch up in these areas where we are behind the curve?

**John Hayes:** Yes. The departments have a three-year project to try to draw together and identify key questions about behavioural change, and public engagement is a critical part of ensuring that we do catch up in those terms. As I described, the human interface for this changing technology is critically important not only to its acceptance but to the effect it has on societal change, well-being and the other things I described at the outset. Yes, we are determined to catch up by engaging the public in a formal way.

**Q66 Lord Mair:** Mr Hayes, I want to ask you a bit more about how connected and autonomous vehicles will fit in with the transport strategy. You spoke earlier about future personal mobility and the big advantages it, potentially, will have. Is there a possible problem with that increased convenience and personal mobility that will be available in that it might lead to an increase in journeys by car and possibly less walking, less cycling and less use of public transport? Will that, conceivably, lead to increased congestion?

**John Hayes:** That is an interesting question and one I posed in the department myself, by the way, because, if I am right that this could lead to more vehicle-sharing, a different perception of ownership, whether to own a vehicle or simply use a vehicle when required, that could have a net effect of the opposite kind, reduce the number of cars on the road and reduce the number of journeys. However, there is a simultaneous effect of the kind that I mentioned and you have amplified, that it will bring other people on to the road who are not there now or may bring them from one vehicle to another vehicle, so from a bus to a car or from a tram to a car and so on. I have asked the question, and this will form part of the modelling we do, which will be partly in the research we do and partly in research that we commission, as I mentioned earlier: how do we calculate what the likely effects of those two simultaneous and contradictory changes might be?

In addition, it is important, as implied by you and the Chairman, that we are mindful of our policy on buses, trains, taxis and trams accordingly because, if we were not to take into account the effect that it all might have in some of the orthodox assumptions about the use of those vehicles, we would be falling into precisely the trap that I outlined at the outset of thinking in a silo. It is really important that we do not hurtle in one direction with our public transport policy only to be hurtling in a different one with autonomous vehicles, so I entirely agree that this has to be thought of in a holistic way.

**Lord Mair:** Do you think the department will have to have quite strict policies to influence the directions that society might go in? This is already all about people's adoption of autonomous vehicles, so will the Department for Transport have to have a policy to try to influence that, do you think?

**John Hayes:** You will know that your House of Commons equivalent Select Committee, or not quite equivalent because that would be the Transport Committee, but a Select Committee in the House of Commons on this very subject of motoring in the future, in its eighth report in the session 2014-15, said: "Witnesses to our inquiry ... highlighted the need for strategic leadership by central Government to shape the outcomes that could be delivered by new motoring technology". It is precisely that kind of strategic approach of the kind you now recommend that the department will have to take. To be frank, I think that will need to be informed by an empiricism that might well best be gleaned from the kind of scientific and independent work that I described earlier. We will want to do this in the department and we will base those policy assumptions on a very good evidential understanding which can come from commissioning the sort of work that I mentioned.

- Q67** **Baroness Neville-Jones:** I am going to pursue the word you just used, Mr Hayes, the word "strategic". I entirely agree with what you have just said. You mentioned that we need to think long-term, and that is also extremely welcome. It seems to me that the Government need not only to think long-term but to help set frameworks long-term and lead long-term. I really want to explore with you the sorts of mechanisms. It has been well said and understood that what we are talking about here has huge implications right across many sectors. For instance, can you get these vehicles on the road without having sufficient 4G? What is the role of DCMS in this and is it

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involved? More than a year ago, when Greg Clark was still the Universities Minister, he said, “We need to set up, and we will set up, a leadership council for robotics and artificial intelligence”. That seemed to us to be a very good idea when he gave evidence to that effect, but it has not happened. In the light of what you have just been saying, do you have any comment on that, whether there is an intention to do it and the extent to which the Government should be in the van of trying to shape progress in this area?

**John Hayes:** It is interesting that you obviously were, as I was, studying the House of Commons Science and Technology Committee, your exact parallel committee, and their report on precisely the subject you describe to which evidence was given of the kind you have highlighted. One of the elements of that report suggested that “appropriate legal and regulatory frameworks will need to be developed to support the widespread deployment of robots and, in particular, autonomous systems”, exactly as you describe. I think, if I might say so, that you are right—we do need to do extra work across government in this respect. I will study what Greg Clark said at that time, because I do not have that in front of me, and look at whether we have done enough to follow it through and, frankly, if we have not, we will.

**Baroness Neville-Jones:** I think part of the implication of what he was saying was that it is not only, and I entirely agree, that the Government need to have an all-government approach, which I think is easily understood, but you also in this area, it seems to me, need to have a partnership with business, so you have several elements that need to come together in order to give the leadership that is really needed.

**John Hayes:** Yes. The engagement with business is undoubtedly there. My officials are in extremely regular communication with the people who are developing this technology and I was with the motor manufacturers yesterday when we were discussing this subject, as you might imagine, so both Ministers and officials are in regular communication. I wonder, given what you have said and what I have been reading in preparation for this meeting, whether we might formalise that a bit more. There are all kinds of committees that sit, and I do not need to bore you with the details of them, and those are part-driven by BEIS, as you know, which I have also been a Minister in, and other organisations. It might be that we need to formalise that and I am very happy to go away and think about that and, having done so, write to this Committee promptly. I want to look at what Greg said and at what we are already doing, if I might say so, but I do not rule anything out. I think you are right, that the better that we can communicate, the better we might be able to anticipate the change.

**Nick Hurd:** If I could just complement that: your point is very well made. Clearly, this is an area that requires a strategic approach because there are different dimensions to it, but that is exactly the approach we are taking through the industrial strategy, which is cross-government, and will have, inevitably, a sector focus, but in a different way from before. We will be saying to sectors, of which the connected and autonomous sector will be a very valid example, “There is clearly a big economic opportunity here. What do we need to do together to make sure that we remain competitive in this area and, through the industrial strategy process, how can we

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move from A to B on a cross-government approach so that we can bring in the other departments?”

The Automotive Council, which has been enormously successful and fundamental to the regeneration of the auto industry since the financial crisis, is a very good example of where these councils can add a tremendous amount of value. To the Robotics and Autonomous Systems Leadership Council, you are quite right: my boss, Greg Clark, did make statements of intent before and we fully intend to revisit that in the conversation with the sector through the process of the industrial strategy. We just feel that we need to refresh that conversation through that process to check whether that is still the right idea and still adds most value. Our instinct is probably yes, but we just need to refresh it.

**Baroness Neville-Jones:** I think that some visibility given to the notion of leadership of the kind we have been discussing would be very helpful in pushing things on.

**Nick Hurd:** I could not agree more.

- Q68 Baroness Young of Old Scone:** Could we take the strategic approach slightly further? In your department’s evidence the dilemma was outlined of whether this is going to primarily be about automated vehicles or a much bigger systems issue where we are talking about interconnected transport, communications and road structures, which is bigger than all of us, a very big task and probably a task that needs to be grappled with now if we are not going to have inappropriate structures, processes and road systems for the future. Where is the Government on that bigger whole-systems approach?

**Nick Hurd:** I think what is important here is that no one quite knows how this is going to play out. What is key, to my eyes and the focus of our strategy as a department, is to try to make sure that the research, so the demonstration, the testing, the thinking and, therefore, the potential IP, is being developed in this country so that we have, if you like, the best possible view on what the future might hold because the people thinking the future are here. I think that is the first step. Again, in the very practical world that I live in, my first question is: what can we do to make sure that the thinkers, the people who are going to shape this future, are operating in the UK? That is why we have set out the stall we have done in R&D, regulation and the testing ecosystem, and it does appear to be highly competitive.

**John Hayes:** I mentioned the scoping study we have done on behavioural changes, which we commissioned in February 2016, and that will report in the new year. You are right too, as was touched on in your question about mixed fleets, that there is a separate piece of work to be done. We have commissioned new research using microsimulation modelling techniques to investigate the potential large-scale impact of connected and autonomous vehicles on traffic flow, network performance, urban roads, interurban roads, and so on. Part of this, of course, is about tying the changes in the technology in vehicles with the changes in the way information is provided in real time in the vehicle and on the road itself. You will be aware that we have developed over time our smart motorway concept where we can provide much more information to drivers as they go about their business. The relationship between that technology, the communications technology that you mentioned, and

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the technology in the vehicle itself is very important, which is why we have commissioned further research to look at that.

**Lord Maxton:** You have, quite rightly, Mr Hayes, and less so Mr Hurd perhaps, talked about the communication between you, your staff and manufacturers, and then you say that we want to keep it in this country. Most of the manufacturers, however, are not in this country, so how do you communicate with the manufacturers if they are not in this country but elsewhere and they are doing the research?

**Nick Hurd:** There is a lot of research being done in this country, in large part because of the Government's support for it, so I dispute the premise and the premise that the auto manufacturers are not in this country; they are in a very big way. In fact, recently we have succeeded in persuading one of the biggest to double-down, if you like, in their investment in the country.

**Lord Maxton:** What percentage of vehicles driven on the roads in this country are manufactured in this country?

**Nick Hurd:** We are one of the biggest car markets in Europe and one of the biggest producers of cars in Europe. Frankly, it has been one of our great industrial success stories since the 1980s and since the financial crisis of 2008. I am surprised at the premise because I think it is generally recognised, in terms of the auto sector in the UK, that the UK is extremely competitive and a magnet for those who want to work with our scientists, researchers and engineers.

**Q69** **Lord Hunt of Chesterton:** I noticed your comment, Mr Hurd, that this whole question of automation of cars is a big international process. We have universal road signs and, presumably, one day we will have universal systems of automation. In the way you were describing it, we are doing clever things in Britain and the industry comes here. We heard this morning from somebody on a panel in the United States, Japan and Europe. This is such an important revolution. Is this not as big a change as the rules for aviation or the rules for climate change? What is the Government's approach to ensure that this technology is efficiently introduced around the world, considering that there has been no mention of that in what we have heard so far? We understand that we are, for example, very strong in this meeting in Geneva, but I wonder whether you would like to expand on that, as it were.

**Nick Hurd:** John will come in on this, but obviously the issue of standards is absolutely critical, as is the harmonisation of those. I think you have heard in previous sessions, and you referred to it, Lord Hunt, that the UK is not just at the table in those conversations in Geneva but chairing some of the most important committees. We are clearly in a position to influence those critical conversations.

The point about the global movement of course is right, and I understand where Lord Maxton was coming from on that. It is clear that we have some competitive advantage, and the capability study demonstrated at least eight areas where we are ahead in the world. The challenge for us going forward through the industrial strategy is where we can retain competitive advantage. We are not going to lead in everything, that is clear, so where do we plant the British flags in terms of the key capabilities? I think that is part of the strategic approach that we have to take and part of the dialogue between governments and industry.

**John Hayes:** It is partly the Government de-risking some of the most risky business aspects of this because, of course, when you are at the cutting edge in business you are, by nature, at the riskiest end of a developing market, so we can de-risk that partly by the financial support we get, which is why we have developed the £19 million for the four cities and the £100 million Intelligent Mobility Fund, which is about trying to ensure that we guide and shape how these things develop. As Nick implied, and I have already mentioned, on the code of practice and the regulatory framework that we need to put in place to make sure it is as good as anywhere in the world, and I think it can be, we are already ahead, as you know; the Lord Chairman highlighted it and it is detailed in my written evidence. We are already ahead in areas such as human-machine interfaces, real-time control, simulation, data privacy, cyber security, and so on. There are eight areas altogether, but I will not go into them tediously as you have them in writing. We have a lot of scientific advantage already here and, if we can get the behavioural stuff sorted out in the way that we are trying to, and if we can get the regulatory framework as good as it can be, I think we can be genuinely world-beating. It is challenging, but the fact that we are already taking this action and doing this work puts us in a good place.

**Lord Hunt of Chesterton:** If you drive, as I did last weekend, from London to Bristol, many of the cars are German cars and the percentage is very high. How will we ensure that the companies, which may be manufacturing in Britain but are owned and their strategy is back in their home country, use this clever stuff that we are doing in the UK? That is a problem, and I am surprised that you regard it as not a problem.

**Nick Hurd:** I certainly did not say it was not a problem. It is clearly a challenge, but we have set out a stall that people tell us is competitive. People are coming here to think this through and to take advantage of the research and innovation offer, to work with our universities and with all the brains in this country and to take advantage of the regulatory and testing system that we have set up, which seems to be extremely competitive, but I do not think John and I have given any impression that we are complacent about this at all; this is going to be very competitive.

**John Hayes:** I think your helpfully provocative question, if I might say so, does oblige the consideration of the value chain. There is a perfectly proper piece, as you implied, of value chain analysis to be done where we identify those areas where we can be genuinely world-beating and where there is higher value for our economy and our businesses and those areas where we are likely to be in a highly competitive situation and may well be out-priced or under-priced. Realistically, I think we should build on our strengths and make sure we cement those strengths in the ways I described a few moments ago, and there are things the Government can do—pump-prime, support, take risk out, et cetera—rather than pretend that we will be able to be in every place and be world-beating in every area. I do not think that is sensible or realistic because, fundamentally, I do not think it is true.

- Q70** **Lord Hennessy of Nympsfield:** Can I just follow up something Nick Hurd said about the industrial strategy? It has been the ghost in this inquiry, shimmering through almost every bit of evidence we are getting, yet we have not had the flesh. I was hoping that we were going to get the Green Paper tomorrow, and I do not know if

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we will or not, on the industrial strategy. There are two things really. Nick Hurd had this interesting phrase, that the industrial strategy is about where we plant our UK flags, which sounds to me suspiciously like picking winners under a different nomenclature, but that is another question. How will having an industrial strategy, which I am very keen on and very supportive of, increase the chances of our getting this transformation that we are contemplating right? Where will it really add the value that we have not got at the moment because we do not have an industrial strategy?

**Nick Hurd:** Thank you for your welcome of the industrial strategy. For clarification, my flag-planting metaphor was strictly in the context of the capabilities within the connected and autonomous sector, but I think it probably translates across to other areas where we have to be very smart in identifying where we have strengths to build on and where we can reinforce great or maybe move from good to great. That is a fundamental part of the process, to reinforce our competitiveness. On the industrial strategy, to be fair, it is a relatively new Government and it is a very big undertaking, so it cannot be rushed and it is evolving.

**Lord Hennessy of Nympsfield:** So we are not getting it tomorrow?

**Nick Hurd:** I am not going to prejudge what the Chancellor says in his Autumn Statement because that would have career consequences that are unthinkable. You have had a clear steer from the Prime Minister about the weight that will be attached to science research and innovation, and I hope that is welcomed by this Committee. I do not know what Philip will say tomorrow, but he has clearly been very articulate about the need for high-value infrastructure. We will follow shortly after with the first output of the industrial strategy process, which will set a framework and then pose some questions. We are very clear that this is a process on which we need to engage quite fully not just with sectors but with localities and with different sectors of society because this is a very big undertaking. It is a different process from the ones we have seen before where perhaps the Department for Business, Energy and Industrial Strategy has picked some sectors or technologies to get by. This is a bigger enterprise that it is trying to address, a very big structural challenge which is, to use the political strapline: how do we make this economy work for more people, how do we create a broader sense of opportunity and how do we tackle the imbalances in terms of prosperity and productivity? It is a very serious undertaking, which is why the Prime Minister placed such emphasis on it.

**Lord Hennessy of Nympsfield:** It will help in this area, you think?

**Nick Hurd:** Yes, I think this is a very good example of a modern sector approach, which will not be the Government saying, “These are the sectors that we choose”. I think the process will be more that sectors come to us and say, “Let’s talk about the opportunities and let’s talk about some of the barriers and let’s see what we can do together to help unlock the potential in this sector”, if we believe in it. So there will be a challenge to the connected and autonomous sector to work through the industrial strategy with my department to see what more we can do to unlock the potential in this area.

**Q71 Lord Cameron of Dillington:** I tend to speak on rural issues in this House and, being a

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glass half full sort of person, I think there is great potential in this at a time, for instance, when we have just heard that rural public transport has dropped by 11% in recent times. I think it will probably start with automated systems between, say, park-and-rides and city centres where there will be automated mechanisms within the transport, and perhaps along the route, helping the bus so that it will be driverless and then, hopefully, that will develop into standardised bus routes along the same mechanisms so that you get cheap to run, driverless mobility pods, as we have learnt to call them, and we will get more public transport in rural areas. The Government's role here must be to take the local transport authorities along with it, and I was wondering what you were doing about that. We heard from the local transport authorities that they want the Government to convene fora that will allow local bodies to share knowledge and expertise, and I was wondering whether you had already kick-started that process.

**John Hayes:** We have funded, as you will know from what you have looked at already, the Technology Transport Forum, which is working with local authorities to look at precisely the issues you describe. We set it up, in essence, to join the technologies together and to explore some of the things we have spoken about already this morning: the way that the technology will work in all kinds of different places with different road networks, the way that it will affect the development of communities and so on and so forth. That forum will be the guide to set out what autonomous vehicles can do for different localities and how local authorities can play their part in this.

We started here talking about the potential advantages and disadvantages of this technology. I like to be very frank with committees like this as it is the right thing to do, and I was discussing with my officials this morning the risk that rural areas might get left out because they are already less well connected in all kinds of ways, not least, as per the question earlier, through the paucity of some of their internet connectivity. If you have poor broadband, poor mobile phone coverage and the inability to communicate already, if autonomous vehicles will interface with those other technologies and those other technologies are not in place, where does that leave an area that is already isolated but potentially more isolated? I am very determined to make sure that does not happen by the steps the Government can take. As part of this work with local authorities, it may well be that we need to look at some particular work in those most rural communities where, potentially, this change could have the greatest benefit. If I am right about the kinds of people who are currently unable to travel because they do not have access to transport, and I mentioned visually impaired people, elderly people and so on, that is just as true for people who are rurally isolated in the way that you understand.

What I will do, and I will drop a line to the Committee about this, if I may, Chairman, is ask my officials, following the meeting I had earlier and the question you have just posed, to look at whether we need to supplement that piece of work I have described with an additional set of requirements or suggestions around rurality. I am of the same mind as you.

- Q72 The Chairman:** If we can move on to regulation, clearly regulation is the role of the Government and Parliament. Much of what we have been discussing up to now of

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the responsibilities will be shared with the sector as the technology advances. Regulation will need to change, and I know that the Government's intention is to keep regulatory reform under constant review. We have to think about insurance liability, technical standards, data ownership and much else and, presumably, the modern transport Bill will deal with much of this. Could you tell us how you are able to track the regulatory reform which will be necessary? I would just quote some written evidence we have had from Kennedy's, a law firm, who say: "We urge the Government to create an industry-wide group that would advise ministers and civil servants on how the technology is developing to inform their thinking on how regulation needs to change with it. One of the main objectives of such a group should be to reach a consensus on what types of vehicles are likely to arrive on the UK market over, say, the next 10 years. This would greatly assist the Government with regulatory planning". I wonder if you would like to comment on that.

**John Hayes:** I mentioned earlier, Chairman, the modern transport Bill, which we will publish early next year. It was announced in the Queen's Speech, as you know, unexpectedly. That will be an opportunity for us to look at precisely the issues you have described and it will be framed on the basis of many of the kinds of discussions you have described. I mentioned earlier the issue of insurance and liability. It is vitally important, if this technology is to have the effect we hope for, that we get the regulatory environment right for consumers and insurers. The insurers, the consumers and the manufacturers all have to sign up to a very different regime where, essentially, we challenge some of the existing assumptions about liability. The modern transport Bill will address that.

Also, looking at fundamental questions about how robust the technology is, the roadworthiness of what emerges and how that is subsequently regulated, the difficulty is of course that, because we are in a highly dynamic set of circumstances in relation to the technology itself, we need to be flexible enough to make sure that we can regulate as we go on, so it will necessitate the Government taking some powers to take further steps down the line as we know more of the questions that the technology implicitly poses. Again, in the Bill, the Secretary of State will take those powers and I will be arguing that case on his behalf. You are right, Chairman, that getting this established early is important, which is why that Bill is important.

- Q73** **Baroness Young of Old Scone:** Could I raise one issue that was in your evidence, which is about the potential impact on employment for the future? Who knows what has been happening globally in the last few months, but it appears that people in lower-skilled jobs are feeling very dispossessed by globalisation and the way things are going. Are the Government thinking about the potential impact on many lower-skilled jobs in the driving professions and current transport arrangements, compared with a generation of a range of high-tech jobs in systems development, communications and automated vehicles, and the impact that could have on employment in this country not just in gross terms but in the nature of the employment and, therefore, whether we are in danger of creating more dispossessed people?

**Nick Hurd:** I think this is a really important point and it is part of our need to understand the balance of risk and opportunity behind some of this, to use the

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jargon, disruptive technology. As John and Committee Members have articulated, there is a whole range of potential benefits, but there are some downsides as well that we need to understand. I come back to what has been described as the ghost in the room, which is the process around the industrial strategy. It is to take stock at this moment in time, which is a genuinely pivotal moment in time not just because of Brexit but because of the big structural changes that so many sectors of the economy now face, so that we really understand the balance of risk and opportunity for the UK and, therefore, the strategies that we develop with the sectors reflect that balance of risk and opportunity.

In the auto sector, our priority is to make sure that we remain fully competitive in this country so that the big manufacturers continue to want to make cars here and develop their thinking about the future, whether it be on electric cars, ultralow emission cars or, what we are discussing today, the connected and autonomous. The key thing is to try to keep them here, which is why we place such an emphasis on retaining the competitiveness of the auto sector.

My final point is that all the research and development goes around that. We do need to be asking these questions about rebound effects and what the consequences are because the fundamental question that the industrial strategy asks is: where are the decent jobs going to be in the future and how do we shape our economy to respond to the trends that are buffeting every country at this moment in time? That partly reinforces the need for an industrial strategy at this point.

**John Hayes:** I would refer again to this report that I mentioned earlier, the House of Commons Science and Technology Committee Report on Robotics and Artificial Intelligence, Chairman, where this very issue was debated at considerable length. The way in which it was debated was to explore the issue of job augmentation. Of course, the evidence that was given to that Committee from a variety of sources, some predictable, such as Microsoft's, but not without value, was that, far from destroying jobs, autonomous and robotic technologies had simply changed the things people did in work. I suppose you would have to say that, if one took a broader view, the evidence is here to see. Deloitte's argue that we often think of this as humans versus machines or robots and, in fact, it is much subtler than that and is about providing support for tasks within jobs. It went on to say, "It did not destroy my industry. In fact, my industry is much larger". Similarly, the Royal Society's Machine Learning Working Group said, "Technology has been an augmenter of many professional and white collar activities". In net terms, I am not so sure that we will see employment reduce as a result of this, but we may well see change.

Now, to be subtler than those witnesses or, dare I say, to be subtler still than those witnesses, I do think there are two concerns about that. One is that, if that change happens quickly, the readjustment would be significant and require a similarly significant reinvestment in skills, skills training and education, so there are big implications there. The second, and perhaps more provocatively still, is that there is this issue about how we perceive work and the working class. It has been, sadly, rather fashionable for some time in this country to pretend that work and the working class were somehow something either to ignore or, possibly, even to

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disparage. As someone who is proud to come from a working-class background, I rather like workers and work.

**Nick Hurd:** Chairman, John has triggered a recollection in my mind that a Member of your Committee, Viscount Ridley, wrote very powerfully on this in *The Times* yesterday.

**The Chairman:** He has sent his apologies.

**Nick Hurd:** He made this point and put it in a historical perspective which is that, over our history of progress as a country, there have always been concerns about the impact of automation and progress on jobs and, historically, they have been overstated and what we have engineered are shifts. The point I was trying to make is that I hope, and I do not want to overstate it, through the process of taking a more strategic approach, we could perhaps be more proactive than we have been in the past in terms of preparing for change.

**John Hayes:** I guess the industrial revolution did not do much for the ostlers and farriers, did it?

- Q74 Baroness Neville-Jones:** I wanted to ask you a bit more, if you can tell us, about the likely approach that will be adopted in the modern transport Bill. Will it contain a vision of where the Government see the transport and infrastructure and the future mobility plan for this country going? Within that, given that, it seems to me, there are an awful lot of questions to which we do not yet know the answers about how we get from A to B, will it set up structures of a kind which enable us to answer some of these questions? Will the Government be taking a leadership role in helping to bring together people's points of view, both from the Government and the private sector, and being able then to push forward the progress in the various sectors that go to make up a national transport infrastructure?

**John Hayes:** Having earlier commended my frankness, I had better live up to the rhetoric now and say that the Bill will, to some extent, do that inasmuch as I think it reasonably can at this juncture. Based on the work we have already done, the research we have commissioned and the extensive discussions we have had with the industries, insurance, the manufacturers, the technologists and those involved with the R&D, there are things that we can do structurally, but, as I suggested earlier, some of it will be taking powers to do things later, which, as you know, neither House ever likes that much.

**Baroness Neville-Jones:** They do not like future-proofing, it is true.

**John Hayes:** The very flexibility it gives the Government also makes legislators nervous, but in this area, if any, there is an absolute justification for us being frank and saying that we do not quite know what the circumstances will be five or 10 years down the line and we cannot simply keep legislating on a routine basis. Yes, we will, where we can, make the structural changes you describe and certainly sufficient to do what we have to and not to inhibit further development, but we may also need to be honest about the dynamism that you and I both recognise.

**The Chairman:** I think we have come to the end of the session. I suspect we could have continued rather longer, but we must not detain you any longer. Mr Hayes, you

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mentioned two research studies in the department, scoping for a bigger study of behaviour and microsimulation of mixed fleets, and indeed there may be other projects under way. If you could send us a note on those, that would be very helpful.

**John Hayes:** Chairman, I was going to suggest before you asked that I ask my officials to brief the Committee, if you are happy for them to do that, on both of those studies.

**The Chairman:** Thank you very much. I can assure Mr Hurd that the Committee welcomes without reservation the Prime Minister's statement to the CBI yesterday and we will take the opportunity, when we complete our report on the follow-up on EU science and Brexit, to give some, I hope, very positive observations on that development. To both Ministers, Mr Hayes and Mr Hurd, thank you very much for rounding up our oral inquiry sessions.

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[Transcript to be found under Government – Rt Hon John Hayes CBE MP, Minister of State, Department for Transport \(DfT\)](#)

Government – Ian Yarnold, Head of International Vehicle Standards Division and Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), Department for Transport (DfT) – Oral evidence (QQ 1-10)

**Government – Ian Yarnold, Head of International Vehicle Standards Division and Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), Department for Transport (DfT) – Oral evidence (QQ 1-10)**

Tuesday 1 November 2016

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Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Fox; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Neville-Jones; Lord Oxburgh; Viscount Ridley; Lord Vallance of Tummel; and Baroness Young of Old Sccone.

Evidence Session No. 1

Heard in Public

Questions 1 - 10

**Examination of witnesses**

Ian Yarnold, Head of International Vehicle Standards Division, Department for Transport (DfT); and Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), Department for Transport (DfT).

**The Chairman:** Could I extend a welcome to our two witnesses to this first session of our inquiry into autonomous vehicles? Welcome to Ian Yarnold and Iain Forbes. I am going to ask you in a moment whether you would like to introduce yourself for the record. We are being broadcast and if either of you would like to make an opening statement, please feel free to do so. Ian Yarnold, would you like to start?

**Ian Yarnold:** Good morning, everyone. It is a great pleasure to be here on behalf of the Department for Transport. My role is head of the international vehicle standards division within the Department for Transport. I am an engineer and I have the opportunity to head a team of engineers within the department. We, collectively, handle all the regulations concerning new vehicles coming on to UK roads. My team negotiates both in Brussels, in the EU, and in the United Nations in Geneva. We have a great deal of contact globally. I cover the whole range of vehicle regulations, from emissions to noise, fuel quality and vehicle safety, including automated vehicles, which we are talking about today. I had not intended to make a statement, so I hope we will be able to cover those issues during the questioning.

**The Chairman:** I am sure we will. Thank you. Mr Forbes?

**Iain Forbes:** Thank you for the opportunity to speak to the Committee today. My name is Iain Forbes. I am head of a team called the Centre for Connected and Autonomous Vehicles, which is a joint unit of two different government departments, the Department for Transport and the Department for Business, Energy and Industrial Strategy, which has been set up to try to keep the UK at the forefront of the development and the deployment of automated road vehicles.

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We have four broad objectives which we are pursuing, the first of which is to work with industry to try to build a world-class, vibrant industry in this sector in the UK. The second is to try to prepare the UK for the advent of autonomous vehicles, including looking at any changes that might be necessary to the regulatory framework. The third is to make sure we get maximum value from our research and development, both the Government’s programme—and the Government are investing over £100 million in this area—and research being done elsewhere. The final one is to look at cybersecurity issues, to make sure that vehicles of the future are secure by design.

- Q1** **The Chairman:** Thank you both. That is a helpful introduction. I should now declare my own interest before I ask a question, as this is the first session. I am an honorary fellow of the Institution of Engineering and Technology. It would be helpful if you could add to those brief introductory remarks an overview as to how within government there is responsibility, not just in your department but with other departments, for policy relating to autonomous vehicles. Are there other government departments with major interests?

**Iain Forbes:** I think the work that will be done on road vehicles is probably more in depth than has been done in other sectors. That is partly because a lot of the early challenges and opportunities are emerging in the automotive sector. The changes, though, that we are discussing are likely to have an impact across a range of sectors, including everything from maritime, aviation, agriculture and military applications too. There is a need to make sure that that is co-ordinated. The Cabinet Office has convened a meeting of senior officials to check that the work that the Government are doing is co-ordinated; but alongside that, for applications that have a transport policy implication, the Department for Transport takes an interest, for example, in looking at the potential applications for unmanned aerial vehicles. As you might imagine, the Ministry of Defence takes an interest in military applications too, with other government departments covering areas relevant to their policy.

Alongside that, the Department for Business, Energy and Industrial Strategy works to try to co-ordinate the activity in industry and in academia, including through Innovate UK and the knowledge transfer network that is part of that body. A special interest group to try to share knowledge in robotics and autonomous systems was set up a few years ago and has been operating for a number of years with about 1,000 members, all with an interest in this field.

**The Chairman:** We have just received evidence from BEIS which gives a sort of scorecard on the relative global capability of our technology in this area, ranging from limited capability to world-class. It seems, for example, on what I might call the social sciences side—traveller behaviour and psychology and data visualisation—we do not seem to have more than moderate capability, whereas on the world-class end of the spectrum we can include real-time control and interaction and design. Would you describe how government ensures that policy development keeps ahead in this rapidly changing field? What do we do when we find we have an area where we are, perhaps, either world-class at one end or weak on the other end?

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**Iain Forbes:** I think this is a constant challenge. A number of the technologies which are underpinning autonomous vehicles are moving very quickly, with developments happening right the way around the world. To keep abreast of what is happening, government uses a range of different means, both formal and informal. A key way in which we do that is through our industry councils. For example, the Automotive Council, which is a body set up to engender strategic dialogue between government and that industry, has done some great work looking at technology road-mapping and the strategy necessary to make sure that the UK has the capability to succeed in that area.

Alongside that, another group called Impact has a broader membership, considering, for example, the implications of this technology for infrastructure and other users of the transport system. Formal means are important to do that, and the Government has invested a lot in those councils over the years. Alongside that, my team is very outward facing and we spend quite a lot of time visiting researchers and companies to understand what the world looks like from their perspective, as well as commissioning research into what the state of the art is in particular areas. As I said at the beginning, this is a constant challenge in such a fast-moving area, but we have a range of different means we use to try to stay abreast of what is happening.

**Lord Maxton:** If you have private company investment, as presumably most of it is in this technology, what are the benefits to a private company of sharing their knowledge with another private company who will be a competitor to them?

**Iain Forbes:** Something which distinguishes the UK research programme relative to other countries is the collaborative nature of the work that is going on here as well as the transparency with which it is happening. There will always be some work happening within private companies which they will want to retain because they have invested the money to develop the intellectual property, but some challenges are recognised as shared. The projects we have taken forward with government funding, I think, have brought in a range of different partners working together around a shared set of challenges.

I know you are speaking later on in this inquiry to some of the projects we are funding in Greenwich, Coventry, Bristol and Milton Keynes. What is really interesting for me about those projects is the range of partners involved. Yes, you have car companies who are keen to develop the technology; you also have technology companies from a range of different sectors, insurance companies, local authorities and others, including representatives of members of the public, all trying to learn together around a shared set of challenges. Some stuff will be done within companies and that is right, that is the development of their products and services, but in this area quite a lot of the challenges are shared. It is a great testament to the work going on in the UK that so many companies are working together around those challenges.

**Q2 Baroness Young of Old Scone:** Can you give us a feel for what you realistically think the time-frame is for autonomous vehicles being deployed? If we can divide it into two chunks, one is road-based ones and the other is the others. Can you also tell us what progress you think is being made on looking at how a mixed economy would

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operate in the interim, where you might have a range of different levels of autonomy, including no autonomy or very little autonomy, all at the same time, and whether that, in fact, is practicable? Timescales, but also the practicability of that intervening period.

**Iain Forbes:** The question about timescales is a really good one and one which is debated quite a lot among the people working in this field. On road vehicles, it might make sense to split the answer into two. Developers are, broadly and very crudely, following two different paths to development. Some developers are seeking to add automation systems to existing vehicles, so building on technology which already exists in vehicles; they are seeking to, over time, increase the amount of work done by the vehicle as opposed to the driver. Those systems already exist, and we anticipate those getting more advanced over the next few years, and a lot of the work to devise a framework for that is done by my colleague Mr Yarnold and his team in Geneva.

The second area of development is an attempt to leapfrog that work to try to jump to fully autonomous vehicles, and some developers are more interested in that sort of technology. Initially, it looks like that technology is going to be deployed in constrained environments in certain areas with particular criteria—geofence is sometimes used as a term. Views about when that might hit the market in a serious way differ; some people are saying the 2020s, some are saying the 2050s. Making sure we have a strategy which is robust enough for a range of different scenarios is one of the things which is very important.

To take your question about the mixed fleet, this is another really important question for us. Understanding the impact of the technology on future road network performance is very important to help us make infrastructure plans for the future. We are still in the early stages of this but we have done some modelling on the effect of having different levels of connected and autonomous vehicles in the vehicle fleet over time, looking at the impact on particular areas, urban and intra-urban roads. For example, if there were a certain level of penetration of these vehicles at a traffic light, what would the impact be on traffic flows through that traffic light? It is still at a very early stage, I should stress, but we are keen to develop that work in future and build the evidence base over time. It is quite important to make sure that we, as I said, have a strategy which is robust for a range of scenarios, so that sort of work is very important for us in the future.

**Baroness Young of Old Scone:** If Audi introduce their A8 next year, are they going to get a licence to be allowed to use it?

**Ian Yarnold:** It depends on the level of technology. There is a huge amount of work going on now to ensure that there is an appropriate regime of regulation to ensure that the safety of self-steering systems is correctly accounted for. In automation there are three principle issues you have to deal with: throttle control, brake control and steering control. Throttle control—and you may be familiar with cruise control or advanced cruise control systems—has been with us for a while. Automated braking has been developed over the last 10 or 15 years and that is being regulated already, but the real challenge is self-steering systems because there is a huge

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amount of inputs to the process of steering a vehicle around an obstacle. That work is now moving forward in Geneva.

The UK is in a very good position in that because we chair the key global technical committee; my staff chair that group, so we are able to influence the way in which that work is being taken forward and the decisions being reached. There is a specific subgroup dealing with automatically commanded steering functions, which is led by Germany. They announced two years ago or so that they wanted to move this forward at a very rapid pace; we felt a more structured approach was appropriate, and we have been able to influence that to get the right controls in place. We have turned it into a structured further approach so that we can deal with the different technology levels and regulate those as we feel appropriate as those technologies come on. I am not exactly sure, because I do not think Audi have published exactly what their system will do, but it will have to comply with the regulations appropriate for when that vehicle is brought into the marketplace. We are an important part of the process in making sure that that happens through a proper regulated process in the United Nations ECE. That is a parallel regulatory body to the EU.

**Q3** **Lord Mair:** I should start by declaring an interest. I am chair of the Department for Transport’s Science Advisory Council, a fellow of the Royal Academy of Engineering, a fellow of the Royal Society and a vice-president of the Institution of Civil Engineers. My question in relation to time-frame is about demonstration facilities, which are obviously all-important, particularly in the context of mixed vehicles: fully autonomous vehicles and what one might call more ordinary vehicles. In your view, is the scale of the currently planned demonstration facilities appropriate for what is going to be a huge market? Can you say a bit more about demonstration facilities?

**Iain Forbes:** Yes, of course. We have made a great start in the UK. The projects that we are running, which I know you will hear from later, are genuinely world-class and we frequently have people from other countries asking us for information about what is happening there. What is important is they are taking place in the real world. A crucial part of the development of this technology is allowing people to experience it: to get into the vehicles, to understand what it means for them and to think about how it might interrelate with the rest of their lives. For example, if you go to Greenwich in a few months you will be able to get into a self-driving pod, go round the peninsula and get a real sense, I think, of what that technology might offer you in future.

It is a great start. There are lots of countries around the world competing to be the world’s testbed for driverless cars, so it is clear that more will need to be done to make sure the UK stays competitive. Over the summer we ran a call for evidence within industry to get views from some of the people developing the technology on what will be necessary, which we are currently sifting through at the moment and anticipate responding to soon. Some key messages were that it is not the case that we need to invest in vast new ground-up facilities; what we should do is build on what we have, including our regulatory system, which is one of the most open in the world. In the UK, unlike in some other countries, you can test anywhere, which is a real advantage for us when it comes to trying to understand what the technology will look like in the real world when people experience it. As we sift through the

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responses we might see that there are other things we need to invest in to try to make sure that we remain competitive, and that is certainly something that my team will look at closely over the next few weeks.

**Lord Mair:** Presumably, it is not just a question of testbed tracks.

**Iain Forbes:** Yes.

**Lord Mair:** Particularly in the context of cities and the urban environment, you need something rather more sophisticated, where the vehicles are being tested in what would be regarded as a real, urban situation with other things around—other vehicles, pedestrians, obstructions and all sorts of things. Is that what is being contemplated?

**Iain Forbes:** We need a range of different sorts of testing environments, everything from controlled environments—i.e. vehicle test tracks—through to real-world environments, as you describe: areas of towns and cities where these vehicles can be tested in the real world and in a safe way, all the way through to virtual environments too, so running systems on computers to see if they work. The piece of work on testing in the real world is hugely important because engaging the public in how this is taken forward is going to be one of the key ways in which you are going to succeed or fail. If people can see the benefit for them then that will speak to the ability of the technology to meet people’s needs. If they do not they will buy out and the technology will not succeed. The short answer is yes, we need real-world testing environments.

**Q4** **Lord Fox:** I should declare an interest. I am employed by and have shares in GKN and I also have shares in Smiths Group, which may be active in this area. You introduced the topic of having a mixed technology environment where you have, normally, manual, semi-autonomous and autonomous vehicles in the same place. How much are you looking at the infrastructure needs? In the end, that may be the rate-determining step, if large investment is required to let this happen. In your view, what level of investment will be required in infrastructure and how are we validating that?

**Iain Forbes:** This is a very important question for the Department for Transport when we sit down to plan out what our infrastructure requirements are for the future. Predicting the future with any level of certainty is quite tough when people are following different development paths. I would say, though, certainly for the foreseeable future, it is likely that the vehicles will have to operate on the infrastructure that exists. As you mentioned, it is going to be a mixed environment and these conventional vehicles will need to use it to anticipate getting value for money from those projects for quite a long way into the future.

At the same time, given the time horizon for infrastructure projects, we need to get a sense of what the potential scenarios of the future might look like and mean for infrastructure development. One way in which we do that is by having a look at different scenarios of the future and testing the strategy against all those scenarios to make sure it is still robust. It may well be that in future we might be able to run our infrastructure more efficiently if vehicles speak to infrastructure, and systems exist which allow safety to be implemented in a more efficient way. To properly

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determine that we will need to test in the real world, and one thing that the Department for Transport is doing is testing these sorts of technologies in real-world roads to get a sense of—

**Lord Fox:** So the Bristol/Greenwich-type tests will be testing that as well?

**Iain Forbes:** The key ones for those sorts of questions are the tests around Coventry, as part of the UK CITE project, and the “connected corridor”, a project the Department for Transport is leading on, between London and Dover, looking at a range of different communication technologies.

- Q5** **Viscount Ridley:** Declaring the only interest which I think is of relevance, I am a former non-executive director of PA Consulting, which is going to give evidence at some point. I would like you to try to speculate, if possible, about how we maximise the benefits from this technology while minimising the disbenefits. We can all see that there are potential benefits in terms of safety, environmental quality, lack of stacked/parked cars in towns, convenience, old people being able to get mobility back, people coming home from the pub late at night, et cetera. There are also possible disadvantages, including losses of jobs among drivers, making congestion worse because these things are ultra-cautious, et cetera. How do we go about working out how we maximise the former and minimise the latter?

**Iain Forbes:** I think you have done a good job of laying out some of the main benefits and potential disadvantages we think about when thinking about the technology. One of the key ways is to learn by doing. If you discuss a lot of this technology in the abstract, it is quite difficult to see how it is going to interact with the real-world environment. Our test programme is one of the core means by which we will explore those sorts of questions. We have a proposition that these vehicles are going to be more safe. When you put them in a real-world environment with appropriate protections around it, does that play out in a way which justifies the claim? Similarly with some potential disadvantages, we can identify some now but there might be others which crop up as and when we do the trialling. We can only operate step by step, I think; it is not possible to plan out the entire future from now and create the framework that is going to allow that to happen.

As part of our trial programme, one thing I would stress is the importance of public engagement. I am very excited about the technology; I think it has huge potential—I am quite a techy person and I quite like technology—and if we are going to see this improving people’s lives, having people touching it, feeling it and participating, participating in the projects is very important to allow that to happen.

**Ian Yarnold:** One of the key things of the trials programme is the behavioural study. There is a lot of work being done about how drivers engage with them and how motorists want to buy a vehicle or not, but from a Department for Transport point of view, we have to understand how these vehicles interact with the urban environment. There has been mention before about pedestrians and such like, and vulnerable road-users. One of the things we will be implementing—and we are part way through the pilot study, or scoping study—is to understand what we can learn from the trials that Iain has described within the four cities and to try to draw together the evidence so that we can make choices around where we go and what

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we do with these technologies. How do we maximise the benefits? We need to understand how people engage with driverless vehicles when they are being used in their local town or city, to help us make the right choices going forward. It is very easy to say “We know best” but we have to understand it in a way that the public can engage with and tell us what they think about it.

**Viscount Ridley:** Just to follow up on the point about public engagement, we have seen one survey saying that 52% of Brits think it is a great idea and another survey saying that 62% are scared by the prospect. Do we know what people really think about this?

**Iain Forbes:** You have to take all these surveys with a little pinch of salt. That famous saying by Henry Ford: if he had asked what people wanted they would have said a faster horse. People have not yet properly interacted with this technology, which is why the demonstration projects are so crucial and why, I think, within the departments our three-year programme is spending a fair amount of time scoping out the right questions and the right methodology. Like you, I read a survey every other week about what people think about driverless cars, and it is a different answer every time.

**Q6** **Lord Hunt of Chesterton:** I wanted to follow up on your opening remark about the importance of networks. I was involved in setting one up for aeronautical research in the 1980s and it now still operates in Europe. You are exclusively using the word “UK” for your networks. Are these research industry networks European-wide, and will they continue to be European-wide?

**Iain Forbes:** The particular network I mentioned, the Robotics and Autonomous Systems Special Interest Group, was set up by Innovate UK and the knowledge transfer network, so a UK body primarily targeted at people doing work in the UK. I know the teams who do that speak very frequently to partners doing research in Europe. There is an awful lot of great work going on in Europe, and understanding what is happening and how we can be involved in that is going to be part of our job in the future. The particular body I mentioned earlier is a UK network.

**Lord Hunt of Chesterton:** I want to ask my proper question now. You keep saying there are no statistics. I went on one of these happy mornings when I had to learn about the driver’s manual because I had gone at 32 miles an hour—

**The Chairman:** We do not believe you.

**Lord Hunt of Chesterton:** The interesting point is that the person running it said that the biggest source of deaths on the road is in rural areas, where perhaps 2,000 people a year are killed. Therefore, the most important thing, as it were, is to get to these people after they have had a crash going round a bend in a leafy lane. This seems to me highly identifiable as a statistic and as a programme. Everyone is always talking about cities, but where people are being killed on the roads is not in cities. I wondered how that is reflected in your programme.

**Iain Forbes:** It is a good point to make, and it speaks to the need to have a look at where we can get the benefits that we are talking about, as opposed to talking in the abstract about road safety. The work I mentioned earlier, to add automation

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systems to vehicles, could potentially have a real impact there. Some developers are talking about putting a guardian angel around the driver to make sure, when they are driving, there is a system checking in to make sure, if it can help, it will do in future, which I am sure will have impact in rural areas as well as urban areas.

Having said that, I do not think it would be possible to direct all our focus on one particular area when so much is still to play for in how the technology might play out. It is certainly of real interest to us and we are definitely bearing it in mind when thinking about the applications of the technology, but we are also keen to create enough space to allow people to innovate.

**Lord Hennessy of Nympsfield:** I have a question for Iain F, if I may. Your enthusiasm for all this is contagious and it is a very nice thing to see, but one always has to be careful of not overselling. Heaven knows how many transforming technologies we have been through, which of course in some cases have transformed lives.

Behavioural studies intrigue me because human nature will not change, whatever the level of artificial intelligence, and the roads have always brought out the worst in some people. It is the Mr Toad syndrome. Ever since the days of the Deadwood stage people have been behaving badly on roads. They do now, and I am sure they will find a way of behaving badly in these things as well. There must be limits to the social psychology you are applying to all this. Do you not need buckets of scepticism applied here?

**Iain Forbes:** We certainly come at this with an air of healthy scepticism when it comes to some of the claims being made by some of the people developing the technology. The systems we are talking about will have to operate in a safety-critical environment, as current road vehicles do at the moment. I am very enthusiastic about the technology and its potential, but it will be important to have the right regulatory framework around that so that people can feel confident they will be operating safely and they are not at risk from the technology too. Part of the work which Ian and his team do is going through in scrupulous detail how these things will operate in the real world to make sure we can be comfortable with the way the technology operates. I do not know if you want to elaborate.

**Ian Yarnold:** Only on the social science side of things. There are different streams of work. Will people be able to misbehave in these vehicles? The answer to that is it depends how much control over the vehicle they have when they are in it. If we move to a fully automated vision then the expectation is that the person in the vehicle, and this may be a few years away, would have very limited control over the vehicle because they will not have any controls. During that period of transition we would have to think about how the driver interacts with the technology, and that is an interesting, large challenge. That is one set of issues.

A separate set of issues is how other road-users who are not in the vehicle engage with the vehicle. That is the subject of the separate behavioural research that I mentioned. We will, in effect, have researchers in various locations where those vehicles are being used engaging with people that are using the roads, walking, cycling—however they move around—to understand how they perceive this driverless technology being used in their locale. If it is used on a Friday will people not come out of their houses on a Friday because they are worried about it, for

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example? That might be a rather extreme observation but it might be that people avoid the particular roads where these vehicles are being used until they become more familiar with them. We need to understand that in terms of how we create an opportunity in the UK for the wider use of these vehicles. We are trying to take a measured approach to it to ensure that the public at large understand this technology, whether they are in the vehicle or outside the vehicle.

**Lord Maxton:** I am sure that I read over the weekend somewhere that the first autonomous cars on the roads would be anonymous to stop other road-users from deliberately trying to interfere with the way they operate. In other words, stepping out in front of one because they know it is an autonomous car to see whether it will stop or not. Are you taking that into account?

**Ian Yarnold:** I read the same article. You are right, there is the issue of the driverless car being too polite and will it ever make progress over pedestrian crossings, because there will always be someone close to the edge of a pedestrian crossing and the vehicle will be in this quandary of “Should I go or should I stop? Are they going to cross?” For those of us who are drivers, you handle that challenge daily when you move through an urban landscape. It is going to be a challenge. You are right that there is a risk that if an autonomous or driverless-type vehicle is painted red then people will test that and keep crossing in front of it to see whether it stops.

**Lord Maxton:** I also have a colleague who said to me that he was at a football match on Saturday and invited to the Chelsea/Arsenal game on Sunday, and he would never have made it in an autonomous vehicle because the autonomous vehicle would only drive at 70.

**Ian Yarnold:** I could not possibly comment.

**Lord Vallance of Tummel:** Can we take a quick look at this from a macro point of view? Sticking to motor vehicles for the time being, assuming all this works and this is going to be a great, big international marketplace, it is going to need big scale; it is going to need the usual control over standards, because if you win the standards game, you win the game, and so on and so forth. Where in the end-game of all this do you see UK plc sitting? What are we aiming to do? Are we aiming, at the end of the day, to manufacture these vehicles or have them manufactured in the UK, or are we providing systems to other manufacturers? If we are, who do we have in our sights? Can we take a macro view of it?

**Iain Forbes:** It is a very good question but a very tough one to answer, given the uncertainty in how the market is going to be taken forward. That terrible word “disruption” is used quite a lot about the future of the automotive sector. Senior figures in the sector think there is going to be an awful lot of change, not just to the technology but to business models as time goes by. People such as Mary Barra of GM think there will be more change in the next 10 years in the sector than there has been in the previous 50. Yes, there will be opportunities, perhaps in producing some of the component parts and systems for these vehicles; yes, there will be opportunities in manufacture too. But also, if we see more of a shift to providing these systems as a service rather than as products, there will be opportunities to explore there as well.

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We cannot predict the future exactly but we can engage closely with industrial partners in the UK to get a sense from them about where they see the future value being, and that is what we do through the Automotive Council and through other bodies.

**Lord Fox:** By deft chairmanship, we were on the same tack, Lord Hunt, and it was very much on that point. What you have described is the technological strategy. There does not seem to be any evidence of any sort of industrial strategy. I cannot believe, even though there is all this uncertainty, that Germany is not looking at this from the other end of the telescope and that the reason they are trying to accelerate things on their committee is that they believe they can take an industrial advantage by doing that. Where is the horsepower located that is having this discussion and developing this strategy for the United Kingdom? It is all very well having lots of collaborative things and working out lots of ways of deploying this technology if all we are doing is creating a market for everybody else to sell their services or their products. I do not see any evidence of that at the moment.

**Iain Forbes:** It is a very good challenge and a fair one. We do not want to produce lots of very excellent research and services which are hoovered up by other people to make money from. My team works very closely with the Transport Systems Catapult, which is one of the innovation agencies set up to try to steer efforts around particular challenges. They look at technology—it is an important part—but also at the value chain in future, how the future industry is likely to shape up and where the UK can play. They published a report called “The Traveller Needs and UK Capability Study” which gave an assessment of current levels of UK capability, which I think informed the Chair’s comments earlier about where we are strong.

The next step of the work for us is to take that initial bit of work and identify where we want to focus our efforts to make sure that we have a proper prioritised sense of how the UK can succeed in this area, which we will be doing with the Transport Systems Catapult and through our partners in the Automotive Council too.

**Q7 Baroness Neville-Jones:** I declare an interest as a member of the Council of the Engineering and Physical Sciences Research Council. These witnesses may not be entirely the right people to ask about the relationship with industry, but it seems to me that what you are doing should be linked with what I hope we will hear about the future of the industrial strategy. Could you say whether in fact there is a prospect that your team will be influential inside that strategy? Secondly, you say that the transport catapult is very important but, again, I would put it to you that it is essentially to do with the technical, technological and research side of the game; it is not to do with commercialisation, crossing the frontier between knowing how to do it and actually getting on and producing the vehicles and the road structure—indeed, I would say, the transport structures generally that are needed—which seems to me to be a much bigger programme. Could you both say something about that? How do you fit into that context?

**Iain Forbes:** On your first question about industrial strategy, the answer is yes, my team is engaging with the process of pulling that together. This is an area which is getting a fair amount of focus, given the potential for the UK genuinely to have a

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leading role in future. Obviously, that document is being worked on at the moment and we will be engaging with the process as it goes forward. Yes, is the answer; my team is heavily engaged in that.

Your comment about the catapult is a fair one too, but it is not the only means by which we are thinking about this. The sector council, the Automotive Council, is a key body for us in making sure that we, as government, are doing the right things to point our industry and our government efforts in the right direction. We can produce a report, which might be very interesting, but if we are not told by industry that it is going to be helpful for them then it is not going to get very far. We constantly validate the work we do with the council itself and the subgroups which look at technology and other services.

**Baroness Neville-Jones:** How does Innovate UK fit into your picture?

**Iain Forbes:** We work very closely with Innovate UK.

**Baroness Neville-Jones:** In what way?

**Iain Forbes:** They are the delivery partner for our research programme. We have over £100 million of government research which we work with Innovate UK to scope, and then they pull together the research competitions and the bids to make sure that the process is delivering value for the UK. We work in partnership around research.

**Lord Oxburgh:** My point has been covered.

**The Chairman:** We will move on to Lord Hunt. Would you like to declare an interest at this stage, Lord Hunt?

**Q8** **Lord Hunt of Chesterton:** Yes. I am a fellow of the Royal Society, and I am director of a small environmental company and an NGO. One of the questions concerns the regulatory regime. As we heard from Ian Yarnold, you are doing this at a UN level, but there are also pretty strong EU regulations on that. My understanding from hobnobbing a bit with some civil servants is that many of the networks of Europe will, it is anticipated, continue although there may not be the funding we currently have in research. I would be interested in your comments on that.

**Iain Forbes:** Shall I give an overview and then pass to Ian for the international discussions? A regulatory forum is a hot topic for this particular subject, and creating the right framework is crucial. The UK has done a lot to set the pace in some respects around that work. A couple of years ago the Department for Transport did an audit, a review, of all the regulations which might relate to automated vehicle use and operation in the UK and found that there were very few barriers to doing tests in the UK. Later on, in July last year, we published a code of practice for the testing of autonomous vehicles, which a lot of people around the world have held up to be one of the best approaches to doing that. It could have been at that point that the department might have chosen to take a regulatory approach and set out in statute what the arrangement should be. Given the pace of change in technology the department decided to take forward a guidance document which could be adapted over time as the technology moves. That approach has been copied by countries around the world, which is encouraging to see. That is around testing.

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On the wider framework around the sale and use of these vehicles, it is not going to be possible to sit down and plan out the framework for the moment; we are going to have to take a step-by-step approach, focusing on what we think to be near to market and what we think to be important to resolve now. We consulted over the summer on the first wave of regulatory reform relating to this area, which focused on motor insurance and some near-to-market technologies. We will be taking forward future waves in the next few years, engaging with people on the priorities to make sure that we are targeted at the right area. One of the key discussion forums for that is the forum that Ian and his team go to in Geneva. As Ian said earlier, the UK is very influential in determining the agenda for those.

**Lord Hunt of Chesterton:** Will you talk about Europe too?

**Ian Yarnold:** I was coming to that now. As you mentioned, all new vehicles coming on to the road in the UK and across the whole of the EU have to comply with European regulatory requirements. We cannot avoid that; it is a mandatory obligation. Those technical regulations are set both in the EU, in Brussels, and in the United Nations Economic Commission for Europe in Geneva. About six or seven years ago the European Union took the decision to move the setting of safety standards to the parallel group in Geneva. They retained the environmental standards in Brussels, so Brussels picks up the technical requirements from Geneva and brings them into the minimum requirements for vehicles entering the EU market. That is why when I talk about Geneva it is quite important to focus globally for setting technical requirements for new road vehicles. When I talk about “globally” I mean truly globally. There are two different approaches, and I can give you more information if you want it. There is one called type approval, there is another one called global technical regulations.

As I mentioned earlier, we are in a very good position, and have been for many years, in setting those standards. I chair the global harmonisation group and that is a shared chairmanship with Japan and the USA. It rotates every two years. I am the EU-nominated chairman on a two-yearly basis. I also chair the ITS—intelligent transport systems—automated driving group within that, and one of my team chairs the technical group of global experts. That brings in North America, one or two countries in South America, the Asian countries, Russia, all of Europe, South Africa and some northern African states as well. It has a very globally-based approach. That ensures we try to build in harmonisation at the origination of those regulations. I would not want to underestimate the challenge of that, especially when you are trying to deal with embedded approaches in those different territories, but we work hard to try to ensure that we bring together a collective approach. That is an important route for our understanding of where the technology is. I think someone mentioned earlier that there is a lot of protected interests, manufacturers guard their IPR very heavily to make sure they do not divulge anything. That networking allows us to understand exactly where they are on a bilateral basis, and you learn far more in those corridor conversations.

**Lord Hunt of Chesterton:** Presumably Nissan was quite pleased to hear this kind of remark.

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**Ian Yarnold:** It would not be appropriate for me to comment on that, but it is a valuable source of knowledge, as we develop our regulations, to understand from different participants in the group; vehicle manufacturers, NGOs and trade bodies are there, along with a wide range of global governments. We are in an influential position, and have been for the last 35 years or so, in shaping that agenda and taking it forward from here.

**Lord Vallance of Tummel:** Picking up on what Lord Hunt said, it is great that we are in an influential position and we take the lead, and so on and so forth, but how does the UK take economic advantage of that, or is it philanthropic?

**Iain Forbes:** You have direct discussions with UK manufacturers but the ability to shape the agenda of a global standard-setting body allows us to target on things which we and companies in the UK care about. Ian and his team have gained that position because of their expertise and knowledge about what works in the real world. It also allows them to make sure that the items being discussed are ones of real relevance to the UK. That is not the only way in which we are going to succeed industrially; building up capability and making sure we have the right ecosystem in the UK is very important, but genuinely over the years I think we have been seen as very influential in setting standards which will determine the future of vehicle technology.

**Ian Yarnold:** There is a judgment call in that you have to be true to the principles of impartiality when you are setting these things, but at the same time you have to understand where the opportunity arises. Someone mentioned that Germany may have had a particular ambition about fast-tracking the steering regulation because it suited their industrial position. We felt that a more structured approach was needed to ensure we could implement a regulation that was fit for purpose rather than one that helped a particular advantage. I am sure that if we had the same approach another Government might have the same outlook and say, “Hang on a minute. Is this an intellectually robust technical regulation that delivers on a technical issue?” We always have to apply that balance.

**Viscount Ridley:** Mr Yarnold, from your chairing of this key committee in Geneva, as you say, you get a perspective on what is happening elsewhere in the world. Which country is most ahead in this technology? Which is going to do to this what Japan did to consumer electronics or America did to social media?

**Ian Yarnold:** I do not know if there is a straight answer to that. I cannot give you a name of a country. They all have strengths and weaknesses. As Iain has described, we established a year or two ago a clear commitment and leadership. When we published our code of practice we were seen as the global leaders in this area.

**Viscount Ridley:** It is possible we are the go-to country on this.

**Ian Yarnold:** That would be my impression of things, but of course, as I think you are alluding to, a number of other countries have some very advanced technology companies, and we are trying to establish ourselves as the best place to do the testing. As Iain has described, we have one of the most open regulatory structures in the world to allow that to happen. I had the opportunity to be in China talking about the UK approach, in Shanghai at a big international conference earlier this year, and

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a number of manufacturers were very interested and impressed with the fact that we had taken the time and trouble to consider how we do things and how they can test vehicles in the UK, and at that time they felt they did not have the same approach locally to how they were producing and doing their technology development in China.

**Lord Oxburgh:** Let us say that people come here to test their vehicles. Is that going to be of significant economic benefit to the UK?

**Iain Forbes:** There are different types of testing and the type which might deliver the most benefit is development. If it proves tough to take forward testing in one particular country and you move your researchers and test teams out to another country to do the development, then you would probably need to buy some equipment and supplies from people in the area and you would probably need to have a relationship with a university to provide you with the skills you need to take it forward. The aim is to try to build that ecosystem, attract people here with the open regulatory environment and the contributions from government for research, and then build out from there to make sure we can take the industrial advantage too.

**Baroness Neville-Jones:** I can see there is a general advantage in providing a good environment for testing but where is the UK advantage in all that, as distinct from the advantage to everybody who can come along and use our facilities?

**Iain Forbes:** If we have a company which develops intellectual property around the control systems for the vehicles, that might end up being embedded into vehicles all around the world, in the same way, for example, as the ARM technology was embedded in mobile phones around the world. The areas in which the value is going to be are not exactly clear yet but we can see there is going to be a lot of interest in the control systems in some of the artificial intelligence-led work to create the way in which the machine interacts with its environment in future. We have strength and depth in universities in the UK in this field, which speaks to the ability for us to potentially take a leadership role here.

**Baroness Neville-Jones:** Are they intimately involved in these testing programmes?

**Iain Forbes:** Yes.

**Baroness Neville-Jones:** Is there an intellectual and commercial link?

**Iain Forbes:** For example, there is a spinout from Oxford University called Oxbotica, who have developed a control system which is being used in many of the UK trials, and we are aware they are frequently in conversation with companies around the world about licensing that service elsewhere.

**Q9 Lord Borwick:** Declaring my interests as chairman of the GATEway project advisory group, the Greenwich vehicle project, perhaps I may ask about the legal accountability for vehicles. There was a case in the papers yesterday about a 40-ton truck being driven by a guy using his mobile phone even though that is clearly against the current regulations—he was apparently photographed doing it. Any vehicle thinking for itself is likely to be safer than that particular truck under those circumstances. Could you see in your regulations legal accountability requiring people to use autonomous braking systems?

Government – Ian Yarnold, Head of International Vehicle Standards Division and Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), Department for Transport (DfT) – Oral evidence (QQ 1-10)

**Iain Forbes:** This is a great question, and liability for autonomous vehicles is very much debated around the world. It is a very complex issue, which is probably worthwhile taking in parts. The first point to make is that the vehicles do not necessarily think in the terms we might think. They assess their environment and make decisions but they are not a sentient being. Ultimately, questions of liability within the UK will be for the courts, as they are now. They have experience of assessing liability across a range of different parties, as for conventional vehicles at the moment when there is an issue, both for criminal and civil liability. For example, if there was a crash because a car was faulty, the court may decide to hold the manufacturer of the vehicle liable for providing a faulty product under product liability laws.

Having said that, Government can provide some clarity and certainty where it is felt useful to do so, and we will explore that in our future waves of regulatory programmes. For example, as part of our code of practice, we have specified that a testing organisation is responsible for the safety of that vehicle. That might be relevant in a legal proceeding if there was an issue put before a court. We are also keen to make sure that, in future, if there is an issue, innocent third parties who might be affected by that crash, or whatever incident it was, are compensated quickly, which is why one of the first areas of focus for us in our regulatory programme is motor insurance and how we create the framework to make sure those conversations happen in a way in which ensures claims are paid quickly to people who are affected.

**Lord Hennessy of Nympsfield:** I should have declared an interest as a fellow of the British Academy. I am not quite sure in what way it is linked but I declare it just in case. Whatever the progress of artificial intelligence, robots on wheels are not going to be ideal witnesses in witness boxes in court cases, are they? How are you going to know? Are you going to have a black box, like an aircraft recorder, in each one of these things? For example, could it be a defence that its sensors were baffled by an extreme weather event? It all seems to me to be beyond A P Herbert’s “Misleading Cases”.

**Iain Forbes:** We recommend, as part of our code of practice, that manufacturers include a data recording device to make sure that that data is harvestable which could be useful, perhaps, in a court if there was a particular issue. Also there are discussions at international level about data recording devices, which I think could be relevant.

**Ian Yarnold:** Yes, coming back to the Geneva discussions, on the back of the work we did and the recommendations in our review of regulations we recognised that there needed to be some co-ordination on the issue of data recorders. We do not refer to them as “black boxes” because that is just a thing; we have to talk about the function of the device and what it would record. That discussion is at a very early stage but I anticipate that moving very quickly over the next year or so to move to thinking about the information we need to collect, the frequency of collection and how long the vehicle has to store it for, for example, so that we have that opportunity to interrogate that information to understand the technology being

Government – Ian Yarnold, Head of International Vehicle Standards Division and Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), Department for Transport (DfT) – Oral evidence (QQ 1-10)

used at the point when an incident occurred and who was in control of the vehicle if there is a switchover between a driver and a vehicle in that particular case.

**Lord Hennessy of Nympsfield:** Is the Government Legal Service helping you on this?

**Iain Forbes:** We have very close relationships with our lawyers. They work very closely on how we take the work forward. You probably have chats with your legal team—

**Lord Hennessy of Nympsfield:** What do they say? What do they tell you?

**Ian Yarnold:** The answer to the question is yes; we bring them in whenever we need to. At the moment it is a technical discussion about what we think are the parameters that we need to collect from a technical point of view based on our experience of the technology and the information we have seen required over the years on accident investigation, for example.

**Lord Hennessy of Nympsfield:** It will need primary legislation, will it not?

**Ian Yarnold:** Not for the vehicle to be fitted with the device because that would be a technical standardisation issue. That becomes more challenging when going back to your point about what you do with the data. From my point of view, it is a technical specification issue.

**Lord Hunt of Chesterton:** Would the cars talk to each other? If you have two cars going round a corner, they have not seen each other and they crash, as they do in north Devon where I have holidays—nobody cuts the trees—so the two black boxes will fight it out in the courts, will they?

**The Chairman:** We must move on because there is not going to be an answer to that one. I have Lords Cameron, Hunt and Fox. I am hoping we can complete this in three minutes because we are running out of time.

**Lord Cameron of Dillington:** My question was going to be on the black boxes but I notice that different brands seem to be accepting different liabilities, with Tesla the least liability and others saying they will accept liability. We had written evidence from the insurance companies saying that they want the Government to create an associated right of recovery allowing insurers to claim costs from manufacturers and other stakeholders, presumably having been proven by the black box. Are the Government going to introduce such an associated right of recovery, do you think?

**Iain Forbes:** We are looking into how the framework is going to operate in future including discussing that with the insurance industry and others. The point I would make about the statement you have made is that it is not really for the manufacturers to say where the liability lies; it will be for the courts to decide.

**Lord Cameron of Dillington:** I would accept that.

**Lord Hunt of Chesterton:** Do they have radios for the cars to, as it were, talk together?

**Iain Forbes:** Some manufacturers are very keen to develop cars that speak to each other using short-range radio communication. That is one path of development which is being pursued by manufacturers in Europe, the US and elsewhere. Some

Government – Ian Yarnold, Head of International Vehicle Standards Division and Iain Forbes, Head of the UK Government’s Centre for Connected and Autonomous Vehicles (CCAV), Department for Transport (DfT) – Oral evidence (QQ 1-10)

developers think they can achieve the benefits and develop systems without the need to speak to each other.

- Q10** **Lord Fox:** Whether they are talking to each other or not, there will be tons of data. Who is going to own it?

**Iain Forbes:** We do not have the full answer to that yet. This is a new and emerging technology and it is going to require transparent discussions about these sorts of questions—

**Lord Fox:** Does this have moral value?

**Iain Forbes:** —including around informed consents, data privacy and security; a huge set of questions which are going to have to be worked through in future.

**The Chairman:** We have covered a lot of ground but we have run out of time, as we inevitably do. There are one or two points on which I think it would be helpful to have a follow-up note, if you would not mind. Maybe you have some other thoughts and might wish, in supplementary notes, to amplify your evidence. There was mention of a Cabinet Office co-ordinating committee. It would be interesting to know which departments are represented. We talked about work on modelling mixed fleets, and a note on that would be of great interest, if you could, and the M2 trial that was mentioned.

**Lord Hunt of Chesterton:** We did not have an answer to your and Lord Vallance’s question on where is the company/economic dimension to developing in the UK.

**The Chairman:** If you read through the transcript, as you will, there may be other points you would wish to follow up on, and I have no doubt you will bear in mind Lord Hunt’s point.

**Baroness Young of Old Scone:** Chairman, I forgot my interests.

**The Chairman:** You did indeed, and I was going to remind you.

**Baroness Young of Old Scone:** I should have said that I am chancellor of Cranfield University, which has a number of funded projects in the field of autonomous vehicles, with some of the funding coming from your money.

**The Chairman:** That completes all our declarations of interests. I thank our two witnesses for their very helpful start to our inquiry. As I say, you will get a transcript. Please make any alterations where the record is inaccurate. Once more, on behalf of the Committee, thank you for your help today.

**Government – Department for Transport (DfT) and the Department for Business, Energy and Industrial Strategy (BEIS) – Supplementary written evidence (AUV0095)**

**Future Uses of Autonomous Vehicles in the UK**

**Introduction**

78. The Government welcomes the Committee's request for supplementary evidence from the following sessions,
- a. 22 November, Rt Hon John Hayes MP, Minister of State, Department for Transport, and Mr Nick Hurd MP, Minister of State for Climate Change and Industry, Department for Business, Energy and Industrial Strategy
    - i. A copy of a letter [Rt Hon John Hayes CBE MP] has written to the Chief Scientific Adviser about work on the future of mobility
    - ii. A note on modelling and microsimulation of mixed fleets carried out by the Department
    - iii. A note on scoping work being carried out for a study of human behaviour in relation to autonomous vehicles
    - iv. A note on further work for rural areas in relation to autonomous vehicles
  - b. 1 November, Ian Yarnold, International Vehicle Standards Division, Department for Transport (DfT) and Iain Forbes, Head of UK Government's Centre for Connected and Autonomous Vehicles (CCAV)
    - v. A Cabinet Office co-ordinating committee [for Robotics and Autonomous Systems] ... which departments are represented?
    - vi. Work on modelling mixed fleets.
    - vii. The [A2/]M2 trial.

**1) A copy of a letter Minister John Hayes has written to the Chief Scientific Adviser about work on the future of mobility**



Sir Mark Walport FRS FMedSci,  
Chief Scientific Adviser to HM Government  
5th floor, 1 Victoria Street,  
London,  
SW1H 0ET

From the Minister of State  
Rt. Hon John Hayes CBE MP

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33 Horseferry Road  
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Tel: 0300 330 3000  
E-Mail: [john.hayes@dft.gsi.gov.uk](mailto:john.hayes@dft.gsi.gov.uk)  
Web site: [www.gov.uk/dft](http://www.gov.uk/dft)

23 November 2016

24 NOV 2016

Dear Sir Mark,

I am very pleased that the Government Office for Science is proposing to undertake a Foresight investigation into the "Future of Mobility".

It's critical that government has a handle on how social, economic and demographic trends will affect the country's transport system.

Moreover, the rapid pace of technological change makes it very challenging to have a clear insight into how transport will look in the future and where the time critical decision points are.

This project is an excellent opportunity to have long and serious look at the issues, challenges and opportunities, and help us in government to plan for the future transport needs of people.

I very much look forward to seeing the emerging and final conclusions.

A handwritten signature in black ink, appearing to read "Rt. Hon John Hayes CBE MP".

Rt. Hon John Hayes CBE MP

**2) A note on modelling and microsimulation of mixed fleets carried out by the Department**

*Overview*

- a. In October 2015, DfT commissioned Atkins to carry out new research (using micro-simulation modelling techniques) to investigate the potential large-scale impacts of CAVs on traffic flow and network performance on urban and inter-urban roads.
- b. This project is amongst the most extensive and pragmatic research of this type, and provides the most comprehensive analysis of the impacts of CAVs on network performance and will form an important part of the UK and international evidence base.
- c. The research sheds new light on how different levels of CAV technology, variations in the degree of cautious or assertive behaviour of CAVs, and different levels of CAV penetration in the vehicle fleet, could impact the journeys people take on our roads.
- d. The findings are largely positive, showing that CAVs offer major potential to reduce delays, improve journey times and improve journey reliability on strategic and urban road networks.
- e. But the work also highlights that these benefits are not a given, depending heavily on the proportion of CAVs in the fleet as well as the extent to which CAVs adopt cautious or assertive behaviour (which may vary according to user or manufacturer preferences).
- f. It is also important to note that this work represents a simplified view of impacts, due to both the limitations of the modelling tools employed, and fact that the work considered lateral and longitudinal vehicle behaviour but did not consider wider factors that will influence network performance – such as demand effects, safety or driver behaviour.
- g. As such, this research should be considered as a first step in understanding the large-scale network impacts of these technologies, with significant further work required. The Department has already commissioned additional research in this area, and is also working with the Transport Systems Catapult to support the development of new analytical approaches to model and assess the impacts and benefits of CAVs.
- h. This research is currently being developed for publication next year.

*Broad conclusions of the research*

- i. Average journey times, delay and network capacity have been shown to improve with increasing penetration and capability of CAVs – and could offer major improvements, particularly in high-speed, high-flow situations. Journey time reliability could also improve dramatically.
- j. Benefits are not limited to CAVs – all road users would benefit from any improvements in network performance, even those in ‘legacy’ vehicles.

- k. At low penetrations, more advanced CAVs are likely to be limited by the vehicles around them. This research suggests the likely tipping point for the proportion of enhanced vehicles in the fleet required to produce major traffic flow benefits may be between 50% and 75%.
- l. Benefits are likely to depend heavily on user or manufacturer preferences – particularly around comfort and safety. If users want vehicles to behave cautiously, network benefits will be reduced, and could even worsen network performance in some circumstances.

*Impacts on strategic roads*

- m. In low-penetration scenarios, benefits are relatively small, but increase as technology and penetration improves.
- n. In peak period traffic, with 100% penetration of assertive CAVs, we could see:
  - i. Journey times reduced by more than 11%
  - ii. Delay reduced by more than 40%
  - iii. Journey time reliability [defined as the standard deviation] improved by more than 54%

*Impacts on urban roads*

- o. In low-penetration scenarios, much greater benefits are seen in peak period traffic in urban areas - with a 12% improvement in delay, 21% improvement in journey times and a nearly 80% improvement in journey time reliability.
- p. This suggests that urban traffic could see significant benefits even from lower-level “driver assistance” technologies

**3) A note on scoping work being carried out for a study of human behaviour in relation to autonomous vehicles**

*Overview*

- q. In February 2016, DfT commissioned a scoping study to understand the main social and behavioural questions relating to autonomous vehicles (AVs) and whether any evidence currently exists to answer these questions. The scoping study involved:
  - i. a review of the literature relating to the social and behavioural aspects of AVs
  - ii. exploration of the research being undertaken by the Government-funded four cities driverless car trials, including visits to each of the trials
  - iii. extensive engagement with experts to explore the social and behavioural implications of AVs. This included topics such as data security, impact on the labour market, city infrastructure, implications for public health and the differences between urban and rural areas.

- r. The findings from the scoping study will inform DfT and the wider research and innovation community in this area, to ensure better and more successful policy development and delivery.
- s. This research is currently being developed for publication next year.

*Headline Findings and Implications*

- t. The main findings from the scoping study and literature review are:
  - i. To date, the social, behavioural and societal aspects of AVs are under-researched and most of the literature has focused on the technical aspects.
  - ii. Nearly 400 social and behavioural questions were identified and they can be broken down into the following four categories:
    1. The interaction between the user/driver and highly automated/autonomous car (e.g. in a partial automation context, how quickly are drivers able to take back control of the vehicle?)
    2. The interaction of other road users, including pedestrians with the highly automated/autonomous car (e.g. how do others in the road environment feel about increased automation and how will they respond to it?)
    3. The attitudes of the general public towards autonomous cars, including public acceptability. (e.g. to what extent are people concerned about issues such as road safety and data security, will people be willing to pay for them, and how might these concerns be alleviated?)
    4. The wider, longer-term social, economic and environmental impacts of autonomous vehicles. (e.g. what are the impacts of AV use on congestion and the environment, will they have public health implications? How will AVs be deployed? What uses will they have? Who will use them and for what purposes - e.g. niche/specialist uses vs intra-urban/local journeys vs inter-urban/long distance travel?)
- u. The Government-funded four cities driverless car trials are each undertaking research which can be expected to produce useful evidence to support the growing understanding of the social and behavioural impacts of AVs. However, this work on its own will not answer all the social and behavioural research questions that need to be understood to inform policy development.
- v. The report makes a number of recommendations for future research to address some of the social and behavioural research questions identified. Those recommendations include public dialogue with citizens and businesses to provide insight into factors that drive attitudes and likely behavioural responses to autonomous vehicles. Government cannot do it alone and we anticipate

contributions towards the social and behavioural research agenda from academia, industry and other stakeholders.

- w. This research should be considered as a first step in understanding the large-scale social and behavioural impacts of these technologies, with significant further work required. The Department is working on developing the next stage of research and we recognise the urgent need to better understand the new relationship between the driver and the vehicle in highly automated modes and also to understand the implications of AVs for people who live and work in rural areas.

**4) A note on further work for rural areas in relation to autonomous vehicles**

- a. The human behaviour study (3, above) involved extensive engagement with experts to explore the social and behavioural implications of AVs. This included topics such as data security, impact on the labour market, city infrastructure, implications for public health and the differences between urban and rural areas.
- b. The Department for Transport is working on developing the next stage of research. It recognises the urgent need to understand better the new relationship between the driver and the vehicle in highly automated modes and also to understand the implications of AVs for people who live and work in rural areas.
- c. The Connected Corridor (see 7, below) provides a unique opportunity to test these technologies on a route comprising a mixture of urban roads in one of Europe's mega-Cities (London), inter-urban (A2 / M2) and international gateway to the Port of Dover / Eurotunnel, as well as on surrounding local road networks in Kent. Integrating these networks is a key outcome for the pilot.
- d. The Corridor will create an open test-bed which will give UK industry the opportunity to develop their own services, business models and partnering agreements, and exploit commercial opportunities for vehicle-to-infrastructure applications.

**5) A “RAS Cabinet Office co-ordinating committee” was mentioned - which departments are represented?**

- a. In 2016, Cabinet Office convened a time-limited working group to support information sharing and coordination of government activities on the Robotics and Autonomous Systems agenda. Departments represented included: BEIS (then BIS and DECC), DfT, Defra, Cabinet Office, MOD, DH and DCMS, plus a number of relevant agencies including EPSRC and Innovate UK. The group has now wound down but its work has fed into current activity including the BEIS-led Industrial Strategy process.

**6) Further information on work on modelling mixed fleets.**

- a. See 2, above.

## **7) A2/M2 CONNECTED VEHICLE CORRIDOR**

- a. Connected vehicles that can talk to each other, and to the roadside infrastructure, are the future. We want the UK to embrace these technologies which will transform our roads and open up a brand new route for global investment. The potential for transformation is significant, and vehicle to infrastructure and vehicle to vehicle communications will enable safer road conditions for users.
- b. The Department for Transport and its partners (Highways England, Kent County Council and Transport for London) are designing a flagship “connected vehicle corridor” on the A2/M2 London to Dover route, a £15 million living laboratory for deploying a range of services and wireless communications technologies that these vehicles will need to operate.
- c. The investigation and testing, then subsequent installation and trialling, of cooperative Intelligent Transport Systems (C-ITS) on the London to Dover Connected Vehicle Corridor will demonstrate how technology can be used to tackle congestion, and to improve journey reliability and road safety, while supporting innovation and growth.
- d. The Corridor will create an open test-bed which will give UK industry the opportunity to develop their own services, business models and partnering agreements, and exploit commercial opportunities for vehicle to infrastructure applications.
- e. The Corridor provides a unique opportunity to test these technologies on a route comprising a mixture of urban roads in one of Europe’s mega-Cities (London), inter-urban (A2 / M2) and international gateway to the Port of Dover / Eurotunnel, as well as on surrounding local road networks in Kent. Integrating these networks is a key outcome for the pilot – as shown below.



- f. The link to the mainland Europe is important – the partnership has developed a partnership with Belgium/France/Netherlands to create a network of connected vehicle services which will enable vehicles to travel from Vienna to London – using the same services, with technology applied to common standards.
- g. The pilot will provide a proof of concept for providing road users with direct information, from the roadside infrastructure, that will provide safety information about hazards ahead and road safety information about road works in the carriageway. Further safety enhancements, including vehicle-to-vehicle safety related information, will be considered within further phases of development.
- h. Feasibility studies considering the technologies, services, and data management have been completed. We are now gearing up to start the detailed design of the infrastructure and communication systems to deliver the services– with first deployment programmed for 2018/19.

December 2016

Andy Graham, White Willow Consulting, Professor Sarah Sharples, University of Nottingham and Professor Natasha Merat, University of Leeds – Oral evidence (QQ 55-62)

**Andy Graham, White Willow Consulting, Professor Sarah Sharples, University of Nottingham and Professor Natasha Merat, University of Leeds – Oral evidence (QQ 55-62)**

[Transcript to be found under Professor Sarah Sharples, University of Nottingham](#)

**Mr John Gunn– Written evidence (AUV0006)**

1. Where is the demand for self-driving vehicles? As a voter no one has asked me and if they did I'd say no thanks.
2. The cost of this technology is monstrous. Presumably the taxpayer is funding it somehow to the detriment of other things such as the NHS etc.
3. Security. What is to stop these vehicles being hacked and used to cause damage or indeed terrorism?
4. Data protection. What safeguards will users have over their data eg where they travel etc. This is a major issue in 2016 let alone the future given that data capture seems to increase daily and get sold on to the highest bidder.
5. Un-employment. Presumably the plan is to take over from taxi drivers, bus drivers, heavy goods delivery etc. When all these people are out of a job what will they do instead (claim benefits?) and how will they pay any taxes? Will this result in higher taxes for everyone else not involved with cars and/or deliveries?
6. Computer error. What will happen when there is a malfunction? My laptop goes wrong on a daily basis so presumably driverless vehicles will be no different.
7. How will they cope with heavy rain, fog, snow etc which may hinder their “vision”?
8. GPS errors or map out of date errors? How will a dumb computer navigate a section of roadworks that wasn’t there yesterday or indeed a new one-way street?
9. Impact on the oil industry? Presumably these vehicles will be electric which could seriously disrupt the oil industry and be catastrophic for jobs and taxes paid.
10. Mix of people driving and driverless vehicles. Unless the end game is to rid the human population from the roads there will be a strange mix of the two. What happens at a junction when there is no eye contact to deal with the “right of way”?

*20 September 2016*

**Mr Robert Harcourt B.Sc. – Written evidence (AUV0001)**

*Mr Harcourt is an engineering systems designer (retired).*

Addressing questions 2, 5, 10, 11 and 17.

1) Prediction Future deployment of micro-taxi fleets in cities, assuming the availability of low-cost mass-produced autonomous electric taxis within 5-10 years.

2) Planning by local government to meet same.

2A) Increased provision of taxi-ranks with power points. Say 20 mile maximum journey between charging ranks. 2B) Provision of pick-up and set-down bays in the majority of urban streets to avoid waiting on carriageway. 2C) Licensing of local operators

3) Intervention by central government committee to meet same.

3A) Mitigation of impact on local bus operators by de-markation of zones served. Say limit of 10-mile radius from city or urban centre for autonomous taxis. 3B) Mitigation of impact on local taxi operators by limiting the size and payload of micro-taxis. Say maximum two passengers and only hand luggage. 3C) Consideration of impact on privacy when the mobile 'phone that summons the taxi is obviously linked to the source and destination addresses thus recorded at the micro-taxi headquarters.

*16 September 2016*

## Heathrow Airport – written evidence (AUV0076)

### Impacts and benefits

#### ***What are the potential applications for autonomous vehicles?***

1 At Heathrow airport there are a number of areas where autonomous vehicles could see application:

- Passengers and colleagues using them on their surface access journey to the airport
- Transfer passengers between terminals and satellite buildings
- Connecting passengers and colleagues around the campus.
- Airside vehicles, those that are in the restricted zone within the security envelope, in cargo, baggage and other parts of the operation.

#### ***What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?***

- 2 The potential benefits or indeed disadvantages of deployment of autonomous vehicle are difficult to outline anywhere close to fully at this stage due to the rapid changes that have and will continue to happen in this industry. From the airport's point of view, it is likely that there will be a continuation of the trend seen with Heathrow's POD parking for terminal five which is both immensely popular with our passengers and has seen a saving of 100 tonnes CO<sub>2</sub> per annum.
- 3 Replicating this around the campus in the future would see more passengers enjoying this new and exciting technology that provides a comfortable, quick and easy journey. Assuming that they would run more efficiently than individual vehicles there is potential for easing traffic and pollution levels around the airport.
- 4 In terms of wider benefits for society, a driverless future could see:
- People spending their time more productively or enjoyably rather than driving
  - It would give enhanced mobility to those unable or unwilling to drive
  - Would enable more efficient use of highway infrastructure by increasing capacity and reducing the impact of disruption due to incidents.
  - Would have real benefits to consumer as the marginal cost of mobility would be reduced
  - Towns and cities would need less space for parking and could then choose how that space could be reclaimed.
  - On demand mobility would be achievable. This could mean car ownership reducing without an equivalent loss in the population's mobility.
  - Improve safety of the road network by eliminating driver error.
- 5 However, there are also risks, a reduced cost of driving might see people continue to use and run cars as today and rather than parking them at a place of employment they send them on errands and the number of journeys goes up not down.

***How much is known about the potential impact of deploying autonomous vehicles in different sectors?***

- 6 No specific comments

***How much is known about public attitudes to autonomous vehicles?***

- 7 The general trend in US and Europe is that the public is warming to the idea of driverless vehicles though there are still concerns about safety, losing the ability to self-drive and the impact it would have on those whose livelihoods involve driving.
- 8 There has been some evidence that younger people are more accepting of the idea of driverless vehicles and more tuned into potential benefits whilst older members of the public tend to focus on the potential downsides.
- 9 A recent study can be found at  
[https://www.researchgate.net/publication/278744106\\_Public\\_opinion\\_on\\_automated\\_driving\\_Results\\_of\\_an\\_international\\_questionnaire\\_among\\_5000\\_respondents](https://www.researchgate.net/publication/278744106_Public_opinion_on_automated_driving_Results_of_an_international_questionnaire_among_5000_respondents)

***What is the scale of the market opportunity for autonomous vehicles?***

- 10 It is difficult to judge at this stage but it is worth noting that penetration of smartphones has risen from 20% in 2010 to about 70% in 2015. Similarly, 2% of UK households had tablets in 2012 and by 2015 that number was 54%.
- 11 There is an expectation with the public that autonomous vehicles will be more expensive and no-one should expect levels of penetration like we have seen in some other areas of technology. However, if the market for autonomous vehicles is centred around mobility services rather than more traditional ownership models then that may result in significantly different outcomes.

**Creating an enabling environment Research and development**

***Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?***

- 12 The current demonstration facilities for autonomous vehicles present good progress in the field and put the UK in a strong position on research and development globally.
- 13 However, there are some gaps in the current testing ecosystem as the tests do not have as much on-road mileage as other global trials, such as GoogleX in California or the Volvo DriveMe project. After two rounds of multi-million funding, the current UK trials have not yet demonstrated much in terms of practical testing, results or knowledge gathering.
- 14 There is a need for connected & autonomous vehicles to focus on demonstrating useful function and benefit, whether this is at a specific location or for a particular segment of the population. Therefore, an ambitious testing ecosystem should move away from demonstrating the technology and more towards solving problems and realising benefits - using technology as a catalyst for positive behaviour change.

- 15 There is a need for a flagship trial that should try to solve tangible, well-defined real-world problems experienced today by applying technology.
- 16 Public communication and engagement should not be an afterthought. Communicating the merits and how CAVs may fit into our transport system to the public is required. This should be about communicating the potential benefits to the wider population and not just within specialist industries.

***Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?***

- 17 The funding that has so far been made available via CCAV and Innovate UK is welcome as it is enabling organisations to undertake valuable research and development in this area. However, many companies operating in this field, especially smaller companies or start-ups, are facing a lot of uncertainty that might threaten their viability and innovation capacity long term.
- 18 Companies do not know in what environment (funding, regulatory, safety, design, standards) they will be operating in 2, 5, 10 years from today. One way to introduce some certainty is to provide funding stream(s) which are approved, hypothecated, well-defined and guaranteed. In light of the Brexit vote and general uncertainty faced by companies based in the UK, anything that would add certainty and stimulate innovation is welcome.
- 19 To date, it appears that the majority of funding has focussed heavily on the technology without much investment into the practical usage of the vehicles. A move towards funding for controlled on road testing, focused on delivery, would be recommended and then real world use that is solving real world problems.
- 20 It is also vital that any research and development that the Government is funding is aimed at achieving strategic goals and realising benefits for the wider transport network. For example, better connectivity and integration between public and private modes of transport or more efficient usage of the road network.

***How effective are Innovate UK and the CCAV in this area?***

- 21 No further view beyond response to previous question.

***Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling? Real world operation***

- 22 No view.

***Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?***

- 23 Both digital and physical infrastructure will have to undergo improvements in order for autonomous vehicles to operate safely on the UK's roads.

- 24 For example, roads, signs, lines, junctions, design and signals will all need to be audited to ensure they are accurate and can be understood by an autonomous vehicle in all weather and light conditions. The increased connectivity of autonomous vehicles will also lead to significant changes to digital infrastructure to ensure vehicles can communicate with signals, and other road users, but also in order to keep data secure. Design standards such as Design Manual for Roads and Bridges would need to be reviewed.

***How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?***

- 25 No view

***Does the Government have an effective approach on data and cybersecurity in this sector?***

- 26 Heathrow is not in a position to comment on the Government's general approach to cyber security at this stage, certainly in terms of technical details. It is understood that research into the current state of security in this area is currently being undertaken with more work to be done.
- 27 We do view the potential security impact of having driverless (and even unoccupied) vehicles operating airside, having access to forecourts or even the terminals themselves as being an area that should be considered and explored further.

***Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?***

- 28 No view

***What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?***

- 29 No view

#### **Wider governance**

***What does the proposed Modern Transport Bill need to deliver?***

- 30 Firstly, funding so that the current climate of opportunity can be turned into outcomes and progress. There is a need to balance between freedom and regulation is essential. It also should have clear objectives linked to Government's overall transport and infrastructure strategy, so that new technology and trials are solving real world problems not just a showcase.

***How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?***

- 31 No view

***Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?***

- 32 The Government needs to be clear how it sees the role of CAVs in the UK transport network and what outcomes and benefits it is seeking to achieve through their promotion and introduction. This will enable prioritisation of the most important benefits to its overall strategy.

***What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?***

- 33 The most pressing implications would be the continuation or replacement of current funding, knowledge sharing and collaboration.

*26 October 2016*

## Highways England – Written evidence (AUV0090)

### Introduction

1. Highways England is the Government-owned Company responsible for operating, maintaining and improving England's motorways and major A-roads (the Strategic Road Network – SRN). Safety is our number one priority.
2. Our road network totals around 4300 miles and forms the economic arteries of the country – connecting regions, business and people 24 hours a day, 7 days a week. We carry a third of all traffic by mileage and two thirds of all freight.
3. Innovation, technology and research play critical roles in helping Highways England make our roads safer, cleaner, more efficient and easier to use – at the same time as increasing capacity to meet rising demand and delivering greater economic returns.
4. Within the transport innovation field, autonomous vehicle (AV) technology is developing rapidly. Highways England continues to work with government, industry and other partners to ensure that the benefits of AV are harnessed for our road users and the SRN, and that the technology is deployed in a safe and sustainable way across our network.
5. It is in that context that Highways England responds to this inquiry.

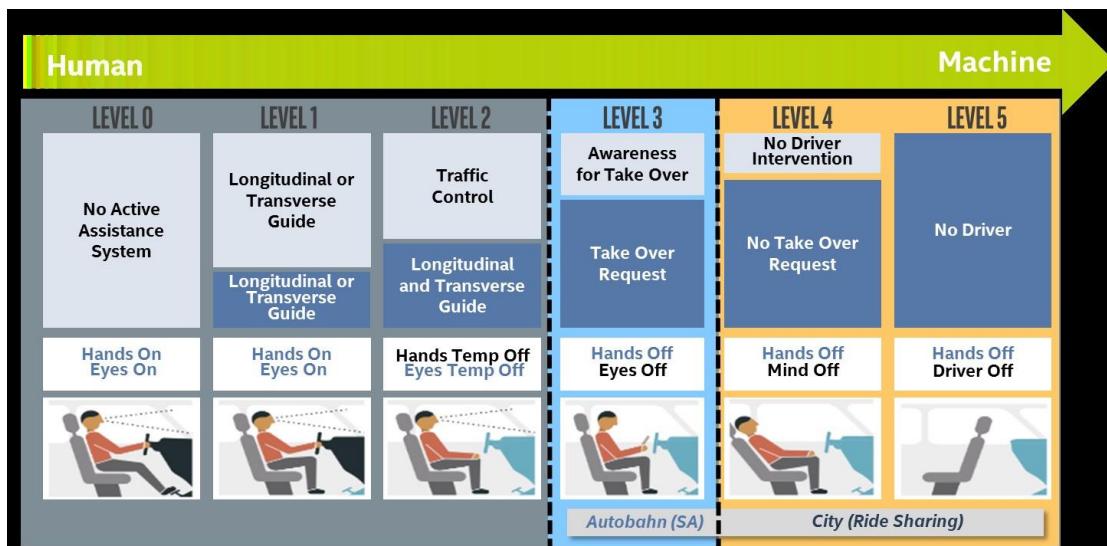
### **Q1. What are the potential applications for autonomous vehicles?**

Highways England has an interest in the potential applications of both connected and autonomous vehicles.

By connected vehicles, we mean those that can communicate with other vehicles or infrastructure on the road network. A good example is freight platoons - where a lead vehicle, within which the driver has full control, is electronically coupled to other vehicles in the platoon allowing drivers of the following vehicles to cede elements of control to the lead vehicle.

Connected highways are also a developing area of interest, whereby vehicles and the network can communicate with each other. This technology has a number of potential applications for Highways England that could give us a better understanding of network conditions, such as traffic flow and speed.

In terms of autonomous vehicles, it is important to recognise there are several different levels of autonomy, ranging from Level 0 (full driver control) to Level 5 (no driver – all control is in the vehicle).



(Autonomous Cars: Navigating the Long Road Ahead – iQ by Intel)

Across this automation spectrum we see two main applications for autonomous vehicles on the SRN:

- **Road users:** AV has the potential to be applied in support of the use of the SRN by the public and by industry and business.
- **Maintenance/Construction:** using AV to undertake some aspects of highways maintenance and construction activities.

## Q2. What are the potential user benefits and disadvantages of the deployment of autonomous vehicles?

There are broad potential **benefits** for the SRN in a number of areas:

**Safety:** Drivers can already benefit from levels of automation in their vehicles including adaptive cruise control (setting the vehicle to maintain a certain speed), lane keep assist (helping the vehicle to stay in lane) and autonomous emergency braking (AEB). Given that up to 94% of all recorded road injury collisions in Great Britain include human error as a contributory factor, we believe there is scope to do more in this area. Causes of accidents including driver fatigue (thought to be attributable to up to 20% of accidents on all roads)<sup>138</sup> and distraction could be reduced by Level 4 and 5 autonomous vehicles.

We believe that autonomous and connected technology can play an important role in the work Highways England is doing to deliver its objectives on safer roads, safer vehicles and safer people.

**Productivity:** Safe AV technology could enable road users to use their travel time more productively. At level 5 autonomy, where the vehicle is fully automated, passengers in the

<sup>138</sup> "Fatigue and Road Safety: A Critical Analysis of Recent Evidence", Road Safety Web Publication No. 21, Department for Transport, 2011

vehicle would be able to hold meetings whilst on the move, without being distracted or responsible for driving.

**Utilisation:** if AV technology could be developed to a position where it enabled vehicles to become part of a more integrated road transport system there is potential to make the SRN even more efficient by better utilising available road space. For example, if vehicles could interact with traffic signals, road works operators and other transport modes then there is scope for a reduction in delays to journeys.

If autonomous vehicles could be programmed to safely travel closer to the vehicle in front at motorway speeds it would provide potential to enhance the capacity of the network.

**Access:** The SRN is a critical component of our national and regional economies. The network also connects people and communities and therefore has an important social function.

AV technology could evolve in a way that enables those people currently unable to drive to access our network and realise the social and economic benefits of doing so.

Of course, there are also a number of **challenges** that AV technology poses for the SRN:

**Safety:** the safe deployment of any form of AV technology on the SRN is clearly of paramount importance to Highways England and our road users. In particular, there are challenges around autonomous vehicles taking emergency action on the SRN and we will work with industry to ensure that these challenges are addressed and take into account the design and operation of the network.

The biggest challenge is the interaction between autonomous vehicles and human driven vehicles and ensuring each vehicle can predict the actions of the other. Some of the incidents reported with self-driving vehicles occur because the human driven vehicle is not able to predict self-driving behaviour. Human factors research will be a key activity to understand this.

**Utilisation:** If autonomous vehicles initially need to be programmed to require larger distances between vehicles (to ensure safe operation) than currently achieved by standard vehicles this could reduce the capacity on our network.

**Insurance:** The uptake of AV technology brings real challenges to Highways England in terms of legal responsibility for damage caused to our network by vehicles. At present, in some circumstances drivers can be held responsible in the event that their vehicle damages SRN infrastructure – however, in an automated vehicle it is less clear where the responsibility lies and this presents challenges around insurance claims.

#### **Q4. How much is known about public attitudes to autonomous vehicles?**

Transport Focus recently (November 2016) published their “Road to the Future” report, which focusses on how Highways England can improve the road user experience during the next Roads Investment period. The largest area for improvement was around increasing road

space and capacity. Although none of the users interviewed mentioned either connected or autonomous vehicles specifically, AV has the potential to address some of their primary concerns. Our experience is that road users are most interested in their experience of using the network, rather than the technology explicitly.

It is worth recognising that whilst fully automated vehicle technology might seem futuristic, road users have already benefitted from a number of semi-automated technologies that are now considered as standard – for example traction control, breaking systems and impact protection.

The three year social and behavioural research programme that DfT is leading will help to build a much fuller and more robust evidence base to understand the attitudes and behaviours of road users with respect to AV.

**Q6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

We work closely with the Centre for Connected and Autonomous Vehicles and in particular on the UK testing for connected and autonomous vehicles.

In our view the proposal for a flagship test facility is a good one, though we think a range of test environments is required in order to progress the technology safely and with public support.

Sections of the SRN could provide a good environment to safely test lower levels of AV technology as they are relatively controlled road environments with clearly defined carriageways, CCTV technology to monitor driver behaviour and few physical hazards such as pedestrians, cyclists and road furniture. Indeed lower level autonomous vehicles are already in use on the network.

We are already supporting a number of AV trials:

- The UK Connected Intelligent Transport Environment (CITE) connected vehicle trial by April 2018, where we are working with Jaguar Land Rover, Coventry City Council, Visteon, Vodafone and others – a project sponsored by Innovate UK.
- The A2/M2 Connected Corridor, working with Transport for London and Kent County Council and supported by the Automotive Electronic Systems Innovation Network.
- The HGV platooning trial working with DfT.

In addition, we are in discussions with a number of vehicle manufacturers about future trials, including on the M4. We also support the ongoing work of the Four Cities Driverless Vehicle Trials as members of the advisory boards, funded by Innovate UK.

**Q10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

It is too early to determine exactly what changes to physical infrastructure might be required to accommodate AV in the future, but our active involvement in trialling both connected and autonomous vehicles will shape our thinking in this area. We would expect connected

vehicles to require changes to both digital (better connectivity) and physical infrastructure (reducing traditional roadside communications infrastructure).

A good example of the uncertainty around the development of this technology and its potential impact on the SRN is that of white lining. Depending on how car technology develops, the requirement for white lines to support Lane Keep Assist Systems may increase or become obsolete from an AV perspective.

Safety will be a key driver in determining what changes to physical infrastructure, if any, will be required in the future and our leadership and support of real world environment continues to be an important part of the evidence base.

**Q11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

A number of key milestones have already been met, including the Government's publication of a regulatory review of what will be necessary to enable the testing and development of AV technology. For us, the development of the safety case for autonomous vehicles to safely operate on public roads is a key milestone.

As part of that safety agenda, there are a number of associated issues, including insurance provision and vehicle licensing that will require further consultation and examination.

**Q13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

As AV technology develops and is deployed in real world environments, we think that inevitably there will be a requirement for insurance, regulation and legislation to keep pace.

Any changes will need to, in part, be driven by experience from real-world testing and guided by the projected path and speed of technology development and deployment. The uncertainty around whether AV technology will develop incrementally or as a breakthrough straight to high-levels of automation will require an adaptable approach to these issues.

*9 November 2016*

## **Highways England, RAC Foundation and PA Consulting Group – Oral evidence (QQ 48-54)**

### Watch the meeting

Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Baroness Morgan of Huyton; Lord Oxburgh; Lord Vallance of Tummel; and Baroness Young of Old Scone.

Evidence Session No. 6

Heard in Public

Questions 48 - 54

### Examination of witnesses

Mike Wilson, Chief Highways Engineer, Highways England, Steve Gooding, Director, RAC Foundation and Charlie Henderson, Partner, PA Consulting Group.

**Q48 The Chairman:** Good morning, gentlemen. Thank you for joining us for this second session this morning. We are being broadcast so perhaps for the record you would like to introduce yourselves. Could we start with Mr Wilson?

**Mike Wilson:** Thank you. Good morning. My name is Mike Wilson. I am the chief engineer at Highways England.

**The Chairman:** If you would like to make an opening statement, by the way, please feel free to do so.

**Mike Wilson:** First, it is a pleasure to give evidence to the Committee. Highways England is the government-owned company responsible for the operation, maintenance and improvement of England's strategic road network, a network that is 4,300 miles long, carries about 85 billion vehicle miles a year, and so is an important part of the UK economy. Innovation is critical to the success of our business and for the safe, efficient and clean operation of the road network. Part of my role at Highways England is to ensure that innovation and technology are pulled through into our day-to-day operations but also into our longer-term strategic plans. Autonomous, connected vehicle-to-vehicle, and vehicle-to-infrastructure technology is developing rapidly and Highways England is actively engaging in this area, as we see potential benefits, particularly around safety, improved network utilisation and operation.

**Steve Gooding:** Good morning. Thank you, Mr Chairman. I am Steve Gooding. I am the director of the RAC Foundation, which is a small, independent research think-tank. We seek to represent the interests of the responsible motorist—and I would like to reassure Lord Hennessy that I am not carrying a tambourine.

I thought I would start with three observations, the first of which is, when I am thinking about the world of the full autonomous driverless vehicle, I sometimes find

it helpful to distinguish between what government needs to do to foster the development of this technology as a matter of industrial policy, and what it needs to do to facilitate the introduction of the vehicles on to our roads as a matter of transport policy. One is about the ability to have a successful and thriving auto industry here, which is not the same as fostering the mobility that we all need. Secondly, we have talked quite a bit this morning about the incremental approach, the fact that the technology coming into our motor vehicles is becoming more and more sophisticated and taking more and more of the driving task away from the driver. The Foundation is rather concerned about this, because at some point it worries me particularly that the driver is not driving enough to be properly in control of the vehicle. I have a particular hang-up, as Professor Sampson knows, with level 3 of the infamous five levels of automation, where apparently the vehicle can hand control back to the driver, who, in my case, might well be asleep at the time, which does not strike me as a very sensible way to go about things.

Lastly, one of the key considerations which I think we are all struggling with when trying to think about the implications of this technology is that currently we do not know what it will cost, so when we think about how individuals might engage with autonomous vehicles and what it might do to the patterns of trips they make, one of the key considerations is whether they will be able to afford them, and we are not yet terribly clear on that.

**Charlie Henderson:** Good morning. My name is Charlie Henderson. I am a partner with PA Consulting Group, a global technology and innovation consultancy. I have worked in the field of transport for over 25 years, helping organisations adapt and take up the challenges of technology. Most recently I helped a European Government around the regulations associated with testing and piloting of autonomous vehicles.

I think this Committee is a great opportunity to provide scrutiny and challenge to the whole development of autonomous vehicles in the UK. I would like to put three issues on the table at the start. First, I am not a technologist, so I do not look at this from a technology perspective. A lot of the work I deal with with clients is around systems thinking, and this is a complex system that we are dealing with. While there is the vehicle technology, there is a whole bunch of other elements which are just as thorny and difficult, some of which the Committee has already picked up on. There is regulation, insurance, compliance and enforcement, and there is a huge chunk around public and political acceptability. I am definitely not an evangelist. I see big issues and challenges in this area.

The second area picks up a point Steve made. I think it is interesting that the Science and Technology Committee is looking at this rather than a transport committee, because many of the issues and challenges we talked about with transport in a local environment and in the rural communities can be addressed by other problems. Autonomous and connected autonomous vehicles need to be thought of in a wider context of a transport policy.

The final point, again, picking up on a point that one of the other witnesses made earlier, is that the whole debate could be made a lot easier if we were more concise around our language. We talk about connected vehicles, autonomous vehicles and

highly autonomous vehicles, and we have different levels. One of the challenges I have when speaking to clients and people in this sector is that the language is used loosely, and people do not really understand what levels of autonomy they are talking about, whether it is spatially fully autonomous or temporarily, or whether it is partially autonomous and at the end of the motorway will hand back control of the vehicle to a sleeping Steve Gooding.

- Q49** **The Chairman:** Thank you very much. That is three very helpful introductions, and it leads in very well to the opening question I was going to ask how you see the benefits and drawbacks. If I could take the observation from Mr Gooding that one of the drawbacks is level 3, where you are moving in transition, perhaps with mixed access to a roadway or other track system, and the alarming prospect of being told by the computer you are back in control as a bus hurtles towards you because the computer cannot cope, we have already heard that in the air we have had automatic pilots. We are quite used to it and we are quite comfortable with it, but, again, there are occasions where the automatic pilot hands back. Air France had a famous case where this happened and the pilots were taken by surprise; they had all of two minutes to work out what was going wrong, but it ended in disaster. We have to recognise that transition is a very real issue here. That is a drawback. Perhaps you would like to elaborate on how you feel we can steer a way through—not meaning to be stupid about that—and how we can plan a way through this clear difficulty of transition. It surely has to be planned.

Secondly, following up on the issue of language, we are talking about these different levels of autonomy, and each of them has manageable, one hopes, steps where we have to understand what needs to be done by whom, not least by Parliament in the form of legislation. I wonder if you could take us through some of these stages—how you think we will need to react as a country as these technologies develop.

**Mike Wilson:** Those are two really interesting questions. The one on transition will be fundamental, because much of that technology already exists, and certainly as we are moving forward in Highways England, one of the objectives we have been set by Government is to have a trial of autonomous vehicles on our strategic road network by the end of next year. These are the sorts of questions we will have to have good answers to before those trials go live. There is work we will need to do on simulation and research and in the development of safety cases that will allow us to be confident that those trials will go live. The challenge in those trials will be that you will have professional people who are paid to be awake and responsive as part of those trials, and how you move from a trial environment into a real-world environment. That will have to be part of our development of the technology, to understand and give confidence to the public in the nature of the vehicles on the network. One of our challenges in and around safety is the mixed use of different types of vehicles on the network, operating perhaps in slightly different ways and how those vehicles will interact.

That is a significant challenge. I do not have an answer to that question but it is certainly a question we will need to answer before those go live.

As for the different levels, a number of those levels already exist on the network, in some of the adaptive technologies that are already available to many people. Be they adaptive cruise control, lane centering or emergency braking, those sorts of things are already in operation on the network and are helping to deliver safer roads. That sort of technology is available; the real challenge will be as you move into more and more automation, where the vehicle is more in control of what is happening. I am not an evangelist either; I see the benefits, but I see in the near term real benefits from connected vehicles and connected infrastructure. That is where we are investing and undertaking trials at the moment in understanding how connected vehicles and connected vehicle and infrastructure can deliver new services and improved mobility for users of the strategic road network, and other networks.

**Steve Gooding:** On the transition point, perhaps I should say that I see some of the problems here more as risks than downsides, but the risks can be managed. The risks inherent in that level 3, as described in the NHTSA guidelines, can be managed by simply not going there. I come back to a point I think Lord Hennessy made in the last session: who is liable? If I have handed over control to the vehicle, I am not expecting the vehicle to shrug and hand it back. The vehicle has to be capable, if I am to hand over control, of coping with the circumstances that the vehicle will encounter, and if that is not the case, that vehicle should not receive type approval and it should not be on the road.

On regulation, there are various aspects. I know my former colleagues in the transport department and in CCAV are wrestling with those. I would probably pick out three things that spring to mind where national government will have to think very hard. One is about the type approval of the vehicle, which historically has been a mechanical issue. It is about how the vehicle functions when operated by a human driver. We are going to need a system that assesses the effectiveness of software, and that is a new thing for the type approval regime. Secondly—we have touched on this in the Committee already today—there are some big questions about data, partly about who owns data but largely about who has access to it and how much weight can be put on it. For example, even today in a modern car, if you are unfortunately involved in an accident, the car will know what happened; the information will be sitting there within the car's telematics system, but not to the point currently where it is court-admissible. It could tell you what it thought was happening. In future I suspect that will change. I suspect that in the unfortunate accident that you have contemplated all the vehicles involved will know exactly what happened. There needs to be regulation—a framework within which that data passes between different parties. Lastly, that question of liability, which is probably the most important near-term, is contemplated in the modern transport Bill to be introduced straight after Christmas. We will need to clarify who is liable for what during this trialling period that the department and the Government are supporting at the moment.

**Charlie Henderson:** Picking up on one of the words used there, “transition”, I firmly believe, as a very passionate country about motor vehicles, that there will be a large number of people who still want to drive a vehicle at some stage, so this idea that we transition to fully autonomous vehicles is one that I do not subscribe to. What I

see happening is that we will have an increasingly mixed environment of vehicles, ranging from absolutely no autonomous elements at all, to some autonomous elements, such as lane change, assisted braking, or assisted parking, through to fully autonomous, and the question then becomes the take-up over time, which is more about demand and business model. As Steve hinted, the challenge around this will be the cost to users, how they will pay for it, who will own the vehicles, and how they will make their money. There are lots of unknowns, and this is why the complex system approach is quite interesting, because the technology is solvable, the risks are addressable, and the direction in which we move will depend on social, cultural, political and economic factors, such as what the driving public want, what the politicians are prepared to put forward, and where we are as a country and where we see we are able to develop our economy.

**The Chairman:** Could I ask Mr Wilson this, in his capacity of speaking for the highways authority, clearly carrying a large amount of the UK freight traffic. You also have the infrastructure which could, without using the word “transition”, be used, one could see, very much more efficiently as further automation is brought into goods vehicles. Do you see further automation being of assistance in managing the quantity of traffic that you are likely to hold in the future?

**Mike Wilson:** Yes is the simple answer. The strategic network, in comparison to the networks we heard about from York and from London earlier, is much simpler from an automation perspective. There are very few pedestrians—there should be no pedestrians—no cyclists, traffic is moving in channels in the same direction, and it provides a much simpler environment for autonomous vehicles. We see there being benefits to greater levels of automation in all types of vehicles, potentially around utilisation vehicles travelling closer together, and narrower lanes. As Charlie has said, how will that work when you have a mixed fleet?

What we see, particularly around HGVs, is the potential for platoons of vehicles, and we will be undertaking a trial of platooning vehicles on part of the strategic road network again over the next year, only when we have a safety case and have done the research necessary to give us confidence that that will be a safe thing to do. Potentially it has significant benefits, not only in efficiently moving the lorries around the network—the trials that have been undertaken elsewhere have demonstrated efficiency with vehicles travelling closer together, they are more fuel-efficient because the wind resistance on the following vehicles is less—but there are also challenges, and one of them that we, as a road operator, will need to think about is: if all of these vehicles are travelling in a single wheel path, they could have a bigger impact on the integrity of the road pavement itself. If they are all travelling exactly the same path, you might argue about why you need the rest of the road, but that part of the road will suffer the greater loads and is likely to need maintenance first. There are opportunities and challenges, and part of the pilot we will be doing will be to really understand what they are.

- Q50** **Lord Mair:** Do you think the biggest challenges are the rapidly changing technologies, or are they the social and behavioural issues that you, Mr Henderson, referred to and you, Mr Gooding, have in your evidence? That is, lots of people have said in your surveys that they are suspicious of autonomous vehicles and unwilling to adopt

them? Do all three of you feel the real challenges are technological, or are they more social/behavioural?

**Steve Gooding:** I would keep those two side by side. I think they relate to each other. There are still some technological challenges to sort out. How we react to them as a society will partly depend on how they then play out. For example, if I pick up on the point about platooning on motorways, there is a challenge in making that work—in getting the lorries to line up and follow each other. There is a challenge to the highway because the inside lane of motorways is often quite severely rutted already, and if you ride a motorcycle, as I do, that is quite an exciting experience. There is also the issue that if you are in your current motor car, driving in the middle lane, and you find you are on the outside of 17 18-wheeler trucks and you think you would like to pull off soon and they are thundering on through the night, you will have a particular view of whether you like platoons or not. The more we start seeing real examples, and come to understand both what the challenge is and what the upsides are, the more we will start to be comfortable with the idea, and I suspect that is the way it will go.

**Charlie Henderson:** Picking up on the trialling of goods vehicle platooning, that is very interesting from a technology perspective. The business model is, as a fleet operator, you still have a driver sitting in the vehicle, so you are still paying for the driver. Do you pay them less because they are not driving a chunk? I would worry that there may be fewer collisions on the Highways England network but, because the drivers are not as experienced and do not drive as much, the minute they come off the network, regardless of the handover issues that Steve was talking about, they are not as experienced. There are business model challenges there as well.

One of the pieces of work we did earlier this year was thinking about the capabilities needed to deliver fully autonomous vehicles on our roads, not just technology but regulatory, insurance and public acceptability. We ran an exercise where we spoke to a number of esteemed and informed people across the industry and affected sectors—not a survey as such but we sought views and opinions to try to understand this timescale issue you were talking about earlier. The consensus view was that it would be about 30 years before fully autonomous vehicles are operating on our roads in any mass form, but within that consensus view there was a huge divergence of opinion between those who were extremely optimistic and said three years as a result of some major disruptor coming along, to those who were slightly more black-hat and thought 30 years was probably about the scale.

Interestingly, across the seven areas we looked at—you asked which is more important: technology or culture?—technology was one area highlighted as difficult, but equally difficult was enforcement. How are we going to deal with compliance and enforcement issues for these vehicles from a policing perspective and make sure they behave and they operate correctly? How will we check the code within the systems and ensure that is appropriate? That touches on a point Steve talked about earlier around regulation and our traditional approach to type approval for vehicles, which up to last year we all thought was perfect. As a result of an issue around vehicle emissions testing last year, we are perhaps not as confident in it.

The challenge around autonomous vehicles is that the complexity of the systems is significantly greater than in current vehicles. The space shuttle had about 500,000 lines of code in it. Windows 10 has 60 million lines of code in it. A production vehicle such as the Ford 150 truck has over 100 million lines of code, and the challenge as a regulator is how you look at this code and decide whether it is appropriate or not. We need to move away from looking at individual elements to thinking about overall outcomes and outputs of vehicles, a bit like how they test medicines. They do not look at the medicine under the microscope and decide whether it is appropriate; they do testing in a real-life environment and look at the impacts of that. You could see an environment where we have ratings of autonomous vehicles, how many crashes they have over 1 million miles or something like that.

**Mike Wilson:** I want to reiterate the importance of changing attitudes. Trials will be really important, letting people touch, feel and understand how these vehicles will work. How people will feel will largely drive the take-up of these vehicles. We talk about timescales, and I think attitudes of motorists will be key in the penetration of these vehicles into the market.

**Lord Mair:** These trials will have to be quite carefully evolved, will they not, because you can do perfect trials and then you can do trials in the real world and there are big differences?

**Mike Wilson:** We have two of those trials on our books at the moment. There are those I have mentioned already around autonomous vehicles and for platoons, and we will be doing very detailed safety cases.

**Lord Hunt of Chesterton:** Will the trials involve pedestrians?

**Mike Wilson:** No, they will not. Sorry, I say they will not because we have not yet designed them, but I would suggest they will be on motorways, where the network is, as I said, much more controlled. We will be doing detailed safety cases, looking at the changes of hazards for a variety of populations.

One of the things I would like to mention is road workers, which I do not think has come up yet, and improved safety for road workers. One of the challenges we have as an operator is the segregation of traffic and those who are maintaining and building new roads. I believe that, first, the autonomous vehicles need to be capable of negotiating all environments, so that will include roadwork layouts as well as ordinary roads, but also ensuring segregation of vehicles and road workers is a key opportunity that autonomous vehicles might present.

**Lord Hennessy of Nympsfield:** Very quickly, do you think the human factor we have been touching on has the central place in this great debate that it should have? It is extraordinary when you look back how the car reflected human temperaments. A great sense of status comes into it: the boy racer phenomenon; the Mr Toad phenomenon; and the people who set up the RAC, these enormous men in great leather coats and goggles. I must admit, I can never see a Royal Autonomous Vehicle Club being set up.

**The Chairman:** This is a question only for Mr Gooding.

**Lord Hennessy of Nympsfield:** There is no poetry in this at all but do you not think the human factor really should be at the centre of this debate?

**Steve Gooding:** Personally, I agree with both points there. I doubt very much whether I could interest my landlord—since we rent a room there—in setting up an autonomous branch of the Royal Automobile Club. By and large, the members there like driving; it is one of the things they do.

In much of this debate I am invited to other events to talk about driverless cars when, frankly, the motorist is written out of the script, because motoring for me involves doing something. What I would say is this, and it harks back a bit to the earlier question of how people will engage with this and how the trials will go. We tend to talk about driverless cars as if they are a homogeneous thing, but we will see many different permutations coming through. For example, the trials that Lord Borwick is involved in in Greenwich will have a relatively low-speed pod trundling around, delivering people a bit like a tube carriage but on the road and occasionally on the footway, and I suspect that people around and about that will become used to it quite quickly, and so long as nothing terrible happens, it will carry on trundling, which is very different from the sense I have walking down Pall Mall and seeing the occasional Ferrari or Aston Martin. I somehow doubt whether in the world we are describing Ferrari will go autonomous. Like Charlie, I fear the world where Ferrari has gone autonomous and therefore has ceased to be; I quite like a world with Ferrari.

- Q51** **Baroness Morgan of Huyton:** Can we move on to timeframe? I know it is an impossible question in a sense, but we are interested to get an idea from all our witnesses of the timeframe we are talking about, and in particular the factors that you think will significantly either speed things up or slow things down, particularly in different categories, as we are talking about that.

**Charlie Henderson:** As I have already mentioned, we have done some research in this area. We think the area that is probably easiest to solve is insurance. A number of insurance companies already have products that they offer for semi-autonomous vehicles. The financial markets are quite good at responding to the opportunities in this area. There is a lot to be done to understand liabilities associated with insurance. Insurers may be willing to take on the risk but there is the question of understanding in courts who is liable, and indeed from a policing perspective, if there is a criminal case to answer. The challenge with regulation is that we continue with an incremental approach. I think we need a drastic change in how we think about regulating the autonomous vehicle. It does not mean we throw out the regulation we have for existing vehicles; it means I do not believe we will reach an end point by incremental additions.

Clearly, there is a lot to be done around the technology and, picking up your earlier point about the public view, having three middle-aged men talking about the love of motoring here is one thing. My daughter is 17 today and has no interest in driving. We need to think about the social changes that are happening. That is not happening at a UK level but at an international level. We have relatively little control over that. We need to understand the implications for transport systems.

**Lord Hennessy of Nympsfield:** I have a question for Mike. I think you said you have 4,300 miles of strategic road network. Are the infrastructure structure implications enormous for your bit, putting aside everything else, to making this work—there is the level of investment that you will need for alterations—given that it is a national thing? We obsess, quite rightly, about the cost of and need for HS2 and all the rest of it but this, in a quiet way, is possibly comparable is it not?

**Mike Wilson:** I suppose the challenge at the moment is really understanding what the implications on the infrastructure will be. You have heard already about better white lines, and we have seen organisations publish reports about roads that cars can read. It might be there is a scenario where no changes to the infrastructure are necessary to facilitate autonomous vehicles. For connected vehicles there is potential for additional changes to the infrastructure. I have mentioned this UK CITE project we are doing with Jaguar Land Rover, Coventry, Siemens and other organisations that is going at the moment, which is looking at the technology necessary to facilitate connected vehicles and vehicle infrastructure, and we are looking at what those infrastructure needs might be. That will help us look at the M2/A2 corridor project, which is another connected vehicle project that we are committed to delivering. In those scenarios we are looking at hybrids of technology. Sometimes we have wi-fi connectivity or other physical infrastructure on the network, and other times we are relying on mobile technology to provide the connectivity that we need.

I suppose the answer to your question is that I do not know. There is a potential to have some impact on the infrastructure but the scale of that at the moment is uncertain.

**Steve Gooding:** May I add a couple of points to Mike's answer? The question that sits behind it is: is the advent of the autonomous vehicle going to materially affect the levels of traffic? That is one way of thinking about it. If there were much less traffic because the system is running a lot more efficiently, maybe we would not need the programme that Highways England is taking forward to widen our motorways, but we would have to depart quite a long way from the existing levels of traffic to get into the future and look back and think we should not have gone that way, we should not have needed that extra capacity, because we already have significant congestion over a lot of the network that Mike tries to run.

The second thing is I certainly tend to think of the infrastructure in a traditional way. It is the pavement that we drive on. It might be the lighting columns that light the way, but we have to think of the data infrastructure and the data handling infrastructure and, as Mike hinted, that is probably the area where we will need most change, depending on how the system architecture develops. Some vehicles will be more reading the road than trying to download data from elsewhere; others will have a higher requirement for connectivity, a far higher requirement than we have ever had before.

The third point is, we have heard this phrase a number of times today, about “the rubber hitting the road”; we are still going to need the road to be there, and one of the key things I feel obliged to say from the Foundation's perspective is, apart from Mike's network, a lot of the roads in this country are falling apart. We have a big

maintenance backlog and one of the things we must not lose sight of is that all these many advantages of enhanced mobility will not materialise if we have not maintained the roads for the vehicles to run on.

- Q52** **Lord Vallance of Tummel:** On the communications technology requirements, we have heard different things from different witnesses. Obviously, there is a satellite requirement; you have talked about wi-fi and cellular of one kind or another, and the European Union is looking at 5G—how is this being dealt with? Do you know? Do you have any input into it? Ideally, one wants international standards in this area. Do you think there is any chance of that happening?

**Mike Wilson:** I think the standards associated with the variety of technologies are well established. It is the availability of that service—this is perhaps where some of the cities have an advantage—where you have greater coverage of mobile data service and you might need less technology from a data collection and facilitation perspective than on, say, the M6 in Cumbria. I think the RAC Foundation did a survey that said that less than 50% of the road network has a full 3G service, so we are some way from 4G or even 5G connectivity. We will have to look at the network and determine what the appropriate service is. We have though a backbone of fibre connectivity that we can use as an organisation that will enable the transfer of this data to facilitate the wi-fi or the short wave technology that might be utilised. I think the standards exist; it is the availability and predicting the uptake of that technology which will be a real challenge. We do not want to put technology on the network that becomes surplus to requirements a short time afterwards. That is where one of the challenges in this will be.

- Q53** **Lord Mair:** Can I come back to a question you have already touched on, this question of the mixed fleet, that, in practice whatever happens, on the highways and on local roads there will be a mixture of autonomous vehicles and less autonomous or non-autonomous vehicles? How is the prospect of what will certainly be a mixed fleet being considered by your organisations? Is that being modelled? Is that being thought about carefully?

**Mike Wilson:** Is it being modelled? Not at the moment, as far as I am aware. I know there are some trials the Transport Research Laboratory are doing that we are engaged with. It is clearly somewhere we have to understand the interaction, not only for ensuring safety but delivery of the benefits we have talked about that greater levels of autonomy might deliver.

To come back on a question that Steve answered earlier about mixed fleet, the challenge for us is, I agree, that there will be people driving Ferraris who will want to drive them, but there are many people who use the network every day for whom driving is a chore, and who might see autonomous vehicles as a way of using their time more productively. Yes, we need to do the modelling and understand the challenges associated with the mixed fleet, but we also need to recognise that people use the road for a variety of different purposes and in different contexts, and I hope there will be an opportunity for people to enjoy driving, because there are many people who enjoy the act of driving.

**Steve Gooding:** I am going to be uncharacteristically optimistic for a moment. What we know of the way the auto companies are developing their systems is that they are putting lots of sensors in vehicles that are on the road now—not to do what Tesla has done and enable autonomous operation, but to track how the vehicle is being driven. Their objective in designing the autonomous system is that the autonomous car will drive as well as the best possible human driver, perhaps even slightly better; so they will drive more smoothly; they will not be braking dramatically, because they will have sensed the road ahead; they will, ideally, be better. We can get hung up on how the interaction between the autonomous and non-autonomous could be problematic. One way of thinking about it is, as the autonomous vehicles penetrate the system and are driving in a better-behaved manner, they might have a calming effect on the rest of the traffic, because if the laws are not changed, these vehicles are not going to go at more than 70 mph, because we are not allowed to, to pick one example.

- Q54** **Lord Hunt of Chesterton:** Can I pick up on that? You talked about driving better. In France on the motorways they say if you drive more slowly it is safer and you produce fewer carbon emissions. In Britain we do not tell people that information, and with PQ after PQ I have put down on that, the Department for Transport always says, “We are not going to use our road signs to tell people about the benefits of driving more cautiously”. There is not a unique best, is there? That is the point.

The question more broadly is about data. We are already generating data with new cars, and, as we go further into an autonomous system, data will be very important. The question is how this will be managed and what uses can be made of it. We discussed in the previous session the question of simulations, and there is obviously potential for doing it well and enabling the designs of systems. We also talked about rural areas. I go down to Devon quite often, and there are all these country lanes. How do you think we will deal with that, where you have a lot of the accidents? Motorways are one side of it but most of the accidents that happen are happening on quite small roads.

**Charlie Henderson:** To start with the data side, it is useful to break the data down into a number of elements. Rather than just say data as a whole, if we think about real-time information on where vehicles are, it is in manufacturers' interests to share that with the highways authorities so they can make better decisions and help inform the movement of that vehicle. In the sharing of that information, as an individual, as a vehicle manufacturer, as a highways authority, there is some common element to that.

Where it becomes more complex is around the movement of those vehicles: where they start, where they are going, how they are travelling, whether their autonomous systems are switched on and how they are behaving. It is a bit about performance. Different manufacturers might be able to work out who is performing better or worse. You start to understand where their customers are based, so you can target marketing at these sorts of people. The overall movement is a really thorny issue, and there is a lot of intellectual property around the ownership of that.

The location data at any particular point is something that can be shared. The overall performance of the vehicle cannot be shared. The final bit is post-incident investigation, where a vehicle has been involved in a collision and there is a bunch of data on the machine. Police already have the powers to be able to seize that data to aid a criminal investigation. The challenge is whether they have the capacity and capability to analyse the 100-plus million lines of code, the huge terabytes of data stored there, and work out who is at fault, who is to blame. We need to break the data problem up into a number of bite-sized chunks and, rather than try to eat the elephant all in one go, slice it up and have a go at each relevant bit.

**Steve Gooding:** I agree. There is a key thing here about the architecture through which data is shared in a way that balances the commercial sensitivity of some of that data, the personal privacy angle, which you touched on with the earlier witnesses, with the benefits of sharing that data, for example, with satnav companies, with companies that can assist you in making your own journey safer and more efficient.

Secondly, I would echo the point Charlie made about the police but draw it more widely. There is having a lot of data and there is being an intelligent client for drawing the knowledge out of the data. I think the witness from York would admit that this needs developing. Thirdly, to pick up your rural road safety point, at some point in this future that we are contemplating, it is entirely possible that I will be in an autonomous vehicle that will know whether there is another car just around the corner that I cannot spot because I cannot see around corners. I do not know whether it will spot a bicycle or a horse, therefore the system which operates it will be a lot more cautious about approaching the corner than perhaps many motorists are today, because they do not know what they will find around the other side.

**Mike Wilson:** I agree with my two colleagues. There are a couple of points I would make. First, there is the importance of data in managing people's movements around the network. At the moment the motorway network is highly instrumented. We understand traffic flows and speeds and journey times. Greater connectivity with vehicles will allow us to understand much more about that is happening on local road networks and all-purpose trunk roads, which have less instrumentation on them at the moment, and we will be able to provide better journey times and better journey information to road users.

We have talked about some of the complexities. We heard from Michael Hurwitz earlier about the importance of fog lights and windscreens wipers. All of those things have an impact on the capacity of the network, and a rich source of information is important to us as a network operator. There is also the point around use of that data to enable us to understand the performance of the infrastructure itself. We heard earlier about potholes, but measuring changes in the longitudinal profile of the road over a period of time will enable us to make better decisions about maintenance. There are some real opportunities in that data, but as for the other parts, I think my colleagues covered that pretty well.

**The Chairman:** If we accept for the moment that there are indeed opportunities to share data, equally, there are cases where commercial confidentiality will be inevitable. Can I go back to the issue which Mr Gooding raised earlier and Mr

Henderson has just raised of being able to interrogate data after an accident, for example? The point has been made on the practicalities that 100 million lines of code may be beyond the capacity of anyone to interrogate.

We have a Modern Transport Bill coming up. It is not unknown for legislation to make provision for future advances in technology. It has happened very often. If it appears that advances in technology make this more practical, there could be a regulation implemented on the back of the Bill. It seems to be absolutely unanswerable that, if there is information which helps identify liability, there should be no question of commercial confidentiality; it is information which should be accessible. Would either Mr Henderson or Mr Gooding like to comment on that?

**Steve Gooding:** Yes, you are right; it should be, and I do not think at the moment there is any question that, if the police requested the information, individual manufacturers would say no. At the moment what I have called the information architecture is at such an immature state that I am not sure the relevant police force would know exactly where to go, and if they went there, it is not absolutely clear that the system would be able to answer the specific questions they had. Although Charlie is absolutely right; there are 150 million lines of code and I could not possibly interrogate that, what I want to ask the system is: how fast were you going? What direction were you headed in? As a non-engineer and a non-software engineer—but I have met such folk—I do not think it is beyond the wit of them to devise something that would allow me to ask the sorts of questions that a police investigating officer would be asking here and now.

**Lord Oxburgh:** Initially, I take it you would want to know who made the decision to go in a particular direction at a particular speed, whether it was the driver or the system.

**Steve Gooding:** Indeed, in the future autonomous or partially autonomous world, where the vehicle can be run in autonomous or non-autonomous mode, that distinction, which is one that Charlie mentioned earlier, needs to be absolutely clear for the enforcement authorities.

**The Chairman:** Can we move on then to Lord Borwick?

**Lord Borwick:** We have talked about the police and what their powers would be, and you mentioned that the police should have the ability to require cars to get out of autonomous mode in the event of an accident, or a new contraflow, or a blocked road, or something of that sort. I could also imagine that they could require that a car should go into autonomous mode and stop safely. That Ferrari that you mentioned in Pall Mall—if it is a stolen Ferrari, it would be an enormous advantage if it had an autonomous mode that could be controlled externally.

**Charlie Henderson:** Certain vehicle tracking systems already have that capability.

**Lord Borwick:** To be remotely controlled now?

**Charlie Henderson:** To be remotely controlled now.

**Lord Borwick:** Really?

**Charlie Henderson:** They have had it for about 10 years. It is not one that the manufacturers widely broadcast but some of the high-end vehicles have that capability.

I think your point about how to direct an autonomous vehicle in a complex incident—you can imagine—it has happened to me sometimes; I have been directed by a policeman to go the wrong way up a one-way road because there is a diversion, and practically he wants to move the traffic. If you tell an autonomous vehicle to go the wrong way up a one way road, first of all, how do you tell it to do that? There might not be anyone in the car. Secondly, its systems will say, “I can’t do that because...” There are all sorts of complex interactions there: the police need to radio back to base to speak to the data providers or whatever, to get that to be permitted in case a further incident happens. Those are the sorts of complexities that I think are quite interesting, the thorny issues that we need to think through. Yes, the pilots, the testing being done at the moment is interesting, but how will it work in reality?

**Lord Borwick:** Are the police thinking about this already, do you think?

**Charlie Henderson:** Yes. The police are involved in a number of the pilot exercises.

**The Chairman:** Unless any of my colleagues have a burning question they wish to address to you, we will bring this session to a conclusion, with very many thanks for what I found very informative. If there is any follow-up you wish to make to submit anything further in the light of your answers, feel free to do so. As I said to the earlier witnesses, the transcript will be sent to you for correction of minor errors and the like. On behalf of the Committee, thank you to Mr Wilson, Mr Gooding and Mr Henderson for helping us this morning.

## Dr Debbie Hopkins, University of Oxford – Written evidence (AUV0021)

*Written evidence prepared by: Associate Professor Tim Schwanen<sup>1,3</sup>, Dr Debbie Hopkins<sup>1,3</sup> and Professor Benjamin K Sovacool<sup>2,3</sup>.*

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1. In this document, we will respond to a selection of the questions raised by the House of Lords' Select Committee on Science and Technology from the social science perspective with which TSU and SPRU analyse large-scale transformations in societal systems such as transport. Our main argument is that, while connected and autonomous vehicle (CAV) technology has enormous potential and can be expected to have significant economic benefits to the UK, there are also important concerns about some of the gaps and omissions in the government's approach to CAV technology:
  - There is selectivity in the representation of the potential effects of investment in the development & production as well as the widespread adoption of CAV technologies. Anticipated economic benefits such as employment growth, productivity increases, inward investments and GDP growth as well as reductions in road congestion are given greater attention than other grand challenges UK transport and society more generally face – i.e., the need to increase physical activity, improve air quality and reduce greenhouse gas emissions, and concerns over social inequality. In all of these issues, everyday transport plays an important role, and widespread investment in, and adoption of, CAV technologies may be less effective in addressing these challenges than a fuller commitment by all levels of government from local to national scale to public transport, cycling and walking. The only potential social impact that is widely discussed is increased road safety, but evidence on this topic is disproportionately USA based. It is hence not immediately transferable to the UK where local transport is less car dominated and cars share roads with cyclists and pedestrians to a larger extent.
  - More generally, the representation of economic and social benefits in government documents<sup>139</sup> is overly positive and does not reflect the very large uncertainties about many of the potential effects of the widespread adoption of CAV technologies in transport.
  - There is an absence of a long-term vision of the role of CAV technology within an integrated and efficient multi-modal transport system. The risk is that investments in CAV technology may cancel out some of the positive social and environmental effects of current and recent transport policies – including those funded by the Local Sustainable Transport Fund in the wake of the 2011 'Creating Growth, Cutting Carbon' White Paper – have had, particularly at the local/urban level. Comprehensive

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<sup>139</sup> E.g.: Department for Transport (2015) [The Pathway to Driverless Cars: A detailed review of regulations for automated vehicle technologies](#); Department for Transport (2015) [The Pathway to Driverless Cars: Summary report and action plan](#).

future visioning is needed that considers the long term (e.g. 2040) and many different future scenarios, not only those assuming that CAVs will be symbiotic to, and complement, other forms of passenger and freight transport but also scenarios in which different types of conflicts and incompatibilities between different systems and investments are explored.

- The government's approach is too strongly oriented at the supply side of technology and vehicle production and infrastructure development, rather than on the demand or user side. The role of citizens is largely limited to that of end-user and consumer, and other forms of agency – resistance, campaigning, etc. – and the motivations and concerns that may drive those are not given due attention. Not only should such motivations and concerns be listened and responded to in a liberal democracy, they can also complicate, delay and disrupt the development and diffusion of technological innovations. The history of innovation is full of examples in which linear narratives of expected expansion and progress (e.g. battery electric vehicles and genetically modified food in the late 1980-1990s) have turned out to be poor approximations of the developments that actually unfolded subsequently. Uncertainty is inherent to the development trajectory of any technological innovation. Yet, there is a large social science literature on the basis of which it can be expected that, for the case of CAV technology, actively involving the public in all stages of the innovation process – technology development, visioning about effects, changes to regulation, etc. – may help prevent some of the mistakes that have been made with other technologies in the past.

Below we offer more descriptive answers to the Committee's specific questions.

What are the potential applications for autonomous vehicles?

2. CAV technology may be adopted for private, public and freight transport. To date, much of the government's attention has been on the application of autonomous vehicles for private use.<sup>1</sup> Yet there are a range of technologies specifically for freight and public transport that are being developed by traditional (e.g. Volvo, Daimler) and non-traditional (e.g. Otto, Starship Technologies, Peloton) companies. The potential opportunities and issues associated with automated vehicles in the context of inter and intra-urban freight, and public transport have attracted much less consideration in government policy and the public debate, and this requires attention to better understand how and where automated vehicles can contribute to the transport system.
3. Prior to considering application, it is also important to examine the scope of automated vehicles; what types of vehicles are in- and excluded. There is a wide diversity of automated vehicle technology ranging from small 'pods' (for both passenger and home delivery) to heavy goods vehicles. The ways these technologies use existing infrastructure, and demand alternative types of infrastructure, will vary substantially. For instance, automated delivery pods will use the pavement space with pedestrians and raise different questions to the use of HGVs on the UK's motorway network.
4. In addition, there may be different applications and implications across the various stages of automation, which require greater clarification. For the freight industry, (semi-) automated vehicles may contribute to increased operational efficiencies (e.g. vehicle

utilisation and labour savings) and reductions in fuel consumption (and associated emissions) in the short to medium term<sup>140</sup>. Nevertheless, research has suggested that environmental benefits of automated vehicles (e.g. potential reductions in energy consumption and emissions) are not assured, as they are not the consequence of automation, but rather relate to changes to the operation and design of vehicles and the transport system<sup>141</sup>. Wadud et al., for instance, report that low-levels of automation (semi-automated vehicles) may see energy intensity savings, particularly relating to vehicle connectedness, whereas highly automated vehicles may result in increased energy demand and travel activity<sup>3</sup>.

What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

5. There is now a substantial literature and discourse on potential user benefits to private individuals, which focuses on greater efficiency, productive use of travel time, fuel cost savings and road safety.<sup>142</sup> In addition, in other studies that have looked at how autonomous vehicles can be deployed to further develop the provision of mobility services (e.g. ride shares, car clubs), the benefits of reduced costs from vehicle ownership and maintenance have been emphasised as well.<sup>143</sup> However, much less is known about a) the magnitude of these effects for individual users, and b) the social or equitable distribution of such benefits. As one recent article has suggested, it is likely that early developments of CAV technology in passenger transport will be “catering to the needs of middle-class, often young(ish) urban professionals and [will be] closely entangled with gentrification processes”<sup>144</sup>.
6. The claim that is sometimes made about the elderly and disabled significantly benefiting from the deployment of CAV technology in passenger transport<sup>145</sup> is particularly problematic. Such benefits will only accrue with level-5 automation (which, according to some commentators, will only become widely available after 2030). Further, in light of their cost premium<sup>146</sup>, it is very unclear whether CAVs will be affordable and acceptable to the elderly and disabled. There are, in short, serious questions to be asked about the social equity of CAV user benefits.

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<sup>140</sup> XAX (2015) [The Future of Driverless Haulage: A report by ANA – September 2015](#).

<sup>141</sup> Wadud, Z., MacKenzie, D., Leiby, P. (2016) Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles, *Transportation Research Part A*, 86, 1-18; Thomopoulos, N. Givoni, M. (2015) The autonomous car—a blessing or a curse for the future of low carbon mobility? An exploration of likely vs. desirable outcomes. *European Journal of Futures Research* 3, 14.

<sup>142</sup> E.g.: Anderson, J.M., et al. (2016) Autonomous Vehicle Technology: A guide for policymakers. RAND Corporation, Santa Monica, USA; Fagnant, D.J., Kockelman, K. (2015) Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, *Transportation Research A* 77, 167-181; Thomopoulos, N. Givoni, M. (2015) *op. cit.*

<sup>143</sup> Spieser, K., et al. (2014) Toward a systematic approach to the design and evaluation of automated mobility-on-demand systems: a case study in Singapore, in: Meyer, G. & Beiker, S. (Eds) *Road Vehicle Automation*. Heidelberg: Springer.

<sup>144</sup> Schwanen, T (2016). Rethinking resilience as capacity to endure. *City* 20(1), 152-160.

<sup>145</sup> E.g.: Anderson et al. (2016) *op. cit.*; Harper, C.D., Hendrickson, C.T., Mangones, S., Samaras, C. (2016) Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions. *Transportation Research C* 72, 1-11.

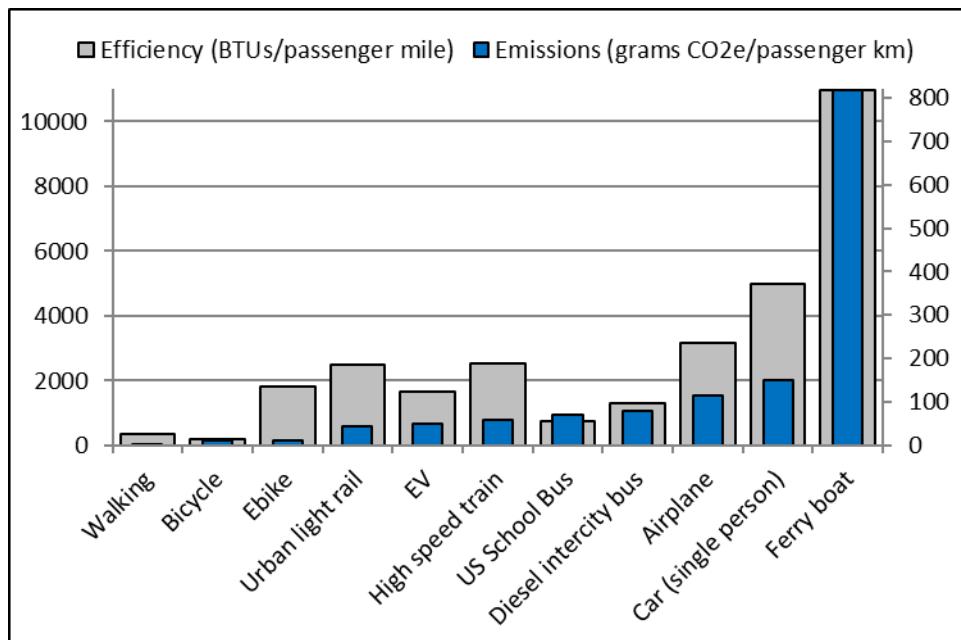
<sup>146</sup> Thomopoulos, N. Givoni, M. (2015) *op. cit.*

7. In addition, the question about user benefits should not distract attention from the indirect effects on non-users and the wider societal benefits and disadvantages of CAV technology adoption in transport. Key to discussing indirect and societal effects is an understanding of how CAV technologies will become part of the wider transport system. This is an area of deep uncertainty at the moment, and radically different scenarios seem plausible. If, for instance, CAV technology is used to turn car use into a service that is fulfils specific functions in a truly multi-modal transport system with combinations of rail, bus and cycling at its backbone, then the social and environmental effects for users, non-users and society more generally may be (very) positive. If, however, CAV technologies become deployed to re-entrench the dominance of privately owned cars and thereby reduce the attractiveness of public and active transport, then indirect and societal effects may be much more ambiguous and addressing such challenges as reducing social inequality and increasing physical activity will become much more difficult. If CAV technologies are powered by fossil fuels, significantly reducing greenhouse gas emissions and pollution from transport will also become more difficult. These points reinforce Thomopoulos and Givoni's conclusion that CAVs will only become a blessing "if technological development will be accompanied by a social change [whereby] public and sharing will be seen as superior to private and individual transport".<sup>8</sup>
8. The importance of the above points about health and equity becomes clearer once attention is focused on the link between transport and physical activity. Motorised vehicles (both automated and non-automated) require less physical activity than walking or cycling, or even than public transport, which usually involve a walking component. The Global Burden of Disease study projects that physical inactivity is responsible for 3.3% of worldwide deaths and 19 million disability adjusted life years annually, and that those that rely on motorised transport have higher rates of diabetes, cardiovascular disease, and obesity than those that walk or take public transport.<sup>147</sup> Far better transport options – from both an emissions standpoint, and an energy efficiency standpoint – are to rely on a mix of walking, cycling, and public buses and trains, as Figure 1 indicates. From emissions, energy efficiency, and health standpoints, a mix of active and public modes is optimal. The potential for reduced physical activity as automated vehicles are adopted is a concern, which is why the development of comprehensive visions about how CAV technology is embedded in the wider transport system is such a pressing concern.

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<sup>147</sup> Woodcock, J., et al. (2007). Energy and transport. *The Lancet* 370, 1078-1088.

**Figure 1: Energy and Carbon Intensity of Transportation Modes<sup>148</sup>**



9. Indirect impacts of CAV adoption are also likely in freight transport as three common concerns in the freight industry actors – the HGV/ LGV driver shortage, fuel duty and road infrastructure<sup>149</sup> – are likely to be impacted by the introduction of automated vehicles. The driver shortage may be exacerbated by the expectation of automated vehicles reducing the need for professional drivers in the future. This needs to be managed to overcome short-term driver shortages, and to ensure skills are being developed. The impact that automated vehicles, which are widely assumed to be electric vehicles (where possible – or alternative other forms of low-carbon fuels), will have on fuel duty is not yet clear. There are, however, opportunities to increase driving efficiencies and thereby reduce fuel consumption and costs, as well as emissions (CO<sub>2</sub>, NOX and PM), particularly in the urban environment. Automated vehicles could benefit the freight industry by overcoming drivers' hours rules in the UK. As with passenger vehicles, non-automated modes also require attention; the impact that automated vehicles will have on rail and coastal shipping requires consideration. A systematic evaluation of the potential impacts of automated vehicles on the freight industry is needed.

#### How much is known about the potential impact of deploying autonomous vehicles in different sectors?

10. From a freight transport perspective, different types of automated vehicles (e.g., small delivery robots, drones, automated vans) will offer very different services. These are likely to intersect with industries particularly healthcare and motor vehicle parts, but

<sup>148</sup> Adapted from: Cleveland, J.J., Morris, C.J. (2013) Handbook of Energy Volume I: Diagrams, Charts, and Tables, London: Elsevier.

<sup>149</sup> Road Haulage Association (2016). [Top Industry Issues](#).

increasingly general retail, which are dependent on high-speed deliveries, often through congested roads.

How much is known about public attitudes to autonomous vehicles?

11. A number of studies on public perceptions of, and attitudes towards, autonomous vehicles have recently been conducted in a range of countries.<sup>150</sup> The general picture that emerges from these is that public opinion is reasonably divided about autonomous cars. A French study by Payre et al. claims that about 2/3 of the sampled individuals has positive attitudes towards full automation but little information on the sample and its representativeness of French drivers is offered. An international study by Kyriakidis et al. based on 5000 responses from 109 countries found, however, that manual driving tended to be preferred over fully autonomous driving. More than two thirds (69%) of participants in the latter study also believed that fully automated driving will reach a 50% market share between now and 2050. Substantial numbers of participants were concerned about software hacking/misuse, legal issues and safety. Other work using data from Austin, Texas by Bansal et al. and from Germany by Hohenberger et al. suggests gender differences in acceptability and interest, with women more likely to experience negative emotions (anxiety) towards autonomous cars. In addition, there may be cohort effects with younger individuals more positive about CAVs than older ones. It is also important to be specific about what type of autonomous vehicle is considered: Krueger et al. found that survey participants considered shared CAVs and individually owned CAVs two different mobility options.
12. To the best of our knowledge, there is no research published in peer-reviewed journals on CAV acceptability among the general public in the UK. Given differences in transport cultures, user practices and the physical lay-out of transport and land use patterns between the UK and countries where peer-reviewed research on user acceptability has been conducted.
13. It is also important to appreciate that not all individuals will want – or be able – to drive. For instance, a recent study on attitudes towards ride-sharing in Denmark by Nielsen and colleagues<sup>151</sup> identified different market segments of travellers and noted that many of them, for instance steadfast bikers, or those that strongly prefer mass transit, would continue to resist private cars. Others seem to make travel choices based on “non-decisions,” rather than active deliberation about travel options.

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<sup>150</sup> E.g.: Bansal, P., Kockelman, K.M., Singh, S. (2016) Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. *Transportation Research C* 67, 1-14; Hohenberger, C., Spörrle, M., Welpe, I.M. (2016) How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups. *Transportation Research A* 94, 374–385; Krueger, R., Rashidi, T.H., Rose, J.M. (2016), Preferences for shared autonomous vehicles. *Transportation Research C* 69, 349-353; Kyriakidis, M., Happee, R., de Winter, J.C.F. (2015) Public opinion on automated driving: results of an international questionnaire among 5000 respondents. *Transportation Research Part F* 32, 127-140; Payre, W., Cestac, J., Delhomme, P. (2014) Intention to use a fully automated car: Attitudes and a priori acceptability. *Transportation Research Part F* 27: 252-263.

<sup>151</sup> Nielsen, J.R., Hovmøller, H., Blyth, P., Sovacool, B.K. (2015) Of ‘white crows’ and ‘cash savers’: A qualitative study of travel behavior and perceptions of ridesharing in Denmark. *Transportation Research Part A* 78, 113-123.

14. In short, on the basis of currently available evidence, it would seem that public opinion on autonomous driving is reasonably divided. Caveats must be made, however: at present familiarity with CAV technology is limited, and very few people will have direct first-hand experience of driving or interacting with autonomous vehicles. Questions can therefore be raised about the extent to which results from recent studies can be extrapolated into the future. It is to be expected that public attitudes will shift and co-evolve with further development and diffusion of CAV technology, and these shifts can go in many different directions: greater support is a possibility, but so is the emergence of significant resistance and contestation. It is impossible to predict what will happen, and much will depend on the outcomes of demonstration projects and reporting in the media. Accidents with autonomous cars may have a significant impact on public attitudes, but as –fortunately – there seems to have been only one fatal accident, Joshua Brown<sup>152</sup>, so far, it is too early to tell how public opinion will be affected.
15. To the best of our knowledge, there has been no work to date examining the perceptions of the freight industry, nor public transport providers. Such research is necessary in order to better understand how the technology may be adopted by different user groups. It has been suggested that there is a ‘strong undercurrent of denial’ with US truck drivers believing that the technology is both undeveloped and not necessary<sup>153</sup> but more and more systematic engagement with multi-modal freight industry representatives is in order.

Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?

16. The four demonstration projects in Bristol, Greenwich, Milton Keynes and Coventry are welcome and important. They involve a suitably wide range of partners and stakeholders. However, there is scope for experimentation on a wider scale:
- The conditions for transport and mobility differ widely across UK cities, towns and communities, and not all of these are currently covered. There is a need for testing in settings where cycling makes up a larger share of the modal split and for experimentation in more rural settings. There may be opportunities for CAVs to address access and public transport inefficiencies for rural towns and villages; further examination of this potential is required.
  - There is a need for more testing and demonstration on motorways and other interurban roads, particularly also with a focus on freight transport. In many ways interurban transport is easier to automate because of the lower levels of complexity compared to urban mobility.
  - There is a need for demonstration projects aimed at social inclusivity – e.g. by focusing specifically on the mobility needs of non-able-bodied and elderly people.
  - There is also need for a more refined look at the distributional effects of CAVs on things like the vulnerable and social justice concerns.

What does the proposed Modern Transport Bill (MTB) need to deliver?

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<sup>152</sup> The Guardian (2016) [Tesla driver dies in first fatal crash while using autopilot mode](#), 1 July 2016.

<sup>153</sup> The Guardian (2016) [Self-driving trucks: what's the future for America's 3.5 million truckers?](#), 17 June 2016.

17. As argued at the beginning of this response, it is essential that the MTB places CAV technology in the context of a) the wider transport system and b) the grand challenges that transport in the UK is currently facing. The MTB needs to focus not only on economic considerations but also – and perhaps especially – on how UK transport policy can contribute to such aims as increasing life chances and opportunities to flourish for all UK residents, reducing social inequalities, increasing physical activity and everybody's health and wellbeing, improving air quality and drastically cutting greenhouse gas emissions from transport. This means that a truly integral and integrative bill is needed that adopts a long-term outlook and does not look at CAV and smart mobility in isolation from other transport. This also means that more is needed than a focus on enabling the development of new technologies for road, rail, air and water-borne transport, the promotion of innovation, and the cutting of red tape.

Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?

18. As already suggested, it is imperative that the Government's strategy needs to place CAV technology into a broader context, one that involves more holistic analysis of interactions with other transport infrastructure as well as social and environmental issues including health and social justice. Attention needs to be directed to the (realistic) possibilities of unintended consequences of CAV technology integration in private vehicles on public transport, walking and cycling as well as the extent to which CAV technology diffusion may clash with existing policy objectives, from greenhouse gas emission reduction to increasing physical activity.

19. Further, the history of technological transitions in transport, including the rise of the fossil fuel powered car in the period 1890-1950, suggests that transformations are long-term processes. This means that government policy needs to consider multiple time scales: long range planning is just as much needed as policy that relates to the years until the next general election. The current strategy would benefit considerably from adopting a longer-term perspective. Doing so will not only place CAV technology into the context of the wider transport system and broader societal challenges; it will also ensure they contribute the most to UK society.

20. Adopting a long-term perspective will also draw greater attention to other issues where a pro-active approach by Government is desired. These relate to the wider processes of transition towards greater autonomy in (multi-modal) road transport, and include: the financing and provision of CAV infrastructure (e.g. sensors outside vehicles); the maintenance of such infrastructure, the standardisation of sensors, data and operation systems; integration of data, software and operation systems across different private operators with specific commercial interests; and the embedding of CAV technologies in a multi-modal transport system that offers seamless mobility for both persons and freight.

## **IAM RoadSmart – Written evidence (AUV0022)**

IAM RoadSmart (previously IAM – the Institute of Advanced Motorists) is the UK's largest independent road safety charity, dedicated to improving standards and safety in driving and motorcycling. Best known for the advanced test IAM RoadSmart has more than 92,000 members and is supported by a local volunteer network of 200 groups in the UK and Ireland. We provide driver risk management solutions to businesses and driver retraining through IAM Driver Retraining Academy. IAM RoadSmart's policy and research division offers advice and expertise on road safety, and publishes original research on road safety issues.

IAM RoadSmart welcomes this inquiry and shares the Committees view that connected and autonomous vehicle technology will have a profound effect on our transport system in the years ahead. IAM RoadSmart and its members positively embrace technology and are genuinely excited by the potential to reduce road casualties that this technology can bring. Managing the transition to full autonomy in the decades ahead will however be a challenge as our roads play host to a wide variety of vehicles with differing levels of ability to assist or indeed replace the driver. Our responses below are shaped by our expert knowledge of what makes a good human driver, our research into issues such as driver distraction and a driver survey.

### **Impacts and benefits**

#### **1. What are the potential applications for autonomous vehicles?**

The applications for mobility challenged groups such as the elderly, disabled, non-drivers and the young are very exciting. However a large core of IAM RoadSmart members and other drivers do wish to retain the right to drive or maintain some manual control over their vehicles in the future.

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

IAM RoadSmart are concerned that just because 95% of crashes have a human factor involved it is axiomatic that driverless cars can remove 95% of all crashes. Removing mundane and boring motorway driving is often seen as the first area to be addressed by driverless cars. However motorways are our safest roads and the full road safety benefits can only be realised with the use of new technology to assist drivers on rural single carriageways where most die.

IAM RoadSmart are part of a consortium of road safety bodies that is working to accelerate the take up of existing technology such as Autonomous Emergency Braking (AEB). In our view a modern car driven by a well-trained driver is a win-win scenario combining the best a human can deliver with back up in the event of distraction, inattention or lapses.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Very little is known about the impact of deploying these vehicles in the real world esp in the UK environment. Fatal crashes are incredibly rare and it may be that driverless cars should focus more on delivering improvements in journey time, emissions, reliability and reducing congestion than in hard to prove claims on road safety.

Loughborough University have stated that there is currently 1 death per 173 million vehicle miles driven in GB, 1 serious injury for every 12 million miles driven and 1 minor crash every one million miles driven.

Google driverless cars have driven over a million miles in the USA but in California alone experienced 272 failures and would have crashed at least 13 times if their human test drivers had not intervened.

It would therefore seem that driverless car are currently struggling to deliver what humans can do with minimal training. Over half of our members believe that the government should still be focused on improving driving standards as the best way to reduce KSI's.

The driverless car as part of a new car sharing model is likely to have a huge impact on our congested urban areas. Outside such areas however people should still have the choice to drive themselves.

### **4. How much is known about public attitudes to autonomous vehicles?**

In April 2015 IAM RoadSmart conducted a poll of over 1000 drivers

The key findings were;

A fifth (20%) of motorists think that driverless cars are a good idea, with another fifth (22%) saying that they can see driverless cars becoming the norm on the UK's roads.

However, a third (34%) think driverless cars are a bad idea, with under half (45%) being unsure. Half (52%) say that they cannot see driverless cars becoming the norm. Following this, a sixth (16%) of motorists think that driverless cars will be exciting and the norm within years.

When asked *when* motorists think driverless cars will become the norm, the median time is "more than a decade away" – of which under half (45%) said this.

Interestingly, when told the statement "the driverless car has completed almost a million miles without an accident. With 95% of crashes put down to 'human error' there is a strong argument that taking driver control out of the equation could benefit road safety positively", a quarter (24%) said they agree, a sixth (15%) said that they don't, and three fifths (60%) said that we'll have to wait and see.

A third (32%) admit that they would actually consider using a driverless car – although nearly two fifths (38%) would not and three in ten (29%) are unsure.

A quarter (26%) think that – like electric cars – driverless cars should be subsidised by the government in the same way. However, there is a mixture of views, as two fifths (41%) disagree, and a third (33%) are unsure.

Of driverless cars, half (53%) think that we should be concentrating on making drivers safer – not just cars. A third (35%), on the other hand, think that driverless cars are a good initiative for the future, and a fifth (20%) think they will help assist everyone to travel and work, in such, helping our busy lifestyles. However, a tenth (12%) brand the idea as irresponsible.

The best liked aspects of driverless cars are the following:

- Drivers behind not able to drive too closely to you (90%)
- You as a driver not being able to drive too close to the vehicle in front (82%)
- Overtaking only allowed when it is safe (81%)
- Parallel and reverse parking done automatically and accurately for you (81%).

When asked to talk about their opinion on driverless cars, a good proportion of the comments were based around the potential dangers of the idea and how alien it seems, for example:

*“Why would anyone not want to be in control of their car?”*

*“Would be worried how the car would react in a non-programmed situation.”*

Once driverless cars become readily available, only 6% of motorists think that driving a car (that isn't driverless) should be banned by law.

In line with this, two thirds (65%) think that human beings should always be in control of a vehicle, and were the ability of driving a car abolished, the key thing that motorists would miss is being in control.

The final two points are perhaps the strongest – in the other questions many simply have not made their mind up yet.

## **5. What is the scale of the market opportunity for autonomous vehicles?**

IAM RoadSmart has no detailed knowledge but our surveys suggest a third of driver would at least consider it – that equates to around 10 million licence holders!

### **Creating an enabling environment**

#### *Research and development*

## **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

IAM RoadSmart are part of the Greenwich Driverless cars pilot study and are keen to be involved in more projects. We believe that our knowledge of what makes a good driver can be translated into a benchmark for driverless cars. Progress has been slow however and CCAV and Transport Catapult should be applying more pressure for early results. Most of the projects involving off road driverless pods do not appear to help in moving forward the debate about the transition to driverless cars on public roads. IAM RoadSmart has concerns but is supportive of pilot studies to help answer the many questions being posed.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

There should give more encouragement to include road user groups in funded projects and more focus on managing the transition between human and vehicle control.

**8. How effective are Innovate UK and the CCAV in this area?**

IAM RoadSmart strongly supports the continued funding and support of CCAV as an expert monitoring and project facilitation department. There should be a clear role for CCAV in maintaining its knowledge of new systems and providing a mechanism for organisations to flag up new technology as it comes on-line or is in development.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

No comment

*Real world operation*

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

In the long term yes, but in the short term driverless cars must be designed to match the real world of potholes, congestion, broken and missing signs and temporary traffic lights at roadworks.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

Ultimately the big changes will only come if incentives or bans are put in place. These may take the form of insurance discounts or even the removal of insurance for human controlled cars. Incentives to purchase new driverless cars must have a clear timescale as the lessons of electric vehicle subsidies show that reducing them too early stops growth.

Incentive such as access to urban areas, certain lanes on the motorway or bus lanes must be carefully managed. In Norway allowing electric vehicles in bus lanes has added to congestion. IAM RoadSmart would not support a two tier level of access where the poorest drivers in older cars are denied access to the safest infrastructure eg motorways.

Car owners must not be placed at a loss if sudden changes in legislation were to make their vehicles lose value. Traditional cars will still be on sale for at least another decade and will last a further ten years beyond that. Protecting the consumer must be a key part in any decision making.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

Protection from hacking was a key issue for over 70% of our members when they responded to a poll on the recent government consultation.

IAM RoadSmart support the FIA ‘My Car My Data’ campaign to ensure more transparency in data sharing and security.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

IAM RoadSmart supported the proportional approach to insurance laid out in the government’s recent consultation on “A Pathway to driverless cars”

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

The debate on the moral issues around driverless cars has only just started and needs to be much wider and more transparent. The impact on vulnerable road users and the moral choices that a driverless car may have to make require a far reaching debate before they appear on our streets. Is it right that a car should be programmed to protect itself and its occupants at all costs? Should a driverless car be allowed to choose what it hits if a crash cannot be avoided?

Such questions require wide consultation before the technology makes the decision for us. We are also aware of the potential for driverless cars to become useful to criminals and terrorists if there is no driver present to be disarmed. Although these issues are still many years away they are of intense interest to the media and to drivers. By addressing them now this will help to ensure a more positive background for the growth of the industry in the UK.

*Wider governance*

**15. What does the proposed Modern Transport Bill need to deliver?**

The modern transport bill must deliver a clear framework for driverless car trials and the insurance approach that will be adopted following the recent consultation.

**16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?**

No Comment

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

As mentioned above IAM RoadSmart would like to see a sharper focus on transition to driverless cars issues such as maintaining driver attention levels.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

IAM RoadSmart support European wide crash testing programmes such as EuroNCAP and these should continue and apply to driverless cars. European Statements of Principle (ESOPs) exist on the levels of distraction allowed when designing in car equipment and the human machine interface (often referred to as HMI). Currently these documents are little discussed out with a small group of car designers and academic experts on ergonomics. This must change no matter what happens after brexit with more transparency on the guidelines for HMI.

*25 October 2016*

## **Information Commissioner's Office (ICO) – Written evidence (AUV0066)**

### **Introduction**

1. The Information Commissioner has responsibility for promoting and enforcing the Data Protection Act 1998 ("DPA"), the Freedom of Information Act 2000 ("FOIA"), the Environmental Information Regulations ("EIR") and the Privacy and Electronic Communications Regulations 2003 ("PECR"). She is independent from government and upholds information rights in the public interest, promoting openness by public bodies and data privacy for individuals. The Commissioner does this by providing guidance to individuals and organisations, solving problems where she can, and taking appropriate action where the law is broken.
2. The Commissioner welcomes the opportunity to respond to the House of Lords Select Committee on Science and Technology's call for evidence on autonomous vehicles. The response addresses those questions posed by the Committee which are relevant to the work of the Commissioner.

### **What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

3. While autonomous vehicle technology has the potential to deliver societal benefits in terms of improved road safety and user convenience, there is a need to consider the volume and nature of the data that vehicles may generate and to adopt appropriate safeguards against misuse of individuals' data.
4. Information generated by connected and autonomous vehicles is likely to contain personal data, which should be processed in accordance with the requirements of the DPA, including the eight data protection principles (see annex). Personal data processed via connected and autonomous systems may include geolocation data, telematics, driver/user settings and collision information. There is also potential for data which may initially be regarded as purely technical in nature, such as safety system information on the number of persons occupying a vehicle, to become personal data if it can be linked to a particular individual or individuals. Data may be stored by on-board systems, transmitted to the vehicle manufacturer or, in the case of autonomous vehicles, used to communicate with other vehicles and traffic management systems.
5. If the personal data of vehicle drivers and users is processed inappropriately, in the case of geolocation data for example, there is a heightened risk of intrusion into individuals' work and private lives. The Government and technology providers should therefore adopt a privacy by design approach and ensure that privacy protections are built in to the design and development of new products and services, thereby reducing the need for costly reworking at a later stage.

6. A privacy by design approach, including the use of privacy impact assessments, can help to reduce the risk of personal data being processed in a manner which breaches the requirements of the DPA and causes detriment to individuals. Mitigating the potential privacy risks at an early stage of development will help to ensure that individuals are able to benefit from connected and autonomous vehicle technology with minimal disadvantage.
7. Technology providers and vehicle manufacturers should seek to create transparency around the types of personal data processed by connected and autonomous vehicle technology and the purposes of the processing. A transparent approach will not only help to satisfy the fairness requirements of the first data protection principle but can also assist in generating consumer trust around the technology.

**How much is known about public attitudes to autonomous vehicles?**

8. The Information Commissioner's Office (ICO) plans to issue its own call for evidence on connected and autonomous vehicles in order to develop understanding of public attitudes towards the technology and gather information on the steps technology providers and vehicle manufacturers are taking to address privacy and data protection concerns.
9. In November 2015, the Federation Internationale de l'Automobile (FIA) Region 1 published the results of a public survey on connected cars, which provided an indication of the public's main concerns in relation to connectivity<sup>154</sup>. Respondents to the survey were most concerned about disclosures of private information (88%), followed by commercial use of personal data (86%), vehicle hacking (85%) and location tracking (70%).
10. While the FIA Region 1 survey focused on attitudes towards the types of connected vehicle technology already available on the market, the results suggest that the public's main concerns all relate to privacy issues, which may act as a useful indicator of the concerns likely to arise as autonomous vehicle technology develops.

**Does the Government have an effective approach on data and cybersecurity in this sector?**

11. The Government is yet to address the challenges related to data and cybersecurity in this sector directly with the ICO. However, the establishment of the Centre for Connected and Autonomous Vehicles (CCAV) is a welcome development. CCAV should seek to place privacy, data protection and cybersecurity considerations at the heart of its work to develop policy in the sector.
12. As noted above, personal data generated by connected and autonomous vehicle technology should be processed in accordance with the DPA and the eight data protection principles. In developing policy around cybersecurity and the processing of

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<sup>154</sup> <http://www.fia.com/news/fia-reveals-what-data-being-tracked-and-how-public-reacts-connected-cars>

personal data in the sector, the Government should refer to the requirements of the seventh data protection principle (see annex).

13. The ICO supports the Government's Cyber Essentials scheme and has encouraged businesses to be assessed against it. As a minimum, the Government should seek to apply the standards and principles promoted through the scheme to the connected and autonomous vehicles sector, recognising the high level of risk associated with potential cyber-attacks on internet connected vehicles.

### **Additional information**

14. The ICO has undertaken some initial work with representative bodies for vehicle manufacturers and fleet management companies in order to develop its understanding of the data protection and privacy risks arising from the deployment of connected and autonomous vehicle technology. The ICO is keen to work with industry and policy makers to help address any challenges at an early stage.
15. It should be noted that data protection law across Europe is due to undergo significant reform when the General Data Protection Regulation comes into force in May 2018. The Regulation will update data protection law to take into account technological developments and globalisation, and reflects the fact that technology allows organisations to make use of personal data on an unprecedented scale. It will be important to ensure any work undertaken in relation to connected and autonomous vehicles takes into account the new data protection framework.
16. The ICO would welcome the opportunity to engage with the Government, the Department for Transport and CCAV to help ensure the issues identified are adequately addressed.

*26 October 2016*

### **Annex**

#### **Data Protection Act 1998**

##### **The data protection principles**

1. Personal data shall be processed fairly and lawfully and, in particular, shall not be processed unless –
  - (a) at least one of the conditions in Schedule 2 is met, and
  - (b) in the case of sensitive personal data, at least one of the conditions in Schedule 3 is also met.

2. Personal data shall be obtained only for one or more specified and lawful purposes, and shall not be further processed in any manner incompatible with that purpose or those purposes.
3. Personal data shall be adequate, relevant and not excessive in relation to the purpose or purposes for which they are processed.
4. Personal data shall be accurate and, where necessary, kept up to date.
5. Personal data processed for any purpose or purposes shall not be kept for longer than is necessary for that purpose or those purposes.
6. Personal data shall be processed in accordance with the rights of data subjects under this Act.
7. Appropriate technical and organisational measures shall be taken against unauthorised or unlawful processing of personal data and against accidental loss or destruction of, or damage to, personal data
8. Personal data shall not be transferred to a country or territory outside the European Economic Area unless that country or territory ensures an adequate level of protection for the rights and freedoms of data subjects in relation to the processing of personal data.

## **Innovate UK – Written evidence (AUV0037)**

*Evidence submitted on behalf of Innovate UK by: Dr Ruth McKernan CBE, Chief Executive, Innovate UK*

1. Innovate UK is the UK's innovation agency, a non-departmental public body sponsored by BEIS. It is the prime channel through which the Government de-risks innovation investment by business. Innovate UK is business-led. Our governing board and executive team is comprised of experienced business innovators and experts. We work with people, companies and partner organisations to find and drive the science and technology innovations that will increase productivity and exports and grow the UK economy.
2. We are working to:
  - accelerate UK economic growth by nurturing small high-growth potential firms in key market sectors, helping them to become high-growth mid-sized companies with strong productivity and export success;
  - build on innovation excellence throughout the UK, investing locally in areas of strength;
  - develop Catapult centres within a national innovation network, to provide access to cutting edge technologies, encourage inward investment and enable technical advances in existing businesses;
  - turn scientific excellence into economic impact and deliver results through innovation, in collaboration with the Research Community and Government; and,
  - evolve our funding models to explore ways to help public funding go further and work harder, while continuing to deliver impact from innovation.
3. In line with our strategy<sup>155</sup> we operate across Government and advise on policies which relate to technology, innovation and knowledge transfer. We also support Government departments to become more efficient by supporting them in developing innovative solutions through harnessing the creativity that businesses can offer.
4. Innovate UK was established in July 2007 (as the Technology Strategy Board). We have invested over £1.8 billion in innovation, and have helped more than 7,600 innovative companies in projects estimated to add up to £13.1 billion to the UK economy and created an average of 7 jobs per company we have worked with. Our investment over the last 9 years has meant that every £1 invested has returned up to £7.3 GVA to the economy and created 55,000 jobs. The private sector more than matches that investment, doubling the power of public sector money. We work with nearly every University in the UK to stimulate the commercialisation of leading-edge academic research and innovation.

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<sup>155</sup> 'Concept to Commercialisation: A strategy for business innovation, 2011-2015'.

[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/360620/Concept\\_to\\_Commercialisation - A Strategy for Business Innovation 2011-2015.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/360620/Concept_to_Commercialisation - A Strategy for Business Innovation 2011-2015.pdf)

5. Innovate UK welcomes the Committee's inquiry. Set out below is our response to the questions raised by the Committee covering all modes for autonomous vehicles across land, sea and air. Firstly, it is appropriate to define terminology of vehicles and systems as applicable for each application:
  - a. **airborne** (remotely piloted autonomous systems (RPAS), Unmanned Aerial Systems [UAS] or Drones);
  - b. **land** (Autonomous Vehicles [AV], Driverless Cars and Automated Transport); and,
  - c. **water** (Autonomous/Unmanned surface vehicles [ASV/USV] or Autonomous/Unmanned Underwater vehicles [ASV/UUV], Autonomous/Unmanned underwater vehicles [AUV/UUV], also referred to as underwater drones).
6. It is useful to clarify our perspective on the terminology of **Autonomous systems**:
  - a. Different definitions exist for autonomous systems; in most cases the view taken for them is one of the external observer, and refer to systems that operate without a Human-in-the-Loop during the execution of their tasks.
  - b. While this definition can serve many purposes, it does not distinguish between systems that have “operational” autonomy, via some type of closed loop control with already embedded control laws or logic (which can also be called automated or adaptive systems<sup>2</sup>), and systems which can “learn” and thus create their own logic, situation awareness, planning capabilities and their “own” laws or logic, thereby enabling “decisional” autonomy.
  - c. While the terms *automated* and *autonomous* tend to be used interchangeably, in order to minimize confusion we adopt the automated vs autonomous distinction herein; the automated systems do not include AI technologies like reasoning, learning, knowledge representation, planning or other higher level cognition, only the autonomous systems do.
  - d. Automation and autonomy can be thought of as comprising the two ends of a spectrum.
  - e. Current autonomous systems contain a set of cognitive capabilities allowing them to operate within certain situational boundaries.
  - f. The vast majority of current robotics systems are automated. Driverless/self-driven vehicles, that are often called autonomous vehicles, are also referred to by the corresponding industrial or regulatory bodies as ‘automated vehicles’.
  - g. Autonomous and/or automated systems may operate in the digital/cyber domain or, with the addition of sensors or actuators, within the real, physical world (e.g. autonomous robotics).
  - h. The reader should also be familiar with the SAE levels of autonomy. We feel that SAE levels 4-5 are the subjects in question<sup>156</sup>. This puts the current lane departure and emergency braking systems of the Daimler, Tesla Autopilot etc. out of scope.

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<sup>156</sup> [http://www.sae.org/misc/pdfs/automated\\_driving.pdf](http://www.sae.org/misc/pdfs/automated_driving.pdf)

- i. It may be pertinent to clarify the distinction between vehicle component of the topic (for movement of people, goods, functional equipment, etc.) and the wider service offering. For example the market value for robotics and autonomous vehicles for Nuclear decommissioning and Agriculture technology are heavily interwoven.

## **1. What are the potential applications for autonomous vehicles?**

- 7. Potential applications for autonomous vehicles across air, water and land cover a broad range of market opportunities including but not limited to:
  - a. Infrastructure – monitoring, inventory, in-situ maintenance, Building Information Modelling (BIM) specific for site management and modeling. UAS/Drone services could support BIM by providing precise, digitised progress monitoring of a construction project, leading to more efficient construction management, enabling contractors to spot construction issues earlier. Also leading to safer sites.
  - b. Transport and Freight – movement of people and goods, off and on-shore delivery and logistics across all existing modes e.g.:
    - i. Platooning of trucks – reduced energy use through aerodynamics;
    - ii. Virtual train carriages - Including virtual coupling of train carriages leading to innovation in railway scheduling, signalling and demand response;
    - iii. Platooning of passenger pods on railway tracks and busways (guided);
    - iv. Small load delivery vehicles;
    - v. Port to port distribution; and,
    - vi. Motorways of the sea.
  - c. Disaster Response and Insurance – risk monitoring and assessment, incident response, monitoring, fraud prevention;
  - d. Media – filming, photography, location management, advertising;
  - e. Telecommunications – Network provision using High Altitude Pseudo Satellites (HAPS) and High Altitude Long Endurance (HALE) type drones;
  - f. Hostile environments - Offshore Energy and Nuclear – installation, maintenance and decommissioning;
  - g. Nuclear decommissioning - historically, the vehicle has been seen as a means of deploying the individual technology e.g. sensors, lasers, cameras. However, there is a greater push to develop fully integrated systems such that the vehicle and its payload can multi-task with the vehicle providing both the delivery to point of use and the power to operate the payloads, with the option to deploy a number of technologies simultaneously e.g. visualise, characterise, cut and remove. This has a:
    - i. major role to play in reducing cost and time of decommissioning and minimising human exposure to radiation;
    - ii. ability to carry wide range of payloads; and:
    - iii. needs to be part of an integrated decommissioning system.
  - h. Agriculture – From small vehicles precision crop management, farm analysis, data capture, crop agronomy and livestock husbandry. Various aspects of

- crop storage and livestock housing could also be involved; from power delivery vehicles; the story is similar to the trend described in Nuclear. The “tractor” unit will transport the implement capability – a seed drill or a cultivator – but will trend towards fully integrated control and powering through appropriate drive shafts. A plough can be an integrated part of the vehicle platform extending the autonomous vehicle system to control lifting and rotating. Also sprayers large and self propelled or micro precision sprayers using lasers, additionally a full size combine harvester is a good customer for full autonomy;
- i. Security and Policing – Monitoring, communications, crowd and incident management;
  - j. Mapping, Surveying, & Construction – Site planning and management, assessment monitoring and measurement;
  - k. Mining - deep mining, subsea mining, and recycling;
  - l. Emergency services and harsh environments - (particularly search and rescue and fire-fighting), waste management and space exploration; and,
  - m. Innovate UK focused on civil applications and has not attempted to cover defence (land, sea, air) focused programmes but it is a huge market so cannot be ignored, especially in light of the US investment through DARPA and the innovation spillovers expected as a result into civil markets. The UK's dual use technology exploitation programme (DUET) is a sign of the potential for re-use of investment identified by the DGP (defence growth partnership).

**2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

8. Advantages include but not limited to:

- a. Increased safety and reduced road accident casualties (94% human error);
- b. Improved transport systems leading to increased productivity;
- c. Increased high value jobs leading to increased productivity per worker;
- d. Increased energy efficiency in vehicles;
- e. Increased vehicle asset utilisation;
- f. Reinventing of railway timetabling and demand management (virtual coupling);
- g. Removal of human workers from dangerous environments;
- h. Improved access to challenging harsh environments or dangerous areas;
- i. Safer and more efficient sea freight;
- j. Improved access to high quality data<sup>157</sup> - UAS/drones enable lower cost services vs. manned flight and therefore game changing in service regularity compared to full scale rotary or fixed wing aircraft;
- k. Improved quality and frequency of monitoring;
- l. Faster reaction to policing, security and disaster management events; and,
- m. Lower cost and higher safety solutions to manned road, sea and air transport.

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<sup>157</sup> Improved access to high quality data enabled by UAS surveillance and image processing is beneficial across infrastructure management and construction, disaster response and insurance, media, telecommunications, precision agriculture, security and policing, mapping and surveying. The improvement in access applies where the need is for repeatable data sets, persistent monitoring and monitoring of situations not readily accessible to humans.

9. Disadvantages include but not limited to:
  - a. Increased automation leading to loss of low skilled jobs;
  - b. Replacement of high value markets with lower value drone ones e.g. the civil helicopter market;
  - c. Cyber security concerns;
  - d. Privacy and safety issues (in UAS this may be driven in part by recreational users' ignorance of, or desire to comply with existing regulation); and,
  - e. Incidents involving civil UAS incursions into restricted spaces and violations of privacy have occurred and get significant media coverage.
- 3. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**
10. Yes, these will be different for different classes of system operating in different environments and controlled in different ways. This is a complex area and a one size will not fit all. To draw a road based metaphor imagine a road with a remote controlled car stopping frequently to deliver parcels, an autonomous car slowly surveying the surface, a person driving a coach full of people, and an articulated lorry transporting freight autonomously all having to interact, sense, and avoid each other and everything else around them. Now imagine this is hundreds to thousands of feet in the air over towns and cities with no, or little, physical infrastructure to guide the various systems.
11. Until recent times the UK had more UAS registered users than the USA. A testament to the excellent work by the civil aviation authority (CAA) in writing regulations. To maintain any advantage more work will be needed. Enabling of Beyond Visual Line of Sight (BVLOS) flight/shipping is key to the development of the UAS/ASV markets that require significant regulatory change; this is to be delivered by the Department for Transport by 2020. This will require the development of regulations in a number of areas including air traffic and shipping management, and sense and avoid certification.
12. Insurance is an area that will need a reasonable amount of focus to understand and legislate on the burden of liability for incidents involving the various types of vehicle and flight control types. BVLOS, automated, remotely piloted, and HAPS/HALE flights are different in nature and will require a different approach to insurance and liability. Whether insurance will be voluntary or mandatory for different system types in different flight situations and uses will also need to be considered. This may also require additional legislation relating to Police actions in the operation and potential misuse of these vehicles.
13. Aerospace legislation governing the certification of systems will also require revision. The range of systems will have different certification requirements along with a defined approach to system manufacturer certification to cover both platforms, as well as systems such as sense and avoid.
14. The UK was not a signatory of the Vienna Convention, which has given us a globally competitive advantage as a place to design, test and commercialise road-going vehicles.

We can imagine only an 18-36mth advantage but with such a disruptive market with early mover and first to scale advantages this position should be maintained. C-CAV as part of the DfT are doing an excellent job in this regard to date.

15. A wider perspective regarding autonomy and liability will need to be resolved. The functioning of AVs will be a consequence of their programming / learning algorithms. Large-scale adoption, may generate legislative requirements for track back into software malfunction, such that the companies writing code (including framework code for autonomy) can be held accountable for its performance. It is not clear currently how this will be done, nor how the vehicle monitoring systems will gather the data that allows a distinction to be drawn between software, hardware, driver or even infrastructure error. These points are speculative although Microsoft has made the test case of liability back to software code during the House of Commons evidence session for robotics and autonomous systems<sup>158</sup>.

#### **4. What is the scale of the market opportunity for autonomous vehicles?**

16. Market size predictions vary widely due to the relative immaturity of the market, forecasting accuracy and key technology enablers. However, future value of the platform vehicles can give some indication to the scale of the opportunity and therefore these market opportunities are really exciting for UK businesses:
  - a. Automotive - In 2014, more than 329 million commercial vehicles and 907 million passenger vehicles were in use worldwide. In 2014, more than 22 million commercial vehicles and approximately 68 million passenger cars were produced globally. According to a forecast by PwC, in 2017 a total of 102 million vehicles will be manufactured worldwide<sup>159</sup> – The AV opportunity is fleet replacement and UK manufacturing, retail and servicing of vehicles and their autonomous control systems.
  - b. Aerospace - In 2015, there were almost 24,000 turboprop and regional aircraft, as well as widebody and narrowbody jets in service worldwide<sup>5</sup>. General aviation [i.e. civil, non-commercial] includes over 362,000 aircraft flying worldwide today, ranging from two-seat training aircraft and utility helicopters to intercontinental business jets. In 2015, there were 2331 new shipments of general aviation aircraft, with total estimated billing of \$24.12bn<sup>160</sup>. There are 45,000 commercial passenger and freighter aircraft<sup>161</sup>. Total new large commercial aircraft production over the period 2016-2020 is forecast to be 8,683<sup>5</sup> – Manufacture and export of propulsion and smart, connected and more electric aircraft systems plus their maintenance, repair and overall.
  - c. Cities and infrastructure industries - Supply, install, supporting infrastructure (connectivity, cyber security, control and optimisation algorithms, intelligent mobility and freight service models across transport modes).

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<sup>158</sup> <http://www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/145/145.pdf>

<sup>159</sup> Statista

<sup>160</sup> General Aviation Manufacturers' Association

<sup>161</sup> JetData

- d. Rail - The total number of new rail vehicles committed for delivery [in the UK] in the five-year period that commenced in April 2014 (Control Period 5, CP5) and in the early years of CP6 (2019 to 2024) is now over 4,500, with a capital cost of more than £7.5 billion<sup>162</sup>.
  - e. Maritime - Over c80% of UK goods arrive via sea so maritime autonomous control systems are also of significance with 190,000+ ships of 100 GT and above in service, on order or under construction. Of the around 50,420 merchant ships trading internationally [as of Jan 2015], some 16,900 ships were bulk carriers<sup>5</sup>.
  - f. Services: consultancy, insurance, etc. - Lloyds position us well for (re)insurance in auto/air, and the Register for shipping and rail.
17. Payload delivery in our end-user industries - mobile robots delivered to point of use on vehicular platforms – offshore energy, nuclear, agriculture, subsea are opportunities for UK robotics and artificial intelligence (RAAI) and less for the vehicle platforms.
18. Automotive - The 2014 report from SMMT/KPMG<sup>163</sup> shows a predominant feature of the opportunity for CAV as economic growth in the order of \$51bn per annum in the UK alone, which is driven to a large extent by increased productive time for workers whilst travelling. This time could equally be spent relaxing and lead to health benefits and reduced NHS costs.
19. However, taken from another perspective the value of the motor car in 2025 is expected to be made up of over 50% electronics. The current automotive electronics architecture designs with distributed electronic control units are unsuitable and therefore have unsustainable market share for fully autonomous cars. Therefore the market opportunity globally for electronics and software suppliers is trillions of dollars. The UK has a strong electronics and software capability but does not have a single tier 1 supplier of automotive electronics at scale. The disruption for automotive electronics is a major opportunity for the UK.
20. Extreme environments such as nuclear decommissioning, deep mining, sub-surface, sub-sea, outer space, and other challenging environments where it is unsafe to send human workers will benefit enormously. For example, an inevitable by-product of the rise of nuclear energy is the creation of a global decommissioning market, currently estimated to be worth £50 billion per annum by 2020<sup>164</sup>. The total cost of nuclear decommissioning in the UK alone is currently estimated at £60 billion.
21. The latest market reports<sup>165</sup> put the total addressable UAS market at around \$127bn in 2015. Infrastructure - \$45bn total addressable in 2016 and Precision Agriculture – \$32bn total addressable in 2016, are assessed to be the largest addressable markets for UAS and both are examples that would complement and enhance existing high-value services

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<sup>162</sup> Long Term Passenger Rolling Stock Strategy for the Rail Industry, Rail Delivery Group, March 2016

<sup>163</sup> <http://www.smmt.co.uk/wp-content/uploads/sites/2/CRT036586F-Connected-and-Autonomous-Vehicles-%E2%80%93-The-UK-Economic-Opportu...1.pdf>

<sup>3</sup> <https://connect.innovateuk.org/documents/2903012/16074728/RAS%20UK%20Strategy?version=1.0>

<sup>165</sup> <https://www.pwc.pl/pl/pdf/clarity-from-above-pwc.pdf>

rather than directly replace. It is important to view these market assessments in the context of the total market that UAS can address, should the technology and regulation allow. Much of the future market potential for UAS depends on changes to legislation including enabling BVLOS. For example, the current drone market for Infrastructure systems is \$0.25bn against an addressable market of \$45bn.

22. In civil Aerospace the technology already exists to fly point-to-point on Autopilot without the need for any human input, only monitoring. Some members of the public on board commercial planes are able to tell through aircraft dynamics whether the autopilot or the captain has landed the plane, from the feel of the landing. The UK is well positioned, and the technology exists – the challenge is how we ensure the UK can leverage this across traditionally siloed modes of transport and large-scale public R&D incentivising funding streams.

## 5. What has Innovate UK done in the area of Autonomous Vehicles?

23. Sectors enabling the markets for AVs connect various part of the UK economy within Innovate UK's priority areas and managed programmes including:

- a. Energy;
- b. Digital;
- c. AgriTech;
- d. Materials and Manufacturing;
- e. Transport (inc. Aerospace, Automotive, Rail and Marine);
- f. Aerospace Technology Institute R&D Programme;
- g. Enabling and Emerging Technologies; and,
- h. Infrastructure Systems.

24. Through Innovate UK's Catapult network we have enabled the LUTZ (Low-carbon Urban Transport Zone) Pathfinder project. A pioneering CR&D project that carried early trials in public pedestrianised areas of fully-automated vehicles in Milton Keynes and has received world-wide press coverage, positioning the UK as a thriving hub of global business activity. Overseen by the Transport Systems Catapult, the project is using electric-powered two-seater pods that operate on designated pedestrianised areas. The pods are designed and manufactured by Coventry-based automotive innovation SME RDM, and equipped with autonomous control systems developed by the University of Oxford's world-leading Mobile Robotics Group and rapidly commercialising in Orobotica.

25. Innovate UK has, to date, delivered<sup>166</sup>:

- a. Multiple sector (e.g. including Agri-tech) UAS related projects - 97 with grant funding of £24m to 100 unique organisations (49.5% of participants were SMEs);
  - i. The ASTRAEA programme was a total investment of £62m investment between 2006 and 2013 of which £12m was grant included above;

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<sup>166</sup> Numbers are in public grant value and are matched or exceeded by public sector investment in these programmes:

- b. Transport - Driverless cars city trials, 3 large consortia with grant funding of £19m to 38 unique organisations across public, private and 3<sup>rd</sup> sectors;
  - c. Transport/Autonomous Connected Vehicles - C-CAV Collaborative Research & Development and Feasibility Studies – 22 projects with grant funding of £25m to 77 organisations;
  - d. Maritime autonomous systems – Collaborative Research & Development – 8 projects with grant funding of £5m to 31 organisations; and,
  - e. Adaptive Autonomous Ocean Sampling Networks (Natural Environment Research Council pre-commercial procurement) - 2 projects with grant of £2m to 11 Feasibility studies and 4 prototype development contracts using the pre-commercial procurement framework (SBRI).
26. UAS is a significantly different market environment to driverless cars (CAV). There are technology crossovers but the technology and legislative challenges to the widespread uptake and deployment of UAS are complex and are being developed by the Civil Aviation Authority in the UK to accommodate a variety of different sizes and types of UAS operated in a number of ways. Civil UAS range from insect sized vehicles operating individually or in delivery swarms, to potentially commercial passenger sized vehicles and all sizes in-between. They can operate at a large range of altitudes though the atmosphere from a few feet off the ground to High Altitude Pseudo Satellites operating above 65,000 ft and into Space for exploration.
- 6. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**
27. Digital infrastructure will be influenced by new demands on existing, and demands for new, secure communications networks that will no doubt arise from increased numbers of sophisticated autonomous vehicles.
28. There are different fields of thought regarding automated vs autonomous vehicles and the requirement for 100% reliable connectivity to enable some manufacturers chosen solutions. There is expert opinion (e.g. Google, Orobotica, FIVEAI) that the most likely current outcome is that 100% reliable connectivity will add and enhance vehicular features, but will not be a requirement for standard operation of autonomous vehicles.
29. We wish to flag UK strengths in the provision of connectivity – linking in to 5G expertise, the LPWAN trials being undertaken by the Innovate UK Digital and Future Cities Catapults, and the planet wide connectivity that satellites can provide. The Satellite Applications Catapult are well positioned to provide the underpinning work, and marine is one of their priority areas.
30. There are competing theories on the need for connectivity in enabling autonomous operation of road vehicles. If a manufacturer decides to develop connected vehicles that require connectivity to operate autonomously then the communication networks in the UK would currently be a hindrance. The reliability and performance of current mobile networks is insufficient to support their widespread use. However, the pace of development of digital infrastructure technology is likely to outstrip that of vehicle

development and so public sector procurement of infrastructure designs and innovation in service supply models.

31. UAS (Drones) may be able to have a positive effect on digital infrastructure through the deployment of HAPS/HALE drones to provide the infrastructure.
32. UAS physical infrastructure will remain largely unchanged, or at least changed minimally to allow for potential increases air traffic management load, a significant plus point is that airborne systems are designed to interact with physical infrastructure rather than make use of it in the way land based vehicles have to.

*25 October 2016*

## **Institute and Faculty of Actuaries (IFoA) – Written evidence (AUV0059)**

*Letter from Fiona Morrison, Immediate Past President, Institute and Faculty of Actuaries*

1. The Institute and Faculty of Actuaries (IFoA) welcomes the opportunity to respond to the Call for Evidence on Autonomous Vehicles from the House of Lords Select Committee on Science and Technology. Members of the IFoA's General Insurance Board and Risk Management Board are jointly responsible for the drafting of this response.
2. The IFoA has taken an active interest in the development of the regulatory, research and policy environment for the development of autonomous vehicles in the UK. We have engaged directly with officials from the Department for Transport (DfT) and the Centre for Connected and Autonomous Vehicles (CCAV). In September 2016 we submitted a response to the DfT/CCAV consultation on proposals to support advanced driver assistance systems and automated vehicle technologies.
3. Most of the Select Committee's questions are not directly related to the IFoA's area of expertise. We would like to focus on questions 12-14.

### **Question 12: Does the Government have an effective approach on data and cybersecurity in this sector?**

4. Cybersecurity is a growing threat across many different areas of daily and corporate life. In the context of autonomous vehicles, the IFoA believes the key points to consider are that there should be open access to data on both driver behaviour and the functioning of vehicle technology, within the constraints of data protection legislation. Failure to achieve open access is likely to give rise to serious risks. For example, if such data is owned by manufacturers there is a risk that they could try to avoid liability in order to protect their reputations. Similarly if data is owned by the vehicle's insurer this could impede competition.
5. The DfT/CCAV consultation document proposed that insurance cover for hacking of an automated vehicle by a third party could be provided by product liability insurance. In our response we suggested the alternative of cyber insurance. This should preferably be paid for by the manufacturer, not by the driver. Reinsurance of terrorism risks may be needed to cover the risk of many vehicles being hacked simultaneously.
6. We accepted the consultation's comparison of hacking with vehicle theft, since a hacked vehicle would essentially be out of the driver's control through no fault of their own. However, the liability could be unclear if the owner was negligent in maintaining the security systems within the automated vehicle technology and this gave an opening for the car to be hacked.

**Question 13: Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

7. As noted, the IFoA replied in detail to the recent DfT/CCAV consultation and have included a link to that. Given actuaries' expertise in the assessment, quantification and financial/practical management of risks, most of our comments in that response related to insurance. The following is a summary of some of the key points we made there.
8. We believe that revisions are needed to create the right environment for autonomous vehicles. One key guiding principle is that relevant parties involved in an accident should have access to compensation and there should not be potential gaps in insurance coverage which may make it hard for them to obtain this. We believe these outcomes would be best achieved through a combination of traditional motor insurance and product liability cover. We therefore supported the proposals in the recent DfT/CCAV consultation to require product liability insurance for automated vehicles.
9. We believe that proposals for product liability cover may need to cover assisted technology (such as remote control parking or systems for maintaining a vehicle's position on the motorway) as well as full automation. Even though the driver remains 'in the loop', it seems reasonable to imagine that a malfunction of the assisted technology could cause an accident that is hard for the driver to control.
10. In our view, manufacturers, rather than vehicle owners, should take out product liability cover, because it is the manufacturer who should ultimately pay the cost of claims that would fall under product liability. Buyers of automated vehicles should have confidence that it will be the manufacturer, rather than themselves, who will be paying for that product liability cover.
11. The way this would work in practice is that, if a person driving a conventional car is hit by a vehicle in autonomous mode, they should be able to claim against the autonomous vehicle owner's insurance policy. If that policy includes product liability cover, the injured party would be fully compensated including damage to their car. It would then be for the insurer to decide if the manufacturer was at fault, and if so to seek the recovery from the manufacturer. Manufacturers might be nervous about accidents involving automated vehicles, because with traditional cars a single incident would not have repercussions, but a single accident for an automated vehicle could be relevant for all vehicles using certain software. A potential concern would be if a gap emerged, where the manufacturer was unwilling to accept liability and hence the insurer of the driver refused to pay out the repair costs for the damaged car.  
It is unclear what the balance will be between company and private ownership of autonomous vehicles. A related issue was explained in the DfT/CCAV consultation document (paragraph 2.29): "Currently, the Consumer Protection Act 1987 only applies to property damage where the damaged property is owned by private individuals for personal use – not where it is owned by companies. Where a

company's property is damaged by a defective product they currently have to prove that the producer was negligent (rather than just prove that there was a defect in the product)". Changing the law might create unnecessary complexity, but it will be important to clarify how the current legal framework would work in practice for autonomous vehicles.

**Question 14: What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

12. We would highlight the challenge of pre-programming a decision for the vehicle when it is forced into a collision but has a 'choice' about who or what to hit - how can the so-called 'lesser of two evils' be determined? For a human driver we would not penalise whatever action they chose in these circumstances, since they did not have time to consider all the pros and cons before reacting. However, for a pre-programmed vehicle we believe it is important to think carefully about the feasibility and desirability of considering all of these scenarios in advance.

*26 October 2016*

## **Institute of Marine Engineering, Science & Technology (IMarEST) – Written evidence (AUV0064)**

### **Summary**

Please find attached the response from the Institute of Marine Engineering, Science and Technology (IMarEST) to the Inquiry into Future Uses of Autonomous Vehicles. The Institute welcomes the opportunity to submit a response to this inquiry. This response was submitted on the 26<sup>th</sup> October 2016.

The IMarEST is an international membership body and learned society for marine professionals, with 50 branches and 20,000 members in over 120 countries around the world. The Institute's role is to promote inter-disciplinary understanding of marine engineering, marine science and marine technology in order to uphold and advance the knowledge and status of professionals across the international marine community.

This response has been prepared in consultation with the IMarEST membership and reviewed by the Institute's Technical Leadership Board. The response tries to avoid opinion but it should be noted that some of the comments within may not be the views of the entire membership.

The IMarEST submission addresses the 5 principle questions from a high level perspective and introduces topics as highlighted below.

What are the potential applications for autonomous vehicles in the maritime sector? In the marine sector, autonomous vehicles are being developed on several scales, from small remotely operated subsea gliders to full-blown unmanned cargo ships. Applications are detailed and include applications within commercial shipping, naval and defence, oil and gas and offshore renewables and marine science sectors.

What are the potential user benefits and disadvantages from the deployment of autonomous vehicles? The benefits include the removal of people from what is a harsh and dangerous environmental and to reduce the risk to human life in addition to being able to reach areas of the world not easily accessible (such as the very deep ocean). Disadvantages are discussed and include concerns over power, payload, speed, security and piracy

Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles? The primary legislation required will be international legislation and this section provides details on the International Regulations for Prevention of Collision at Sea (COLREGS) and introduces codes of practice already in place

What is the scale of the market opportunity for autonomous vehicles? A market assessment has been undertaken by the Marine Industries Leadership Council (MILC), and the total available market is estimated at £10-20M for ocean science, mine countermeasures and

survey. However the global market for autonomy in traditional shipping is estimated at £136Bn with the UK Serviceable Available Market estimated at £13.6BN over 15 years

Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure? Changes to physical and digital infrastructure are likely to be required and these are introduced in brief.

### **What are the potential applications for autonomous vehicles?**

1. In the marine sector, autonomous vehicles are being developed on several scales, from small remotely operated subsea gliders to full-blown unmanned cargo ships.
2. The terminology used outside commercial shipping (where the aim is to develop an autonomous ship) is primarily marine or maritime autonomous systems which range from ships through to smaller observing platforms. Throughout this document large vehicles, primarily for the transport of people, bulk cargo and containers are referred to as autonomous ships. For other applications, such as for monitoring and science services they are referred to as maritime or marine autonomous systems. Other terms commonly used terms are Autonomous or Unmanned Surface Vehicles (ASVs or USVs) or Autonomous or Unmanned Underwater Vehicles (AUVs, UUVs)
3. The most high profile application would be for fully autonomous ships. Autonomous ships could eventually be used for the transport of bulk cargo and containers, over medium and long distance.
4. In this context of an autonomous ship there can be two generic alternatives that are combined in an autonomous ship:
  - the remote ship where the tasks of operating the ship are performed via a remote control mechanism e.g. by a shore based human operator and
  - the automated ship where advanced decision support systems on board undertake all the operational decisions independently without intervention of a human operator.

Ref: <http://www.unmanned-ship.org/munin/>

5. Rolls-Royce is one of the most enthusiastic commercial concerns developing large autonomous ships that could be used for seaborne trade and are taking this forward as part of the Advanced Autonomous Waterborne Applications Initiative (AAWAI). In February 2015, the Finnish Funding Agency for Innovation Tekes approved a joint industry-academia research project on autonomous ships. AAWAI seeks to address the key technical challenges related to autonomous shipping operations. It is exploring both autonomous and remote operation for ship navigation, machinery and all on-board operating systems. The project was kicked off in March 2015 and continues until June 2017

<http://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/ship-intel/aaawa-whitepaper-210616.pdf>

6. In October 2016 the Danish Maritime Authority announced it is “preparing for a future that includes autonomous ships” by launching a pre-study on the matter. The Authority says that unmanned ships becoming a reality is not a matter of if, but when, where, and to what extent. To prepare for this new reality, the Authority has teamed up with the Technical University of Denmark to initiate the pre-study, with the purpose of increasing the knowledge base surrounding the technology and set the preliminary framework so the development and use of unmanned ships is done in an appropriate manner.

7. This stance is replicated in Norway, where the Norwegian government has designated the development of unmanned ships as a major priority for the country’s technology industry. To this end, it is supporting the Norwegian Maritime Authority, the Norwegian Coastal Administration, the Federation of Norwegian Industries and MARINTEK, as they together establish a forum as platform to coordinate research into the technology.

<http://nfas.autonomous-ship.org/index-en.html>

8. Navigation specialist NAVTOR is to spend the next three years helping the EU chart a route towards autonomous ships. The Norwegian firm has been selected to represent the maritime industry in the ENABLE project - conceived to prove, verify and validate the safety of autonomous vehicles in Europe. NAVTOR has now received funding to investigate the concept of ‘shore-based bridges’, a crucial steppingstone on the path to autonomy.

9. ENABLE was originally proposed by the car industry, before the EU widened its scope to take in the full spectrum of transport, including ships. NAVTOR was chosen to represent the maritime sector’s efforts due to its background in the field of navigation, planning and monitoring.

10. An additional application is within the Naval and Defence sector. The deployment of autonomous sensors and weapons from naval mother ships or shore control stations extends capability, and reduces human risk. The hazardous operations of mine hunting and clearance are primary tasks suitable for autonomy. Additionally, autonomous systems (smaller vessels rather than ships per se) can be used for Rapid Environmental Assessment (REA) to provide a characterisation of the physical environment to increase mission effectiveness, reduce risk, and reduce timelines for operational units arriving on scene. Other applications for autonomous systems include detect-to-engage, waterside perimeter security systems which can be used to provide effective port protection of High Value Assets (HVAs) and critical infrastructure against surface and subsurface threats.

11. In line with the Strategic Defence and Security Review direction on innovation and defence exports, the RN invited industry, academia and certain Defence partners, including the US Navy, to safely experiment and demonstrate the potential offered by maritime autonomous systems within the Joint Warrior operational environment. The multinational event held in October 2016 saw around 40 companies and organisations showing off the latest technological developments in this field in a tactically representative environment. The event took place off the west coast of Scotland & Wales, as part of Joint Warrior 162, Unmanned Warrior will involve Unmanned Aerial Vehicles (UAVs), Unmanned Underwater Vehicles (UUVs) and Unmanned Surface Vehicles (USVs) conducting a number of challenging

scenarios across different themes. Details can be found at  
<http://www.royalnavy.mod.uk/uw16>

12. The Office of Naval Research in the US provides a number of summary “posters” that highlight the potential uses of autonomous systems for naval applications.

<http://www.onr.navy.mil/Media-Center/unmanned-warrior.aspx>

13. Classification society Lloyds Register (LR) became involved in autonomous systems via its support role with the Royal Canadian Navy (RCN). The RCN has been steadily upgrading its naval mine countermeasures capabilities while simultaneously trying to reduce the costs associated with this role. Through a series of contracts with the RCN’s research labs, LR’s Applied Technology Group began to develop a series of add-on wireless communication systems, including mission control/planning software, integration of RCN-supplied automatic shape recognition capabilities, and AUV navigation control and recovery methodologies.

(See: [http://www.lr.org/en/\\_images/229-81351\\_Marine\\_Technology\\_Report\\_Driving\\_New\\_Technologies.pdf](http://www.lr.org/en/_images/229-81351_Marine_Technology_Report_Driving_New_Technologies.pdf) PDF-Page 21)

14. Whilst there is great scope for the use of autonomy in the naval sector not all naval activities would be suitable. Diplomacy, "flying the national flag" overseas and other relationship-building activities are achieved with presence, dialogue and the building of trust. The promotion of UK trade overseas or the rendering humanitarian assistance for flood and storm damaged territories are traditional naval roles requiring face to face engagement in negotiation and diplomacy.

15. The use of autonomous systems in the offshore oil and gas sector is well established and is also increasing used in the offshore renewables sector. Autonomy is used to reduce exposure to personnel, increase data return through the ability to obtain regular uploads of data from sub-surface instrumentation, improving the ability to perform baseline type measurements, enabling data acquisition in more severe sea-states, when manned vessels cannot operate and providing a multi-discipline (metocean, survey, Environmental Impact Assessment) platform.

16. Oil major BP already employs a wide assortment of different marine autonomous systems, including wavegliders, autonauts and deoptrekkers. The company states that it's only in recent years, as technology has advanced and costs fallen, that these vehicles have become ready to take over underwater surveillance duties. It has partnered with manufacturer Oceaneering for a large-scale AUV trial to survey pipelines and subsea infrastructure in the Gulf of Mexico, ahead of a full roll-out. More at:  
<http://www.bp.com/en/global/corporate/bp-magazine/innovations/ocean-monitoring-with-robot-technology.html>

17. A principal application for the oil and gas sectors is for the detection and tracking of oil in water. The International Oil and Gas Producers Association have undertaken studies and are in the process of completing a study that looks at the compatibility of candidate oil detection sensors and autonomous vehicles. Potentially multiple viable combinations of direct and indirect oil detection sensors can be hosted on each of the classes of unmanned vehicles and this is evaluated in the study. The final report has not yet been issued to the public but a

similar report on the use of ROVs is available at <http://www.oilspillresponseproject.org/wp-content/uploads/2016/02/RR-Oceaneering.pdf>

18. Scientific research can be considered an immediate application for marine autonomous systems. The ability to sustain longer periods on task or to go into physically hostile zones such as deep-ocean or beneath ice-caps, are best done autonomously.

<http://noc.ac.uk/research-at-sea/nmfss/mars>

19. The UK National Oceanography Centre (NOC) began the MASSMO project in 2014, deploying multiple USVs and UUVs in a joint deployment off the southwest coast of the United Kingdom and other exercise have since taken place. The project has successfully deployed a wide range of sensors offshore for an extended period, observing ocean fronts, marine mammals (MMO), and tracking tagged fish. For details visit

<http://projects.noc.ac.uk/exploring-ocean-fronts/>

20. Plymouth University, together with submarine engineering firm MSubs and other local SMEs, are teaming up to build a 32.5m-long wind and solar powered autonomous vessel. The plan is to build the Mayflower 2020 as a technology demonstrator in time to make an unmanned crossing of the Atlantic to commemorate 400 years since the original Pilgrim's Crossing and after that for carrying out scientific missions in remote seas and possibly for remote monitoring of subsea infrastructure in the North Sea. For details visit:

<https://www.plymouth.ac.uk/campaign/mas>

**What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

20. A key driver in the marine sector is to reduce the HSE risk to personnel working offshore. If a vessel or a process can be autonomous/automated it removes the requirement to place personnel in a dangerous environment. Commercial ship operators may be excited by the prospect of a reduction in costs related to employment and retention of crew. However questions remain about the skillsets required to support autonomous systems (and whether these will offset the savings generated by removing onboard crews). This is an area that would merit further consideration. The adoption of autonomous ships in particular may help the UK to increase the number of UK flagged vessels if it is an early entrant to such a market.

21. The Finnish ship engine manufacturer Wartsila reasons that unmanned cargo ships would pave the way for 'ultra-slow steaming', thereby reducing expenditure on ship fuel. Although limited to non-perishable cargos, this could have a transformative effect on global supply chains. <http://www.wartsila.com/resources/article/slow-steam-ahead>

22. For the smaller classes of marine autonomous systems such as underwater vehicles (AUVs), gliders and autonomous surface vehicles (ASVs), principally used to support scientific research, there are different strengths and weaknesses. Principal among these are:

23. Launch and recovery (L&R) requirements – although research is underway regarding launch and recovery present mitigation relies heavily on vessel operations during the launch and recovery procedure.

24. Non Recurring Engineering - Many of the vehicles will likely have some amount of non-recurring engineering (NRE) associated with accommodating novel sensor configuration (one which the manufacturer has not already performed). This is due to the need to maintain and verify that overall vehicle trim and balance and hydrodynamics are maintained within acceptable design tolerances. This is especially true for the smaller AUVs and gliders.

25. Commercial Availability - Different sizes and configurations of AUVs, gliders and ASVs are available commercially though some have only been produced in limited numbers and the price may be seen as limiting for some operations.

26. Bio-fouling - The endurance of small USVs, especially wind and wave propelled, will be limited by the effect of bio-fouling. Dependent on climate, the marine growth suffered by USVs can significantly decrease performance significantly, slowing the vehicle and reducing the accuracy of most sensor payloads. Whilst marine chemical and electrical antifouling solutions are available, self-polishing non-stick coatings are most effective on fast moving vessels, and still susceptible to 'green fouling' (algae) still affects the performance of slower moving wave and wind propelled USVs. Whilst most modern anti-fouling coatings are effective at reducing the adhesion of marine growth, and ultrasonic antifouling works well as a deterrent for marine growth, there is no definitive anti-fouling solution available as yet.

27. Payload and Power - The small, offshore USVs are currently limited by their payload volume, weight and power generation capability. Due to their innovative propulsion techniques, the power they generate (via solar or fuel cell) is available for sensor payloads and their command and control systems. However relatively few small USV systems can provide consistent power for high draw sensor payloads and high bandwidth satellite communications. The power generation of some surface vehicles is for example is limited to solar generation, which provides sufficient generation in high solar areas, but can struggle when overcast and in low light conditions (e.g. overnight).

28. Speed- Without an electric propulsion system, wave propelled USVs are limited to 1-3 knots average water speed, reducing their ability to track fast moving assets on the surface or underwater. The slow speed limits their ability to be deployed alongside a moving taskforce, presently limiting them to independent slow or static offshore tasks. As power availability increases, electric propulsion can be used to provide hybrid, wave – electric propulsion, with speeds of up to 8 knots. One example of this is the C-Enduro.

<http://asvglobal.com/product/c-enduro/>. Wind propelled vessels in certain circumstances are capable of much higher speeds, but are less covert and provide a lower power generation capability.

29. Security – This is a known issue on two counts: vehicle security and communications security. Although the visual profile of small USVs is low, due to the likely operational areas and location on the water's surface, USVs may be prone to offensive attack from manned vessels, including military and security forces as well as inquisitive local fishing fleets.

Without fitting countermeasures or deterrents on board, there is little an operator can do to avoid interception by an assailant. Whilst the cost of the asset may be low, the data stored on board and sensor payload can be valuable, classified or commercially sensitive. The US Customs and Border Protection department have been deploying UAV systems to monitor illegal traffic across the Mexico / US border. Due to cost restrictions, the border patrol vessels have been fitted without military P/Y code receivers, which have high immunity from spoofing. This has led to drug cartels ‘spoofing’ the GPS receivers in the UAVs, sending false GPS data, which then causes the UAV to leave its normal patrol area allowing vehicles across the border unnoticed.

### **Reference**

Dan Alldis (2016) *Utilising unarmed unmanned surface vehicles in the ‘Triple A Navy’*. International Naval Engineering Conference. IMarEST, London. Copy available on request.

### **Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

30. With regards to commercial operations; regulation is said to be among the largest challenges for autonomous shipping operations to materialize. In the maritime world, the global adoption of IMO regulations means there is a clear vehicle to engage with the international community and drive forward requirements to enable adoption of autonomy in the maritime sector. The UK is at the forefront of this effort through the work of the Maritime Autonomous Systems Regulatory Working Group (MASRWG), supported and driven by both the private sector and government agencies, in particular the Maritime & Coastguard Agency. The UK, together with the IMarEST and the International Association of Institutes of Navigation (IAIN) submitted a paper on this topic to the International Maritime Organization’s Maritime Safety Committee entitled MSC 95/INF.20 - The IMO regulatory framework and its application to Marine Autonomous Systems. Details on the MASRWG can be found at <http://www.ukmarinealliance.co.uk/content/masrwg-faqs> and the paper is available on request.

31. Whilst technological solutions are being developed and deployed at greater rates and higher numbers, there is a lack of clarity in the requirements for, and means of complying with, some of the primary pieces of international maritime legislation. It is deemed necessary to seek clarification in these areas to allow maritime autonomous systems designers, builders and operators to demonstrate compliance with the regulations.

32. It will be necessary as a starting point to identify equivalence of maritime autonomous systems to manned vessels in terms of, inter alia, classification, registration, insurance and operation; and to identify issues and requirements concerning skills, training and accreditation in order to provide a basis for maritime autonomous systems operator competence.

33. The primary requirement of any maritime system is to be able to operate safely. In conventional systems, this is usually guaranteed by the material state of the equipment and the competence of the people using it. In practical terms, the platform material state is

certified by compliance with design standards, such as Class Society Rules & Guidelines, Defence Engineering Standards (DefStans) or compliance with statutory codes, both in construction and maintaining compliance through-life. There is also the requirement for an individual who is responsible for defining operating procedures for the intended use and for ensuring that personnel using the system are competent (via training courses/qualifications) in the operation and maintenance of the system.

34. With maritime autonomous systems, by definition, the human component of the system is being replaced to varying degrees by equipment. Essentially, while the physical performance of the system may be comparable with a manned equipment and can be subject to much the same body of standards and regulation, maritime autonomous systems replace the human element (certified primarily through training and experience) with a combination of software and equipment which must replicate that functionality. The certification (or clearance) requirement becomes, therefore, that the autonomous system needs to predictably and safely respond to stimuli with at least the equivalent performance to that of a human operator. As the level of autonomy increases, the range of scenarios, stimuli and required responses multiplies, to the point where the equipment itself cannot possibly be tested (for acceptance) in a physical environment in an acceptable timeframe. This means that the “intelligent” functions of the system must be tested in complex simulated / synthetic environments in order to achieve timely acceptance, whereas the physical components of the autonomous system can undergo more traditional acceptance testing.

35. There is currently no accepted regulatory regime for maritime autonomous systems. The principal deficiency being the current inability to demonstrate compliance with the International Regulations for Prevention of Collision at Sea (IRPCS) - herewith referred to as the COLREGs - which are written around manned watch-keeping by appropriately certified personnel. For example the COLREGs require that all vessels must “at all times maintain a proper lookout by sight and hearing” and by other means. Questions include: How does an unmanned vehicle comply? How many cameras constitute a lookout? Can the requirements be met with technology?

36. The COLREGs also spell out how vessels must act when approaching, passing, overtaking or crossing the path of another vessel. And there are rules for what ships must do in the presence of vessels that have limited manoeuvrability, and vessels that are towing or fishing or under sail. All of that and more will have to be programmed into the navigation systems and linked with the sensors of autonomous vehicles.

37. When it comes to COLREGs, there is less uncertainty about remotely operated vehicles. They’re considered to be manned and must comply with current regulations, even though an operator is not on board. Refining how the COLREGs and their application to autonomous vessels could take upwards of 3 years. Proposed changes must be transmitted to the International Maritime Organization’s Maritime Safety Committee, then translated into multiple languages for the 170 member nations to study before they can be agreed to. This presents a risk that the technology will be ready far before regulation catches up.

38. In the meantime, a number of codes of practice and research activities aiming at devising a regulatory approach have been developed or are underway. These include:

- Society of Underwater Technology - The Operation of Autonomous Underwater Vehicles Series, Second Edition (<http://www.sut.org/books-and-conference-proceedings/the-operation-of-autonomous-underwater-vehicles-series-second-edition/>)
- IMCA Code of Practice for the Safe and Efficient Operation of Remotely Operated Vehicles (<http://www.imca-int.com/remote-systems-and-rov-division/code-of-practice-for-the-safe-and-efficient-operation-of-remotely-operated-vehicles.aspx>)
- Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) (<http://www.unmanned-ship.org/munin/>)
- Safety & Reliability of Unmanned Systems (SARUMS) (<http://www.eda.europa.eu/docs/documents/sarums-flyer-2012>)
- Draft Convention on the Legal Status of Ocean Data Acquisition Systems, Aids & Devices. Intergovernmental Oceanographic Convention (of UNESCO) 1993. (<http://unesdoc.unesco.org/images/0009/000979/097992EB.pdf>)
- Industry Code of Conduct for Maritime Autonomous Systems Launched by Marine Industries Alliance (<http://www.ukmarinealliance.co.uk/>)

39. Some of these are based on existing codes of practice for Remotely Operated Vehicles (ROV) and deal with appropriate build standards and operating procedures, rather than explicit acceptance of complex behavioural software. Nevertheless they do form the basis of a body of standards and regulation that would go a long way towards allowing widespread certification and acceptance of highly autonomous systems, particularly for the elements of vehicle (as opposed to control system) design and build.

40. For acceptance of the control system software it will probably be necessary to build on the practices established for other industries with similarly demanding reliability requirements, such as nuclear and aviation. However, even these have significant differences in the operating environment, in that in general, the operating environment is more constrained or easier to monitor with a human in the loop, rather than the uncontrolled environment to be found at sea.

41. With regards to insurance, in shipping, private maritime law and insurance determines who is liable for damage caused by vessels. If maritime autonomous systems (vessels) are introduced, the status quo is likely to change. In autonomous vessels, accidents will be increasingly caused by technical failures as the operator errors are eliminated. This disrupts the prior liability rule landscape, in particular when product liability is considered. Studies are being undertaken that focus on the eventual liability vessel manufacturers may have for defective autonomous vessels. Also the key insurance issues on this matter will be taken into account. It is likely that (among others), the Limitation of Liability Marine Claims 1978 (LLMC78) agreements will need amending to cater for autonomous vehicles. Reference: <https://www.utu.fi/en/units/law/research/research-projects/Pages/aawa.aspx>

42. Whatever the acceptance regime, care will need to be taken to ensure that it is proportionate. To realise the potential benefits of autonomy, it must be affordable. That

makes the development of an appropriate body of regulation against which a practical regime can be developed, a necessity.

43. In addition to the COLREGs maritime autonomous systems will come up against the United Nations Convention on the Law of the Sea (UNCLOS), which spells out the rights and responsibilities of nations that use the oceans. Initial work in this areas has been undertaken with regards to Marine Scientific Research and highlights some common principles.

[http://www.un.org/depts/los/doalos\\_publications/publicationstexts/msr\\_guide%202010\\_final.pdf](http://www.un.org/depts/los/doalos_publications/publicationstexts/msr_guide%202010_final.pdf)

## References

D Venn, A Higgins, M Paxton and T Rabbets (2014) '*How will the UK test, evaluate and certify highly autonomous maritime capabilities?*' International Naval Engineering Conference. IMarEST, London. Copy available on request.

Glen H. Sturtevant, CDR Cara G. LaPointe and Jeffrey M. Voth (2016) *Innovative integration: unmanned systems coming of age*. International Naval Engineering Conference. IMarEST, London. Copy available on request.

44. Earlier this year Classification society Lloyds Register issued new guidance concerning autonomy levels. The six ALs are intended to provide clarity to designers, shipbuilders, equipment manufacturers, ship owners and operators, enabling accurate specification of the desired level of autonomy in design and operations and paves the way to a clearer understanding of the investment opportunity/risk equation. <http://www.lr.org/en/news-and-insight/news/LR-defines-autonomy-levels-for-ship-design-and-operation.aspx>

45. There some issues which are very much still under debate and which warrant further investigation. A number of working groups are looking at these and they may include issues are as salvage and piracy. Some initial offered opinions include:

46. Salvage – which will need to be considered where a third party may attempt to claim salvage of an unmanned ship by arguing that it went to render assistance on the high seas (in accordance with established norms of "good seamanship"). This act could constitute piracy. This scenario should be studied and the risks established.

47. Piracy - With regards to piracy an autonomous ship in mid-ocean may be more vulnerable to piracy than a manned ship. Whilst the ship would be capable of informing shore controllers of events, the ability to respond would be reduced and the time needed to react greatly increased. A counter-argument to this is that an autonomous ship is a less attractive target for pirates, due to a lack of crew to take hostage and ransom. The insurer's opinion needs to be formed to offer advice on this balance of risk and the scenario needs to be further studied and the risks established.

48. Rendering Assistance - The 1974 International Convention for the Safety of Life at Sea (SOLAS Convention) obliges the "master of a ship at sea which is in a position to be able to provide assistance, on receiving information from any source that persons are in distress at sea, is bound to proceed with all speed to their assistance, if possible informing them or the search and rescue service that the ship is doing so..." Sensors and cameras could be provided

to search for and locate a vessel or marooned crew of a ‘manned’ vessel but the rescue capability will not be in place and this may need to be considered.

49. More so, general elements of risk need to be considered. The National Oceanography Centre, via the MARS facility, have developed a Risk Management Process for AUVs that is based on targeted reliability. An accepted risk is defined by the AUV owner. This acceptable risk converts into a reliability target that must be met by the AUV operators. We have developed extensions to existing statistical survival methods that allow us to assess the risk of loss for an AUV undertaking a mission in a defined environment, under sea ice, for example. The MARS website lists a number of references that cover this in detail  
<http://noc.ac.uk/research-at-sea/nmfss/mars/risk-reliability>

50. There is potentially also an issue with skills and an emerging skills gap. It is clear that different skills will be necessary depending on the level of autonomy involved; operating at distance from land-based control centres will likely require personnel to have a strong grounding in communications networks and cyber security, for example. For high levels of autonomy, operators need to be much more familiar with mission planning, and as these ships grow in size obviously these skills will need to start to move towards the operation of vessels in international waters. The Maritime Coastguard Agency (MCA) as well as the Merchant Navy Training Board (who look after the UK’s interest in occupational standards for seafarers) and organisations such as the IMarEST will seek to identify which skills from the existing frameworks for seafarers are required and which additional skills should be developed.

### **What is the scale of the market opportunity for autonomous vehicles?**

51. The UK is well on its way to becoming a world leader in marine autonomous systems supported by research funding from the Government. A market assessment has been undertaken by the Marine Industries Leadership Council (MILC), and the total available market is estimated at £10-20 million for ocean science, mine countermeasures and survey. However the global market for autonomy in traditional shipping is estimated at £136 billion with the UK Serviceable Available Market estimated at £13.6 billion over 15 years. Source:  
[http://www.ukmarinealliance.co.uk/sites/default/files/UKMIA%20Roadmap%202015\\_0.pdf](http://www.ukmarinealliance.co.uk/sites/default/files/UKMIA%20Roadmap%202015_0.pdf)

### **Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

52. Again, these are topics that require further investigation. For example, to implement a fully autonomous voyage, unmanned berthing and un-berthing technology is likely to require intense development. Potentially such technology could be designed, but the cost of mitigating all the risks of weather, sea state, close proximity of other ships and vessels, and the physical loading of placing a floating, surging ship alongside would be high. In the longer term such autonomy might be possible with purpose-built and located harbours.

53. A further key issue in autonomy will be cyber security and changes to the digital infrastructure will likely be required to address the potential associated threat which may include attacks against ship navigation systems by adjusting the course of a ship or making them invisible to other maritime vessels plus accessing valuable data and information.

*26 October 2016*

## **The Institution of Engineering and Technology (IET) – Written evidence (AUV0069)**

The Institution of Engineering and Technology is Europe's largest professional engineering and technology organisation. The members represent a wide range of expertise, from technical experts to business leaders, encompassing a wealth of professional experience and knowledge.

The IET is continuing to engage with key stakeholders on the technology and policy implications of adopting autonomous vehicles. The technology is progressing rapidly and our experts in industry and academia would be delighted to have an opportunity to discuss with you further the impact this will have on the transport system.

The below response is a short summary of the key issues on autonomy. Many of the points noted have been taken from the IET report on “Cross-modal Learning in Autonomy” that will be published in December 2016.

### **What are the potential applications for autonomous vehicles?**

- 1) The idea of highly automated or autonomous vehicles is not new, however, the landscape has been transformed over recent years with the application of advanced sensors, communication technologies and databases. Autonomous systems are already pervasive, particularly in aerospace with autopilot on planes and military drones.
- 2) The opportunities across the transport modes; road, railway, aerospace and maritime are immense and wide ranging but cross-cutting technologies are not often developed or even considered outside of each specific industry area leading to duplication of R&D, resourcing and implementation. One key opportunity here is to pool resources that can be transferable and provide technologies and innovations across all transport sectors for the benefit of all, including the end user.
- 3) The benefits of a move towards more autonomous vehicles are broadly similar in all sectors - ultimately promising significant safety enhancements, more efficient transport, greater flexibility of operation and, potentially, reductions in environmental footprint. However it is not yet clear how these systems will be introduced to deliver these expected benefits.
- 4) Taking autonomous cars as an example, congested cities might better optimise their road networks by eliminating the role of the driver, so they could control speeds and lane discipline and achieve steady flow. Recent demonstrations have shown that autonomous vehicles are technically feasible and we are starting to see them operate successfully on ‘live’ roads in ‘demonstration mode’.

- 5) As well as the major societal benefits, the introduction of autonomy is a multi-sector and multi-discipline opportunity for the UK manufacturing, infrastructure and services industry. The UK can build on the leverage of recent tests in autonomy to further enhance its position in research and development of autonomy where we are one of the leading nations at the moment.
- **What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**
- 6) Benefits – Road vehicles
  - Driverless cars can carry out tasks and drives that would be too long, dangerous or expensive with a human driver;
  - Congested cities might better optimise their road networks by eliminating the role of the driver; they could control speeds and lane discipline and achieve steady flow;
  - DVLA figures record that nearly 4 million people holding a current driving licence are aged 70 or over. Autonomous Vehicles can bring holistic benefits to the health and well-being of our ageing population in remaining independent for longer where various automated function or full autonomous vehicles could deliver real benefits. This also applies to impaired or disabled people for whom autonomous cars can bring greater freedom of mobility;
  - An autonomous vehicle can reduce fuel bills quite significantly. The human factor is removed from making the many decisions we are used to, making journeys smoother and increasing capacity. This also leads to better fuel efficiency and a reduction in emissions due to ‘steady-state’ driving and interaction with the traffic management infrastructure to minimise stop-start driving;
  - Reducing or removing the human factor can also improve safety.
- 7) Unmanned aircrafts are able to carry out tasks/ flights that would be too long, dangerous or expensive with a human pilot. These uses could include,
  - Infrastructure monitoring
  - Police and law enforcement
  - Environmental and agricultural monitoring
  - Disaster support
  - Military
- 8) There needs to be recognition that the technological and behavioural changes likely to result from a shift towards autonomous vehicles will initiate new and differing demands being placed on the public infrastructure. Consideration needs to be given now to how responses to these demands will be funded and how the current models of funding the provision of transport infrastructure need to change.
- 9) Autonomous vehicles will raise issues of safety, security (including cyber security) and resilience of networks in the future. Before large scale deployment of such technologies, there are many immediate issues in safety to be addressed.

- 10) There is a concern that trying to move straight to driverless trials may not foster public understanding and support. A roadmap from what we have now in terms of cooperative vehicles, through all the stages of automation to fully driverless vehicles needs to be established.
- 11) The development and use of automated and autonomous vehicles and issues related to these, including safety, insurance and land planning, are of great importance to the vehicle manufacturing industry as well as to infrastructure provision. It is recommended that this both technical and socio-economic trend is reviewed regularly by the government.
- **Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**
- 12) Regulators of different modes of autonomy need to work together to develop a common approach to autonomous regulation and software standards across all transport sectors. The UK should not do this in isolation from European and International partners.
- 13) The legal aspects of autonomy in road vehicles still requires further debate; the technology is enabling the car to make decisions and there needs to be a framework that clarifies the ownership of this decision making.
- 14) In addition to insurance and regulatory issues, there needs to be further work on the ethical decisions an autonomous system is programmed to make.
- 15) Currently the road vehicles that are being tested still require the driver to be fully engaged; “driver apathy” therefore needs to still be managed until driverless car technology reaches full autonomy.
- **What is the scale of the market opportunity for autonomous vehicles?**
- 16) Among experts there is generally high level of confidence that autonomous vehicles will become more pervasive. However, currently most road vehicles that are being tested have not reached a full level of autonomy. ‘Assisted’ rather than ‘autonomous driving’ might help the public get used to driverless vehicles on the roads.
- 17) The Government’s and the public’s appetite for risk will shape the regulatory framework required to permit the widespread introduction of autonomous vehicles, which in turn will impact the speed at which the technology becomes economically and commercially viable for individuals and organisations. User acceptance beyond the niche enthusiasts cannot be assumed (similar to electric vehicles – there are lessons that can be learned from their adoption).
- 18) Government should focus on explaining the benefits at the individual level and address the need for long term planning to introduce solutions onto the existing transport infrastructure, clearly safety will be uppermost in people’s minds and

greater efforts to communicate the safety and mobility benefits would be a key focus.

- **Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

19) Current road vehicles fitted with automated systems make their decisions based on the speed and acceleration of other vehicles and through the use of sensors. However there are various methods of spatial and obstacle recognition being adopted by different manufacturers.

20) Connectivity will play a major role in the development of autonomous vehicles. In order to make better decisions, target vehicle behaviour will be broadcast using “Car to Car” and “Car to Infrastructure” communications and used to truly cooperate.

21) In level 2 autonomy, at least 2 functions within the car are automated, and the driver is disengaged from physically operating the vehicle however must still always be ready to take control of the vehicle. In order to progress beyond level automation 2 the industry requires further developments in 3 key areas:

- a. The ability to get much more information into the car and process it, so that it can be acted on appropriately. i.e. multi-sensor information being fused into something meaningful, so that systems can be aware of the situation and project what other vehicles will be doing accurately.
- b. The ability to re-engage the driver appropriately from automated level 3. i.e. The Human Factors in driver handover. This will include taking the appropriate course of action if a driver cannot be re-engaged.
- c. The ability to navigate and resolve vehicle position accurately. i.e. The creation (or downloading of) high fidelity maps that are updated when changes (like road-works) are detected, so that they are useful to other vehicles AND matching what is sensed to that map to resolve position.

22) Much of the above cannot be investigated and resolved without the implementation of trials and demonstrations, where all the ‘what ifs?’ can be identified and addressed.

26 October 2016

## **International Underwriting Association (IUA) – Written evidence (AUV0057)**

*The International Underwriting Association of London (IUA) is the focal representative and market organisation for non-Lloyd's international and wholesale insurance and reinsurance companies operating in the London Market. The IUA exists to promote and enhance the business environment for international insurance and reinsurance companies operating in or through London.*

### **Response to questions posed**

Rather than answer each question, we have focused on the questions that directly impact the insurance industry and fall within our area of work.

#### **Question 3: How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

- 3.1 There are likely to be significant implications to the insurance sector following the deployment of autonomous vehicles (AVs), particularly in respect of the first and third party liability regime. However, the motor, cyber liability and product liability markets hold substantial capacity and would therefore be in a strong position to meet any increased demand for autonomous vehicle insurance cover.
- 3.2 One concern for the insurance industry is the potential for aggregated losses to occur. This relates to the platooning aspect of AVs in which a failure in the Autonomous Vehicle Technology (AVT) or the use of the AVT could result in multiple incidents occurring.
- 3.3 Whilst the public opinion is that in the long run premiums will be lower for consumers with safer AVs, as may well be the case, it is worth noting that the cost of the vehicle and the technology used is substantial and therefore the average costs of claims for AVs will probably be higher than that of vehicles currently in use.

#### **Question 4: How much is known about public attitudes to autonomous vehicles?**

- 4.1 The key aspect for consideration, in respect of public attitudes, is the need for autonomous vehicles to be classified and therefore for consumers to understand the capabilities and limitations of the technology they are using. The possibility for misunderstanding and perhaps overestimating the abilities of the AV, in a developmental world whereby control is still deemed to be in the hands of the driver, could result in a number of incidents occurring. This is specifically prevalent in ensuring the difference between Advanced Driver Assistance Systems (ADAS) and AVs is clearly understood. If manufacturers and other industry representatives such as insurance companies engage with consumers in order to educate them on the technology in use these risks can be mitigated. However, clearly, government needs to play a leading role in this regard.

- 4.2 It is anticipated that the majority of consumers would today, with their current knowledge, not purchase a driverless car. But, it should be considered that autonomous features exist in a wide number of cars at present and that consumers have become comfortable with technology, such as Anti-lock BS, of which they feel they have an understanding of.
- 4.3 From an insurance perspective there may be a need for insurers to monitor AVs in a 'black box' style manner in order to determine liability should an incident occur. AV drivers should be given the option to provide telemetry data to insurers in order for them to rate the risk of the individual driving more accurately. It would also allow faults in technology to be identified at an earlier stage and ensure that fraudulent claims whereby consumers could blame AVT are countered. In a developing data environment where personal information is held on individuals by many different types of firm, it is hoped that consumers will be comfortable with this fact in view of the potential benefits of safer AVs, such as lower premiums. Furthermore, this concept is not completely new to consumers given the prevalence of telematics within current insurance policies, particularly those for young drivers.

**Question 5: What is the scale of the market opportunity for autonomous vehicles?**

- 5.1 The insurance market is highly competitive with significant levels of capacity. These levels of capacity will ensure that market opportunities exist in relation to AVs in terms of the ability for insurance products to be provided.
- 5.2 However, there are several issues that need to be considered that might impact the insurance market opportunity following the introduction of AVs. For example, AVs are far more complex and will require greater expense to maintain, monitor, update and repair. Further, data is obviously very limited in respect of large loss injuries involving AVs. Arguments about severity and frequency will not be resolved for some time. As with any emerging risk, this impacts how products are priced.
- 5.3 It is likely that catastrophe exposure pricing will rise in line with claims inflation until sufficient data is gathered to suggest there is an actual change in exposure. Products liability costs would increase if a higher compulsory limit of liability is applied (than is currently normally provided), claims handling could become costlier and protracted, particularly if the traditional policy triggers and defences, such as negligence and the 'state of the art defence' are not in place. Given that current profit margins are relatively low it would seem likely that, if the initial costs of providing AV cover were significantly higher, in the short term this may be passed on to insurance buyers.

**Question 7: Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

- 7.1 Whilst it is clearly vital that a robust regulatory framework is developed, our members have expressed concerns in respect of the rolling programme of regulatory review in that the adoption of new AV systems may be hindered as it could be

considered limiting. It should also be noted, in reference to the programme, that the AV technologies extend beyond motorway assist, remote control parking and platooning.

- 7.2 Clearly the pace of technological advancement requires a flexible and responsive regulatory review in order to ensure that the UK is a world leader in regards to the development and use of driverless cars from both a public and corporate perspective. Therefore, in parallel with the regulatory framework, there needs to be a similarly robust research and development programme in place to ensure that the UK does not fall behind other global players in bringing AVs to the roads. We think more can be done from this perspective.

**Question 8: How effective are Innovate UK and the CCAV in this area?**

- 8.1 We have responded to the CCAV's consultation entitled Pathway to Driverless Cars: Proposals to support advanced driver assistance systems and automated vehicle technologies. The consultation addresses many of the key questions being considered by the insurance market. We are looking forward to seeing the results of the consultation and the continued work of CCAV in this area.

**Question 9: Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

- 9.1 It is important to consider that SMEs are the most vulnerable types of business to large scale change and to give sufficient consideration to this fact when assessing future statutory / regulatory / policy proposals.

**Question 11: How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

- 11.1 The key milestone for the insurance industry will be deemed to be the finalisation of a clear insurance liability regime in respect of AVs. A regime of this kind that clearly depicts how liability is apportioned and determines how claimants are indemnified is vital. We would urge government to continue its work with the industry to progress this.

**Question 12: Does the Government have an effective approach on data and cybersecurity in this sector?**

- 12.1 At this early stage it is difficult to be certain as to the government's approach on cyber security in relation to driverless cars. From an insurance perspective the level of security of manufacturers' systems would be taken into consideration when apportioning liability to a loss resulting from a hacking incident. Furthermore, it is possible that such incidents could be covered by a cyber-insurance product attaching to the motor policy - this would obviously be factored into pricing. However, the need to clarify where liability resides with regards to hacked vehicles remains, this is

the same issue that is being discussed within the aviation insurance market in respect of UAVs (drones).

**Question 13: Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

- 13.1 Our members have suggested that the Government's proposal to amend road vehicle compulsory insurance primary legislation (in Part 6 of the Road Traffic Act 1988) to include product liability for automated vehicles, is the simplest way of accommodating AVs within the current insurance framework. This would incur the least amount of changes to current practices whilst ensuring that victims of collisions are indemnified without unnecessary delays.
- 13.2 This is not, however, the universal opinion of our members. Some have expressed the contrary opinion that this is not a suitable amendment, stating that the right of motor insurers to subrogate against product manufacturers should remain. It was also suggested that consideration should be given to whether or not there should be minimum products liability limits that should be purchased by manufacturers. If this amendment was to be made, the limits of indemnity for products liability should ideally mirror those limits under the motor policy.
- 13.3 Overall, our members have proposed that the following situations should be avoided:
  - an injured party would receive more or less compensation in an accident depending on whether the claim was classed as a product or motor risk.
  - any areas of uncertainty whereby forum/class shopping occurs for higher possible rewards.
  - where the motor insurer or the MIB, whilst not liable, picks up the exposure value of an award over and above the limit of liability provided under the product liability policy.
- 13.4 Members recommend further considerations within the proposal as follows:
  - many current motor insurers, whilst providing some public liability cover (taxi, households), may not be geared up for writing, understanding or managing products exposure, especially complex risks such as Vehicle Crucial Parts and Cyber.
  - as things stand, the proposal would require substantial changes to regulatory licencing requirements and might have an effect on solvency calculations. If the size of motor claims is duplicated in the product liability arena and an increased use of Periodic Payment Orders (PPOs) occurs, then solvency issues may then again ensue.
  - these exposures could be picked up as an extension to existing product liability policies already placed with the market. All Motor Critical Parts, for AV or otherwise should have compulsory insurance requirements with minimum limits of liability.
  - the government should consider the possibility of a firm, specifically an AVT manufacturer, entering voluntary liquidation in the event of a major claim and therefore how those aggregated claims may be dealt with and any impact on the fund for uninsured losses (MiB).

13.5 In reference to consideration of other insurance options in respect of driverless cars:

In general, we support the proposal that there should be required products liability cover for AVs. Whilst this might be achieved by extending the current motor insurance requirements there are other potential options. If provided as part of the motor cover there needs to be a clear right of subrogation, possibly enshrined in statute, allowing motor insurers to recover product liability losses from the negligent vehicle manufacturers. It is also possible that a process could be put in place whereby the motor insurer would deal with the product liability claim in the first instance to ensure that the injured parties are compensated immediately before liaising with the vehicle manufacturer on their potential liability (as being responsible for the malfunction that gave rise to the claim). Subrogation rights would also need to be established in this scenario.

**Question 18: What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

18.1 We would suggest that the key action for the government from an insurance perspective is to ensure that the current regulatory certainty applicable to UK motorists is maintained in light of 'Brexit'. Specifically, the Motor Insurance Directive (MID) should be replicated or maintained with a clear and comparable safety framework that includes parameters for AVs.

*26 October 2016*

## ITS International Magazine – Written evidence (AUV0009)

*Author: Colin Sowman, Editor, ITS International.*

### **Key issues**

*K1/ ITS International* is a UK-based globally-distributed magazine covering issues concerning all facets of intelligent transport, including connected and autonomous vehicles and ADAS. Two of the most vital points we wish to make fall under the '**Crucial issues not captured under the questions**'. We are deeply concerned about the excessive security risk autonomous vehicles pose and negative impact their introduction would have on society.

*K2/ Readily available autonomous vehicles, especially cars, would greatly increase the risk of a terrorist attack far beyond that of a suicide bomber. Instead of sacrificing themselves in a one-off suicide mission, an extremist would be able to use unoccupied autonomous vehicles to deliver bombs to several targets simultaneously. The terrorist would be many miles from the target(s), giving them time to make good their escape before any device explodes.*

*K3/ As the use of autonomous vehicle removes the need for the terrorists to sacrifice their own life, many more extremists would become active in dispatching devices to intended targets. Furthermore, through the use of autonomous vehicles a group of individuals could easily coordinate simultaneous attacks on one or more targets and such plots would be very difficult for authorities to intercept or stop.*

*K4/ We have highlighted this potential to senior figures on both sides of the Atlantic (including UK Catapult) but so far nobody has provided a satisfactory method of neutralising this threat.*

*K5/ We have also seen significant global marketing impetus behind the introduction of autonomous vehicles which has drowned-out any debate about the wider social implications and desirability of this technology. As detailed below, the widespread introduction of autonomous vehicles will increase congestion and CO<sub>2</sub> emissions while benefitting only those inside the vehicle, which would be socially divisive and unacceptable.*

Answers to questions posed:

### **Response to question 1 – Applications**

*1.1/ A report by Allianz indicates there are 600,000 unmanned aircraft, or drones, in commercial operation and highlights safety and security issues these raise (see [http://www.agcs.allianz.com/assets/PDFs/Reports/AGCS\\_Rise\\_of\\_the\\_drones\\_report.pdf](http://www.agcs.allianz.com/assets/PDFs/Reports/AGCS_Rise_of_the_drones_report.pdf))*

*1.2/ From this point onwards, we will limit this submission to on-road applications which include buses and shuttles, trucks and vans, cars and taxis.*

### **Response to question 2 – Benefits & disadvantages**

**Benefits:**

2.1/ The autonomous operation of some buses and shuttles running on pre-set routes, could lower fares and running costs and thereby allow an increase in service frequency and overall capacity. Platooning, (rather than autonomous) trucks could reduce transport costs in certain circumstances but could hamper other vehicles joining and leaving the motorways and consequently would be difficult to achieve in many parts of the UK.

2.2/ Safety gains must be excluded from this section as they are not unique to autonomous vehicles and are already being realised through the use of ADAS. Furthermore, the risk taking and inattentive drivers are the ones least likely to utilise the autonomous function if there is a manual alternative.

2.3/ While autonomous vehicles will provide a reduction in emissions compared with most human drivers that reduction is dwarfed by the gains available from advances in driveline technology such as electric vehicles. This has a greater effect on reducing emissions regardless of whether the vehicle is autonomous or not.

2.4/ Also excluded is any increase in car sharing and ride-sharing as these services are already providing very high levels of convenience with traditional vehicles through innovations such as free-floating car sharing. See:

<http://www.itsinternational.com/sections/general/news/zipcar-launches-free-floating-car-sharing-service-in-belgium/>. So in practice it is unlikely that the introduction of autonomous cars will lead to a major increase in car sharing beyond that already being realised.

2.5/ Despite the availability of ride-sharing, 80% of journeys are still undertaken with a single occupant. Ride-sharing usually occurs between people who know or have found each other through a ride-sharing website and it is unlikely that users of autonomous cars, especially those from vulnerable groups, would allow total strangers to be picked up enroute. The Spitscoren project in Holland has shown how journey-matching websites and mobile phone apps can encourage ride-sharing by introducing individuals to each other before a journey (see [www.spitsscoren.nl/default.aspx](http://www.spitsscoren.nl/default.aspx)).

2.6/ The suggestion that autonomous vehicles' faultless lane keeping would increase capacity by enabling a traditional three lane motorway to be reconfigured with four narrow lanes is equally misleading, because at least two lanes will have to remain wide enough to accommodate trucks overtaking each other.

2.7/ As ADAS can provide the safety gains, emissions reductions are dictated by driveline technology, car- and ride-sharing are better fostered by other means, and the predicted increased in road capacity is unlikely to be realised, it is clear that the unique advantages of autonomous vehicles relate only to those people or goods on board.

**Disadvantages:**

2.8/ Contrary to idealised projections, in reality autonomous cars will increase congestion because they would be the equivalent of having a chauffeur, allowing commuting 'drivers' to work, sleep or socialise during the journey. This means commuting time could be used productively and consequently the occupant is less concerned about congestion extending

travel times or the practicalities and cost of parking. These factors will encourage more people to commute by car leading to increased urban congestion, which will inconvenience other road users. With like-for-like drivelines, CO<sub>2</sub> emissions would increase and air quality would deteriorate.

2.9/ Autonomous cars would make more journeys than traditional vehicles because some commuters would send their vehicle back home for other family members to use during the day, before summonsing it back into the city in the afternoon for their homeward trip. The additional congestion, longer travel times and emissions created by unmanned journeys would not inconvenience vehicles' owners who are still at work or at home, and when they occupy their autonomous cars their travel time is productive. The consequences of these actions would again disadvantage other road users and the local population.

2.10/ Owners of autonomous cars could also set them to circulate around local roads while they have a meeting or a meal in order that they are instantly available once the meal or meal is finished.

2.11/ Owners of autonomous vehicles would use them to deliver 'forgotten items' and on a business level they would replace fleets of motorcycle and bicycle couriers who deliver packages around large cities and take-away meals. This would adversely impact employment as well as increasing congestion and emissions.

2.12/ A recent white paper published in America by consultancy SBD and location-cloud company Here concludes that the US could suffer severe increases in congestion for up to 40 years if driverless vehicles are released for general sale. See:

[www.sbdautomotive.com/c/here/traffic\\_congestion\\_autonomous\\_vehicles/media/index.html](http://www.sbdautomotive.com/c/here/traffic_congestion_autonomous_vehicles/media/index.html)

2.13/ Uber is testing driverless taxis (<http://www.itsinternational.com/categories/location-based-systems/news/uber-tests-self-driving-cars-on-pittsburgh-streets/>), however the widespread use of such vehicles would devastate the employment prospects of the UK's 397,600 licenced taxi and minicab drivers while offering no advantages to travellers other than potentially lower fares. Beyond the loss of employment and income tax revenue, there is a distinct probability that large companies operating driverless taxis would be tax domiciled abroad.

2.14/ Having reduced or removed the risk of being run over, criminals gangs could stop autonomous vehicles by walking out in front of one, braking sharply ahead of them or placing cones across the road in order to hijack it, steal any cargo, rob the passengers or even take the occupant(s) hostage. This is a particular threat where the driver cannot retake control. The recent behaviour of people-smuggling gangs around Calais should be noted in this respect.

### **Response to question 3 – Impact of deployment**

3.1/ Currently pilot schemes of on-road autonomous vehicle are under way in various countries but none has yet concluded and when they do it is likely these will concentrate on the technical aspects of deployment rather than the impact on society.

#### **Response to question 4 – Public attitudes**

4.1/ When asked, the public have generally been sceptical about using autonomous vehicles and their enthusiasm is waning (see <http://www.itsinternational.com/categories/location-based-systems/news/consumers-showing-less-interest-in-autonomous-driving-systems/>)

4.2/ It is clear that much effort is being expended to convince the public of their desirability (see <http://www.itsinternational.com/categories/utc/news/alliance-aims-to-influence-transportation-policy/>)

#### **Response to question 5 – Market potential**

5.1/ Analysis by John Greenough of Business Insider Intelligence is predicting 10 million self-driving cars to be on the road by 2020 (see <http://uk.businessinsider.com/report-10-million-self-driving-cars-will-be-on-the-road-by-2020-2015-5-6?r=US&IR=T>). This obviously presupposes regulations are changed to allow the sale of autonomous vehicles to the public at large.

#### **Response to question 6 – Facilities**

6.1/ The demonstration facilities may be adequate but the government must insist that the research is not simply confined to the technical aspect of autonomous vehicles and that there is adequate evaluation of the wider implications of allowing autonomous vehicles on our roads.

#### **Response to question 7 – Government funded R&D**

7.1/ The funding could be distorting the true image and impact of autonomous vehicles because the availability of funding will spur the creation of projects without necessarily addressing the social desirability of autonomous vehicles. If this were done, funding could be targeted at those autonomous vehicles which provide the greatest public benefit.

#### **Response to question 8 – Innovate UK and CCAV**

8.1/ Innovate UK and CCAV are engaged in fostering the development of autonomous vehicles and may well be doing so competently but in doing so they have a vested interest in maintaining the deployment of autonomous vehicles. Therefore they are unable to provide the balanced view needed by regulatory authorities.

#### **Response to question 9 – Environment for SMEs**

We have no information or view about this issue.

#### **Response to question 10 – Infrastructure changes**

10.1/ Ensuring in-service reliability of autonomous vehicles would require a higher consistency of markings and signage than is currently available on most of the UK's 250,000 miles of roads, in addition to very high definition digital maps that are constantly updated. The upgrading and ongoing infrastructure and mapping costs may well be beyond the reach of the public funding and would take many years to accomplish.

10.2/ Any obscured sign or 'inadequate' demarcation could raise public liability issues in the event of a collision.

10.3/ For reasons set out in Paragraph 2.5, it is unlikely that the autonomous vehicle advocates' idea of converting a traditional three-lane highway or motor way to four narrow lanes to increase capacity could be achieved without major infrastructure investment.

**Response to question 11 – Deployment**

11.1/ For the reasons set out Paragraphs 1 to 18, it is imperative that deployment of autonomous vehicles is restricted – possibly to public service operations. The needs of elderly, blind or otherwise disabled people would be better handled through the expansion of technology such as 'Mobility as a Service' where a driver would be on hand to assist special needs passengers.

**Response to question 12 – Cybersecurity**

12.1/ Systems in an autonomous vehicle are safety critical so a breach of cyber security is unthinkable and an ongoing 'battle' against the hackers will be necessary but extremely expensive. While progress has been made in preventing 'mass' hacks (see <http://www.itsinternational.com/categories/detection-monitoring-machine-vision/news/karambas-carwall-thwarts-mass-hacks/>), currently there is no counter to individual hacks.

12.2/ It should be noted that the consequences of a hack on an autonomous vehicle are likely to be far worse than with ADAS. With ADAS the systems are active only for part of the time on a limited number of functions and the driver retains full control.

12.3/ Vehicle manufacturers must not be allowed to use cybersecurity as a pretence for restricting access to diagnostic and repair of ADAS or other systems and provision will be necessary for trained independent repairers and third party checks such as the MOT test.

**Response to question 13 – Insurance & Regulations**

13.1/ Any revision to the legislation should await information about the full effect of autonomous vehicles in the wider society.

**Response to question 14 – Ethical Issues**

14.1/ To restrict ethical questions to the mechanical functioning of autonomous vehicles would be an error as it would exclude consideration of the ethics of the wide impact. This includes exposing the public to an increased threat of terrorist action, the loss of driver employment (and possibly tax revenues), the divide (probably regressive) between autonomous vehicles users and the general public, whether society should tolerate empty journeys and the effect on the climate of increased CO<sub>2</sub> emissions.

**Response to question 15 – Modern Transport Bill**

15.1/ Authorities worldwide acknowledge that congestion cannot be solved with single occupancy vehicle solutions. Therefore the Modern Transport Bill must force the authorities controlling road, rail, air and water-borne transport out of their individual 'silos' to fully own, embrace and facilitate multi-modal transport including cycling, walking, car- bike- and ride-sharing and 'Mobility as a Service'.

*29 September 2016*

## **ITS United Kingdom – Written evidence (AUV0036)**

### **Introduction**

1. ITS (UK) is a not-for-profit public/private sector association financed entirely by members' subscriptions and can therefore independently provide a forum for all organisations concerned with Intelligent Transport Systems (ITS). These are combinations of sensors, communications and information technology designed to assist all modes of transport. The Society works to bring the advantages that ITS can offer in terms of economic efficiency, transport safety, and environmental benefits to the United Kingdom – and at the same time expand the ITS market. It has a diverse Membership of over 150 UK organisations comprising of Government Departments, Local Authorities, Police Forces, consultancies, manufacturing and service companies, and academic and research institutions. ITS (UK) encourages discussion on issues such as public/private co-operation, standards, legislation, information provision and new technology. ITS (UK) was a significant contributor to the Parliamentary POST Note 322 'Intelligent Transport Systems' published in Jan 2009.
2. We note that the enquiry is into autonomous vehicles but we would like to note that there is growing use of data from connected vehicles already on the roads to increase safety and manage congestion. This use should grow to encompass better planning and management of assets, reduced emissions and economic growth through better travel. This can all happen far more quickly than automated vehicles, and is a necessary step for them to work safely in a road network with other legacy vehicles, cyclists and pedestrians.

### **Responses to the questions in the Call for Evidence**

#### **1. What are the potential applications for autonomous vehicles?**

- 1.1 For private use, either owned or (more beneficially, see below) as part of transport-on-demand provision.
- 1.2 They can also offer similar benefits to "traditional" private vehicles to those who cannot use these, such as teenagers and disabled people. They can also provide a better option for city centres than "traditional" cars by not needing to park where they drop off.
- 1.3 They can offer benefits as delivery vehicles for goods, from container transport to tools and spare parts for maintenance and building work.
- 1.4 They have potential to make public transport more flexible, reliable, environmentally friendly and in the long term, cheaper. Fully autonomous services are already operating in the UK, such as the Docklands Light Railway in east London, and the ULTRA pod service running between a car park and Terminal 5 at Heathrow Airport.
- 1.5 They are also already in use in ports, warehouses, mining operations and military applications, and their use there is likely to increase.

## **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

2.1 Most of the potential benefits rely on the vehicles being part of a connected system of vehicles and infrastructure, commonly identified by the term “C-ITS” i.e. cooperative intelligent transport systems. By linking vehicles with each other and with the infrastructure, safety and environmental benefits will be much better than those realised if vehicles operate independently.

2.2 AVs may be a beneficial addition / eventual substitute for the fleet of private cars, if their likely capacity of being safer and more environmentally friendly is proven. They may also potentially allow users to get non-driving tasks done while in the vehicle, although this means a level of smooth vehicle travel that may not be attractive to some users as it may actually result in slower travel.

2.3 If their adoption coincides with a switch from owning to on-demand provision of vehicles as the norm for private citizens, they also have the potential to free up valuable land in towns and cities which is currently used to park privately owned vehicles

2.4 There is also a potential benefit to accessibility. (It is no longer universally accepted that “mobility” is a worthwhile goal in itself.) AVs can improve access for disabled, older people and those too young to drive, to the locations they need to visit.

2.5 There is a potential benefit if AVs are implemented according to C-ITS principles in Government being better able to deliver transport policy objectives, by having more influence over journeys. Congestion could be reduced, bridge strikes eliminated, goods deliveries arriving at the optimum time etc. This is of course only the case if the public sector retains control of the infrastructure and data used by AVs in their decision making. This is by no means a given, bearing in mind the open data strategies and the support for private sector service providers currently adopted by Government, which may have unintended consequences.

2.6 If the adoption of AVs coincides with users switching to using them when needed rather than owning them, and they are adopted in the form of connected vehicles, then it will be possible to build demand-related road pricing into their pricing model and thus provide an important tool for highways authorities to manage congestion.

2.7 The main potential disbenefits are probably congestion and the loss of low skilled jobs. Congestion may seem counter-intuitive but while highways authorities may gain more control over vehicle movement, and enable pricing models which encourage travel outside peak time, both of which will help them reduce congestion, widespread adoption of AVs by e.g. elderly and disabled travellers who currently either do not travel or travel by bus and rail, has the potential to increase the overall number of vehicles on the network. Vehicle miles could increase as currently unsustainable driving commutes become part of the working day, and rural communities become dormitories for urban workers currently not well connected by rail or road.

2.8 AVs will also sharply reduce the number of driving jobs available, whether traditional taxis, buses or freight transport – especially if “platoons” of autonomously guided trucks become a reality. The AV industry will also create jobs but these will be much more highly skilled, requiring more training and even academic education. The result will be higher unemployment at the lower end of the jobs market as not many van drivers will retrain as electronics engineers. Many driving jobs are currently only marginally financially sustainable, by being minimum-wage with zero hours contracts. In the local delivery sector, drivers sometimes work for less than the legal wage by being allocated an unachievable number of drops to make during a set time

2.9 The unavoidable shorter term scenario of AVs sharing road space with traditional vehicles and cyclists and pedestrians will present both benefits and disadvantages. AVs will interact with vulnerable road users in a safer way, since the high risk human factor effects of inattention, moods and tiredness are removed from the picture. However, in order to function acceptably safely in a mixed environment, AVs will initially need to proceed slowly and may regularly “fail safe”, including stopping for periods of time. We know that 10% of any fleet has a noticeable effect on overall fleet behaviour, e.g. from trials of Intelligent Speed Adaptation (ISA), where vehicle speed is automatically controlled to avoid exceeding the speed limit. So once 10% of vehicles are AVs, they will influence traffic flow. In some cases this may slow traffic (particularly where overspeeding is common) and in others traffic might be smoothed.

2.10 The interaction between human drivers and AVs is not understood well yet, and needs to be a key focus for the early deployment. There are certainly issues about how much time drivers would need to take back control of their vehicle if the autonomous system could not cope and wanted to hand over to them, because their minds would be on other things. There is evidence from studies of airline pilots, when the autopilot malfunctions or cannot cope, that many seconds are needed for the human pilot to take back control and become aware of the (potentially dangerous) situation.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

3.1 More research is needed. In these early stages funding has been more readily available for proof-of-concept trials such as the currently active Innovate UK projects, and for studies into public attitudes. More work is urgently needed on what the introduction of AVs might really mean in terms of traffic management, parking provision, public transport services, and transport to and from hubs such as hospitals and air ports. Analysis on how AVs may affect the level of control public authorities have over traffic behaviour on their networks is particularly urgently needed.

3.2 The Department for Transport’s intention is to commission trials of truck platooning, which will investigate potential benefits such as fuel savings and potential disbenefits to safety, among other aspects.

3.3 These comments are true in terms of international knowledge and research, not just relevant to the UK.

#### **4. How much is known about public attitudes to autonomous vehicles?**

4.1 There have been some studies done on this, notably by the University of Michigan (2014) and this also forms part of the work of some of the current Innovate UK projects in this area. The work already completed has focused on the technology – whether people understand it, trust it and so on. It would be very valuable to know more about public attitudes to the future ownership of vehicles. AVs, since they can be summoned and dismissed “at the touch of a button” do away with much of the argument of vehicle ownership being essential for convenience. We do not know how important the “convenience” factor is in car ownership compared to e.g. the social status conferred by ownership, or how important “being a driver” may be to a person’s sense of self. These non-technical questions are crucial to how and if AVs become widely adopted and under what ownership model.

4.2 See also Item 2 for our comments on drivers interacting with AVs.

#### **5. What is the scale of the market opportunity for autonomous vehicles?**

5.1 In our opinion, there are too many unknowns relating to public acceptance and to what role the public sector wishes to take (e.g. in terms of infrastructure provision, and relinquishing or tightening control over how their networks are used) to make any firm predictions in monetary terms. This has not stopped several reputable organisations offering fairly firm predictions of future market sizes. We believe that these figures, at the moment, should at most be taken as a very rough guide.

5.2 However, the market opportunity for connected vehicles has already opened. Far more could be done to exploit data already collected to make UK road travel improve.

#### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

6.1 The establishment of the Centre for Connected and Autonomous Vehicles by DfT and the then BIS provides a good indicator of that the Government does have a broad and ambitious scope for connected vehicles and AVs.

6.2 The technical demonstrations completed (the LUTZ project) and under way (the Innovate UK projects and some others) are as good as any similar projects completed or under way elsewhere in the world and demonstrate UK AV capability very well.

6.3 It would be good to have more work done involving C-ITS rather than stand-alone AV technology. The instrumented corridor project Kent – London is an excellent initiative and the West Midlands region is pushing ahead with a similar facility but in a city context. It would be good to see more Government support for this type of work, since the public

benefits in terms of safety, environment and better journeys are greater than those we will realise from stand-alone vehicle development research.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

7.1 See item (6) for suggestions regarding a broader and deeper research undertaking, particularly with more attention on the transport and social context AVs will have to work in, and on driver behaviour, rather than limiting work to the technology and design of the vehicles.

**8. How effective are Innovate UK and the CCAV in this area?**

8.1 Innovate UK and C-CAV are functioning well as co-ordinators as well as funding channels for the research, and would appear to be acting precisely according to the political priorities set for them. If these priorities could be shifted away from pure, stand-alone AV technology and broadened into cooperative systems and a more in-depth and politically neutral approach to the social and transport context, this would be more likely to deliver shorter terms results and more defined and certain benefit.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

9.1 Yes, AV research and trials are probably one of the transport areas most welcoming to SMEs at the moment. They are well represented in all project consortia and this evidences that funding access has been designed to support their participation. However, terms and conditions for government studies (liability and insurance) mean SMEs often have to work via larger companies.

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

10.1 As before, to be most beneficial, AVs should be implemented in a cooperative context which means that the roads infrastructure instrumentation needs to be extended, the processing of data and creation of information services from and for vehicles and infrastructure needs to be enhanced, and additional services need to be designed to enable AVs and traditional vehicles to co-exist as efficiently as possible. Gaps in radio communications connectivity need filling. “No signal” is frustrating for a human being but potentially disastrous for an AV.

10.2 The current widespread popular understanding of an AV as a vehicle which is digitally isolated from other vehicles and infrastructure and which therefore collects and processes its own data, requires road markings, road signs, fencing etc. in order to function, and in many locations this is currently inadequate for this purpose. However, we regard this version of AVs as a technical cul-de-sac in terms of adoption by ordinary vehicle users and advocate taking the cooperative route forward rather than spend on enhanced road

markings to support this type of vehicle. It should be sufficient to ensure that such infrastructure continues to adhere to design guidance which developers of unconnected AVs can refer to.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

11.1 We believe that the best way forward is a gradual and “natural” evolution, in terms of acceptance both by vehicle users and by infrastructure providers, adoption of increasingly sophisticated driver assistance systems which ultimately will lead to highly automated vehicles dominating our fleet. The two key milestones would be a public acceptance of this new style of vehicle operation, and public sector acceptance that it is necessary to instrument their infrastructure to the point where these systems can function fully.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

12.1 Not entirely (and this is not just the UK situation). The motor manufacturing sector is politically very powerful in the UK as in other European countries and elsewhere, and it is therefore difficult for Governments to drive through regulations regarding vehicle and driving data which the OEMs regard as harmful to their commercial competitiveness.

12.2 Cyber security is also vital. There have already been examples of “connected vehicles” being hacked, and controlled remotely (for example opening their doors) – though as yet only in trials and demonstrations. But an AV could potentially be a guided weapon. The National Cyber Security Centre provides a good starting place for an integrated and coherent cyber security policy. The threats to connected and automated vehicles are technically similar to other cyber environments, though the consequences of successful penetration are unique. The technical mitigation can easily be derived from existing guidance, but the threat analysis needs to be dedicated to the sector.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

13.1 Yes. All three areas currently contain plenty of reasons why aspects of AVs are either illegal or at best highly irregular and liable to causing complex and costly litigation when something goes wrong. However, there is plenty of evidence that C-CAV and DfT are working effectively in these areas, and we can vouch for their positive and meaningful engagement with stakeholders. At a slightly informal level, Governments are usefully exchanging information about their work in these areas too, which is sensible and will save time.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

14.1 There are “urban myths” in this area about whether an AV will be programmed to kill a child or a pensioner, whether it will care about dogs, and so on. This is media driven froth

and in reality an AV will not encounter these moral dilemmas more often than a human driver, in fact less often since it will get into highly dangerous situations less often. And when it does happen, the AV's automated decision is unlikely to be worse than that of a human driver, since it will have been programmed by a team of people.

14.2 The need is not for any formal addressing of ethical issues, it is for an effective information campaign to highlight how much safer highly or fully autonomous vehicles can be both for their occupants and for other road users. Research already undertaken (for instance by TRL) suggests that the number of killed and seriously injured road users we as a society apparently accept now as a result of the use of standard vehicles, is larger per kilometre driven than what AVs will cause.

## **15. What does the proposed Modern Transport Bill need to deliver?**

15.1 Commitment to further legal and regulatory reform including in the insurance sector, commitment to appropriate data collection, processing and sharing regulation even when OEMs will object, and enablement of UK innovation to proceed so that we continue to be among the leading nations in this field.

## **16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

16.1 We can see from the current UK AV projects that there is a pool of very good people with the right expertise. However, most of the skills needed are in sectors where we know there is a skills shortage already which on current trends will worsen: the STEM disciplines. It follows that if the UK is to have a thriving, world leading AV sector, we must recruit and retain more staff in these sectors. This is an issue much wider than AV skills, but if everybody working in STEM does their bit to improve recruitment, training and retention, we have some chance of making a successful change.

## **17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

17.1 The media friendliness of the various “pods” on trial in the UK and the glamour of Tesla is no doubt contributing to steer political priorities away from more prosaic applications such as warehousing and ports, and connected vehicles . One might ask why the on-road AV industry deserves political support and public funding more than, say, a UK company developing automated mining vehicles. However, as with all public funding, this is not an either / or scenario and we welcome the fact that the Government is providing political and financial backing to any part of the UK technology sector. However, as stated in item 14, for long-term success it also need to have some focus on achieving public trust and acceptance of these new vehicle technologies.

## **18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from**

**the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

18.1 It is absolutely impossible for the UK to make a success of its AV industry if it is isolated from international research and development in this field. If UK Government wants to hold on to the UK's current position as, say, in the four top countries for AV expertise, then access to these international contacts must be safe guarded. If the Government does only one thing, this should be to enter into a Norway-style arrangement to pay in order to maintain UK access to European Union research programmes. If it does two things, let the second one be to make it simple for UK organisations to hire foreign staff to work on AVs. This fills shortages in the short term and grows the UK skills base in the longer term, as the foreign experts share their knowledge with colleagues even if they limit their stay in the UK to a few years. Conversely it is enormously beneficial for UK experts to be able to work abroad for sections of their career, acquiring expertise from foreign research teams that they can then bring back to the UK.

*25 October 2016*

## **Kennedys – Written evidence (AUV0046)**

### **Legal advice in black and white**

Kennedys is a top 30 international law firm with specialist expertise in litigation/dispute resolution and advisory services. Our growing network of offices delivers straightforward legal solutions to the insurance, corporate and public sectors.

Kennedys is now one of the only true international legal services providers to the insurance industry. Indeed, we are the **only** firm whose business overwhelmingly consists of insurance work (89%). This puts us in a unique position to understand fully the challenges and opportunities the insurance industry faces.

Some experts predict that by 2023 there will be only three global insurance law firms standing, with Kennedys being one of them. In order to achieve this, we will continue to invest in talent to ensure that we have the best legal experts for complex work, and the technology to automate processes and increase efficiency for volume claims. This includes improving data analytics (both legal and industry data), predictive analytics (for case management and outcomes) and artificial intelligence (for speed and automation). We constantly think about the future.

We have over 1,450 people globally across 26 international offices and 12 associate offices (including nine locations in the UK).

Our lawyers provide a range of specialist legal services across many areas such as: aviation, construction and engineering, healthcare, insurance and reinsurance, public sector, rail, real estate, retail, shipping and international trade, sport and travel and tourism. Our expertise in insurance claims includes cyber risks, marine and product liability. In the personal injury claims space, we are leaders in catastrophic injury, employers' and motor liability, occupational disease and public liability.

We handle a wide range of insurance disputes and litigation with a client base that includes general insurers, global composites, Lloyd's syndicates, underwriters, self-insured PLCs and self-insuring government bodies.

### **Preamble**

Kennedys shares the Government's desire to ensure that the UK is at the forefront of emerging automated vehicle technology – both with regard to the improved safety aspects that such technology can bring, as well as the commercial advantages to business. To that end, we agree that investment in this technology should be embraced and championed.

In the midst of domestic and international political upheaval, we are pleased that the UK Government is maintaining momentum with its domestic policy agenda with regard to

autonomous vehicles. In doing so, it is demonstrating the UK's capability for innovation and policy leadership, which is to be encouraged.

The UK has a robust and extensive regulatory system that is agile enough to be able to respond to new innovation and lead the way in providing a suitable regulatory framework. This will support the UK to maintain its position as a global leader – something of particular importance in light of the UK's impending departure from the EU.

### ***Regulatory reform***

Regulation should support technological advancement rather than hinder it, whilst maintaining the safety of vehicle users or those who may be affected by a vehicle's use. Taking a sensible approach to regulatory reform is vital – too much, too soon could be damaging.

We support wholeheartedly the Government's intention to keep regulatory reform under constant review as the technology evolves. Providing for an ongoing and agile regulatory review means that, as far as is possible, long-term technological change is anticipated. This will ensure that future regulatory change is seamless and occurs only when necessary to reflect a major leap in technological advancement.

While we agree that the UK has the capability to adapt its legal and regulatory framework to accommodate the development of this technology, it is too early to redesign insurance law to take account of driverless vehicles. Amending the Road Traffic Act 1988 to extend compulsory cover to product liability will, in our view, suffice for now.

In time, we have every confidence that highly or fully autonomous vehicles will be considered a different class of vehicle requiring additional compulsory cover. It is most likely that one go-to entity will provide all necessary cover – rather than a set of entities – and that such requirements can be encapsulated in a single piece of legislation. It also recognises the fact that some vehicle users may wish to continue to use more traditional vehicles for the foreseeable future. For those users, the more traditional insurance model will need to continue in parallel with the new insurance regime for highly or full autonomous vehicles.

Input into the process by industry stakeholders is vital and must be ongoing. We, therefore, urge the Government to create an industry-wide group that would advise ministers and civil servants on how the technology is developing to inform their thinking on how regulation needs to change with it. One of the main objectives of such a group should be to reach a consensus on what type of vehicles are likely to arrive on the UK market over, say, the next 10 years. This would greatly assist the government with regulatory planning.

### ***Legal practice***

Looking at how driverless vehicles might impact defendant legal practice, is an important strand to developing this technology. Such an aim must go hand in hand with causing as little disruption to legal practice and the justice system as possible, not least due to the risk of legal-friction-costs generation – an aim which the current and previous Government has

worked so hard to address.

The Government should also be alive to and explore now the discussion point as to whether claims involving autonomous vehicles are suitable to go through the online Claims Portal, which facilitates the process of low value personal injury claims covered by the Ministry of Justice's pre action protocols.

As the Government is aware, there are costs benefits of claims remaining in the Claims Portal. However, based on the experience to date, and despite best (and ongoing) efforts to achieve a proportionate and fair claims process, we anticipate that claimant solicitors will look to keep automated vehicle road traffic accident (RTA) claims out of the Claims Portal for cost-building purposes. Claimant firms will pursue claims on the basis that they do not contain solely a negligence issue vis a vis the defendant and there could be issues of product liability, allegations of potential defects with the vehicle which would (under the current Rules) render these types of claims as complex and, therefore, not fit for the Claims Portal.

In our view, as a defendant firm, there is no reason why claims involving vehicles that make use of automated vehicle technology cannot remain within the RTA Claims Portal. The defendant's default position would be that the Portal should continue to apply to all low value RTA claims (up to £25,000) unless the claimant suggests otherwise i.e. an allegation of defective product.

Product liability cases are notoriously expensive. Typically, expert engineering evidence would be necessary. Therefore, one consideration to highlight now would be to amend the protocol to ensure the claimant's claim for damages remains in the Claims Portal and the product liability aspect be left out – with a subrogated claim being brought against the relevant manufacturer/producer of the product (similar to the way credit hire claims are currently dealt with). This would not represent a significant amendment. The wider context and objective to continue to seek ways to drive out bad behaviours should, however, remain an integral part of the Government's ongoing regulatory review and discussion with industry.

### **Impacts and benefits**

#### **Question 1: What are the potential applications for autonomous vehicles?**

Much has been written in the academic space about the potential of autonomous vehicles to significantly improve transportation safety and offer immense social, economic and environmental benefits.

We recognise that potential. From our perspective as an insurance dispute resolution law firm, the UK has a strong car manufacturing expertise to draw on in developing this technology and doing so could boost UK GDP and increase productivity levels.

It is clear that car manufacturers are innovating to stay competitive. Developing autonomous vehicles is already creating a battle between large information technology

companies and car manufacturers – the former no doubt having an eye on the significant profit that can be made from developing the operating systems.

The connected road system that will be required to accommodate autonomous vehicles also presents opportunity for the UK construction industry – which will need to work with car manufacturers to ensure infrastructure dovetails with technology in order to create a connected environment. This scenario is likely to have both domestic application as well as overseas where UK expertise is sought in creating a connected environment.

As well as the commercial advantages to business, the other key potential application of emerging automated vehicle technology is with regard to the improved safety aspects that such technology can bring for the consumer.

As driving functions become increasingly automated (and are supported by a suitable connected road system), the shift in responsibility from the human driver to the vehicle itself becomes apparent. Therefore, in the race to develop driverless technology and get it to market, it is vital to pause and analyse the safety and liability concerns.

While the Government and business are both eager to get automated vehicles on the road, insurers have called on Government to amend legislation proportionately and remain agile to make future changes. We agree with that approach. Such consideration should, in our view, be done on an ongoing basis to allow safety and liability regimes to respond to anticipated technological change – thereby allowing innovation to prosper and integration of vehicles to occur within a controlled framework.

Please see question 13 below for further consideration of the liability aspects.

Whilst much of the current debate has centred around vehicles used on the highway network, the Select Committee have rightly identified that autonomous vehicles may have a wider application in a variety of sectors ranging from warehousing to farming; anywhere where a vehicle is used. The possibilities for using robotic technology are infinite. However, the application of such technology in any setting must be after full consideration of the associated safety and liability issues.

**Question 2: What are potential user benefits and disadvantages from the deployment of autonomous vehicles?**

As a leading dispute resolution law firm, we act for motor and other insurers and self-insured organisations.

Looking at the cost of an insurance product for autonomous vehicles, the advantages and disadvantages can be summarised against the following timeline:

**Immediate future:** when the first vehicles with AVT are rolled out on to UK roads, manufacturers will take steps to try and encourage uptake of such vehicles and seek to artificially reduce or subsidise insurance cover at the point of sale.

However, over time and in the shorter term, the cost will be passed onto the consumer.

**Short term:** whereas motor manufacturers who have invested heavily in this technology may at first try and promote it by discounting at-point-of-purchase insurance, we believe it is most likely that, after the initial launches of autonomous vehicle technology (AVT), cover for autonomous vehicles will be more expensive.

Initially, underwriting risk for such vehicles will be difficult and take several years to form an accurate pricing model based on established levels of first and third party claims, frequency of claims and so forth. Underwriters will need to build up a body of data on which to assess accurately the risk, whilst bearing in mind that the full benefit of AVT vehicles (in terms of accident reduction etc) will not be seen until a significant number of vehicles on the road are deploying such systems.

**Medium term:** as underwriters' experience of these products increases, the cost of insurance premiums for AVT vehicles is likely to become roughly equivalent to conventional vehicles.

**Long term:** as the larger proportion of vehicles on the road become AVT, it is most likely that the cost of insuring conventional vehicles will escalate considerably.

Conventional vehicles will not be able to communicate with the connected road systems or other vehicles. When the road system is less mixed (between various levels of manual and AVT) and AVT dominates, conventional vehicles will almost certainly be considered the bigger risk to underwrite, on the sound assumption that AVT vehicles in that environment will be safer to drive and more reliable.

**The reality:** for the foreseeable future, a vast swathe of the UK will not be able to be part of a connected road system (rural communities in particular) necessitating a multi vehicle types insurance environment. If, as predicted above, insurance for conventional vehicles is significantly higher than vehicles with AVT, we are likely to see resistance in the consumer market.

It will depend on how society's vehicle use changes over time and indeed how widespread any connected road system becomes with the introduction of autonomous and connected vehicles.

When the larger proportion or a significant proportion of vehicles on the road have AVT, it is likely that conventional vehicles on un-connected (or maybe even more so on connected roads) will cause most crashes.

### **Question 3: How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

#### **Insurance sector**

Please see Question 2 above for the broad impact on the consumer with regard to the cost of insurance.

For insurers themselves:

**Shorter term:** difficulties will arise with the application of AVT on the road and there will be a flurry of claims in the first few years. There will be some frictional litigation too.

There will also be some additional costs to our insurer clients, including:

- Re-gearing their insurance products and policy wordings.
- Staffing and resourcing for first and third party claims.
- Training to upskill their claims handling teams in the interpretation of data being supplied from the vehicles in the event of an accident.
- Substantial increase in investment in IT (whether internally or through outsourcing) to be able to cope with additional data that will need to be stored and managed.

**Medium to long term:** increased claim activity and additional costs will abate. When we reach the point where most vehicles on the road have AVT, and most policies are extended to cover AVT, the cost of total cover for AVT will probably be less than for conventional vehicles. Given the sale of AVT extended cover policies is likely to increase slowly over time, the call on insurers' resources and associated costs should be manageable.

### Legal sector

As a defendant insurance litigation firm of lawyers, we will need to work with our partners and invest in capabilities to interpret and reference telematics, Enhanced Data Rate (Bluetooth) and Environmental Data Record (EDR) and other AVT-technology data.

We anticipate the need for additional training for our motor lawyers in other areas of insurance litigation – most notably product liability law - in order to upskill to be able to deal with new and potentially complex liability arguments (especially in the short to medium term as the new legal landscape unfolds).

In turn, our bills to clients will contain higher amounts for disbursements for use of engineers and other experts – required to interpret in-car and other data in ascertaining share of liability between driver and vehicle manufacturer and others when collisions or damage occurs.

We anticipate, in time, far fewer lower value third party claim instructions. The focus is likely to shift to a smaller subset of more serious injury road accidents (which will fall in frequency too) and an increase in related litigation between AVT motor manufacturers, software houses and manufacturers of autonomous systems, as well as manufacturers and maintainers of connected road systems and street furniture.

Looking at the lower value end of claims, the government should also be alive to and explore now the discussion point as to whether claims involving autonomous vehicles are suitable to go through the online Claims Portal, which facilitates the process of low value personal injury claims covered by the Ministry of Justice's pre action protocols.

There are costs benefits of claims remaining in the Claims Portal. However, despite best (and ongoing) efforts to achieve a proportionate and fair claims process, we anticipate that claimant solicitors will look to keep automated vehicle road traffic accident (RTA) claims out of the Claims Portal for cost purposes.

The wider context and objective to continue to seek ways to drive out bad behaviours should remain an integral part of the government's ongoing regulatory review and discussion with industry.

**Question 4: How much is known about public attitudes to autonomous vehicles?**

No response, save to comment that informal discussion on this topic at some of the insurance conferences considering autonomous vehicles has identified that many are wary of autonomous vehicles and not yet convinced of the benefits. This may be partly down to a lack of knowledge. This is best answered by those in the consumer sector but would probably warrant further study.

**Question 5: What is the scale of the market opportunity for autonomous vehicles?**

Please see Question 1 above.

Globally, manufacturers are rapidly developing advanced driver assistance systems (ADAS) against the expectation that advancement to Stage 5 might be achievable by 2025. While precise timelines for the phased advancement of such technologies vary, the reality is that increasing levels of ADAS are already being integrated into new vehicles.

**Creating an enabling environment**

***Research and development***

**Question 6: Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

No response. This is best answered by manufacturers and research centres in vehicle safety technology.

**Question 7: Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

Input into the process by industry stakeholders is vital and must be ongoing. We have urged the Government to create an industry-wide group that would advise ministers and civil servants on how the technology is developing to inform their thinking on how regulation needs to change with it.

One of the main objectives of such a group should be to reach a consensus on what type of

vehicles are likely to arrive on the UK market over the next 10 years (in incremental stages of, say, two, three, five years and so on). This would greatly assist the government with regulatory planning.

Attendance at recent industry conferences and meetings has allowed us to receive feedback from the larger motor manufacturers, and in particular, those in the engineering and research and development (R&D) sections. The overriding message received is that they need more direction on what will constitute good, non-negligent, driving behaviour of autonomous vehicles. Such guidance is required for every aspect of vehicle use, from executing a good left turn or overtaking manoeuvre through to more complex driver behaviours.

The tone of the comments suggests that this important issue has (as with other jurisdictions) been left in the gift of and to the imagination of the engineers. In the alternative, what is required is an urgent top-down approach from Government and, in particularly, the DfT.

We are aware of the various ongoing research projects in relation to autonomous vehicles, particularly those being run by TRL. If the UK is to continue to lead the way post Brexit, it is imperative that research funding is made available for organisations, such as TRL, who have the expertise to properly review the safety aspects of the technology.

**Question 8: How effective are Innovate UK and the CCAV in this area?**

No response.

**Question 9: Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

No response.

*Real world operation*

**Question 10: Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

Yes - both.

Please see our answer to Question 1 with regard to creating a connected road system and Question 12 below with regard to cyber vulnerabilities.

**Question 11: How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

No response

**Question 12: Does the Government have an effective approach on data and cyber security in this sector?**

No.

While one question was dedicated to third party hacking in the CCAV consultation, it was couched in terms of such an incident being treated, for insurance purposes, in the same way as an accident caused by a stolen vehicle.

The brevity of the question and the reasoning behind it suggest that the Government does not understand the nature of cyber risk or the best approach to adopt.

The ‘fault’ insurer of a driver (or user) of an AVT or connected vehicle does not have the technology to prevent a vehicle from being hacked. The technology rests with the car manufacturer and the use of that technology and its security rests with the owner of the vehicle.

Therefore, the fault insurer should be able to exclude liability. Moreover, ‘hacking cover’ should not be included as standard cover that motor insurers provide. In the alternative, drivers should have to purchase additional cover for liability arising from hacking.

The fault insurer insures a driver based on the **driving of a vehicle** (supported by factors including age, past driving history and underwriting data). Conversely, cyber security of a vehicle is a risk concerning the **driver’s attitude** to cyber security and cyber maintenance and will depend on different factors (such as whether the driver allows other smart devices to be connected to the vehicle’s smart system).

The ‘hackability’ of a vehicle might also depend on whether the driver has ensured that the vehicle’s software updates have been installed and steps taken to prevent others from accessing the vehicles communication network. For instance, diagnostic ports used by mechanics to assess a vehicle’s systems could be a pathway for a hacker.

A fault insurer of the driver of a vehicle does not have access to the data behind such factors that underpin cyber security, which is the underwriting data that allows a full and comprehensive assessment of the cyber security risk.

Given that absence and disparity in underwriting data, should a fault insurer be required to offer hacking cover as standard, it would result in a significant increase in insurance premiums for drivers.

Further, if motor insurers were to have to ‘pick up’ the liability in the first instance for accidents caused by hacking, manufacturers might have cause to be less concerned about their responsibility for ensuring, educating and maintaining the cyber security of these systems.

Therefore, and in the alternative to the proposition, the manufacturer should be responsible for taking steps to ensure that the smart technology installed in autonomous vehicles has the necessary cyber security installed. The manufacturer of a vehicle has the resource and know how to achieve appropriate cyber security to ensure that the data on the vehicles systems are encrypted or otherwise secured.

Indeed, the smart technology in autonomous vehicles needs to be considered as part of the guidance on the vehicle's operation and maintenance. The manufacturer must also remain responsible for issuing the appropriate guidance to the vehicle owner about updating the vehicle's software.

By placing the onus of purchasing additional 'hacking cover' on the manufacturer (via the driver), hacking risks can then be underwritten by reference to the:

- Driver's attitude to and habits in respect of cyber security of their vehicle
- Type of vehicle
- Type of technology used by the vehicle

What systems that technology controls.

**Question 13: Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

Yes.

The current UK legal and regulatory framework for vehicles and road safety is extensive. It has evolved over many years, reflecting developments in the UK automotive industry and safety requirements and the UK's obligations under EU legislation and UN regulation.

As stated above, it is vital to analyse the safety and liability regimes and ensure an ongoing review is in place that allows legislation to be amended proportionately.

The insurance/liability rules specifically for automated vehicles are sufficient for now, but will need to evolve as the technology and its related claims evolve. Overall, establishing fault in accidents involving autonomous vehicles will involve complex questions of liability shared by drivers, car manufacturers and technology designers. The insurance in place will obviously need to reflect this complex paradigm of potential fault and the associated risks.

**Road Traffic Act 1988**

For now, it is sufficient to amend road vehicle compulsory insurance primary legislation in Part 6 of the Road Traffic Act 1988 to include product liability for automated vehicles. To do otherwise would require considerably more primary legislation and be 'too much, too soon' against the background of the:

- Intention to encourage innovation and inward investment in this area; and
- Estimated period of 15-20 years before the majority of vehicles on the road in the UK are highly or fully autonomous.

**Insurance**

In time, highly or fully autonomous vehicles will be considered a different class of vehicle requiring additional compulsory cover. It is most likely that a single go-to entity will provide all necessary cover – rather than a set of entities.

The appropriate level of insurance cover for automated vehicle technology (AVT) vehicles (as a new class of vehicle) should be compulsory and governed by one existing statute. This will provide a transparent and straightforward structure to insurance cover and encourage the one entity to arrange the insurance (compulsory motor insurance and extended cover for product liability) – plus any other additional possible liabilities arising from use of highly and fully autonomous vehicles.

Looking forward, insurance cover is likely to focus on the registered keeper/owner and the automated vehicle itself.

To ensure simplicity and to catch all additional liabilities with this extended cover, professional indemnity insurance (for software authors of software in autonomous systems) and business insurance (including cyber risk) should be included with the extended cover that is compulsory for such classes of vehicle.

In terms of drafting the additional compulsory cover requirements within Section 6 of the Road Traffic Act 1988, it may prove easier to extend the cover to all other liabilities and then list exceptions to that.

#### ***First party model***

As and when fully automated vehicles become the dominant choice of road vehicle, a first party model may become more attractive. For now, a first party model applicable to motor insurance as a whole is not appropriate at this stage, especially while the ‘driver’ of an automated vehicle retains an element of control.

To allow otherwise would be a significant change to current insurance practice, and place the UK out of step with the rest of Europe, leading to additional confusion where UK-insured vehicles are involved in an accident in Europe (and vice versa).

#### ***Failure to maintain automated vehicle technology***

Where a driver attempts to circumvent the AVT, or fails to maintain the automated vehicle technology, the insurer should be able to exclude liability to the driver but not to any third parties who are injured as a result.

In civil cases in such circumstances, the insurer should be able to exclude liability to the driver, but not to their own insured, if s/he is not the driver. This will encourage good behaviours and use of AVT. In criminal cases, any attempt by either the driver and/or insured to circumvent AVT or to fail to maintain the AVT (resulting in accident) should amount to criminal activity with a very limited number of exceptions or exclusions – for example, to preserve life.

There needs to be clear and strict criteria for how failure to maintain AVT is proven – especially during the transition stage where drivers relinquish more and more driving function to autonomous systems.

## **Consumer Protection Act 1987**

The Act removes the need to prove the manufacturer's negligence and is based specifically on the consumer's expectations of the safety of the product (the 'consumer expectation test').

Currently, the Act only applies to property damage where the damaged property is owned by private individuals for personal use. Where a defective product damages a company's property, the company has to prove that the producer was negligent.

We agree that the product liability and insurance requirements for automated vehicles should follow the existing rules – as differentiated by whether the injured party was an individual or a company.

### ***Consumers***

The application of the consumer expectation test could raise a number of the issues, including:

- An allegation that the claimant did not fully appreciate the active safety devices on the car.
- Unrealistic expectations on behalf of the claimant with regard to the technologies capabilities.

It is inevitable that there will be arguments as to whether the claimant, as a driver, should have intervened with the autonomous driving function or not. Arguably, as the technologies become more familiar to consumers, the risks to autonomous car manufacturers will reduce because it will be easier to comply with the consumer expectation test.

### ***Companies***

Currently, there is no need to remove the need to prove negligence just because the company car is autonomous. Given that companies effectively manage property damage claims as caused by a range of allegedly defective products, we see no reason why an exception should be made with regard to automated vehicles.

Furthermore, attempting to change the rules which focus specifically around the consumer's expectation test will be extremely complex and will require a much wider ongoing discussion.

For example, if the company driver connects his personal smart device to the smart system of the company vehicle and causes a security risk for hacking the vehicle that result in an accident, who is responsible? Is it the:

- Company for failing to ensure the driver does not create a security risk on the vehicle's software?
- Manufacturer for allowing the security risk to exist in the first place or failing to warn about potential security risks?
- Developer of the software?

### ***'State of the art' defence***

The product liability and insurance requirements for automated vehicles should, for now, be limited by the ‘state of the art’ defence.

The state of the art defence may come to the aid of manufacturers in design defect and failure to warn cases. For warning defects, the manufacturer will be judged by what they could have reasonably foreseen based on current technology and scientific knowledge at the time of production. For design defects, the state of the art defence will involve the feasibility of adopting appropriate design measures to reduce or eliminate a risk of which the manufacturer is aware.

A claimant can always argue that better technology would have prevented the accident but the manufacturer may not have a reasonable design alternative even with the latest technology.

### **Highway Code**

See comments above. An entirely separate section in the Highway Code for semi-autonomous/driverless cars is required, rather than amending the current applicable Rules to provide a detailed explanation and avoid any confusion. The engineering and R&D side of the larger motor manufactures are evidently already calling for an urgent top-down steer on this from Government.

Specifically:

**Rule 150 (use of driver assistance systems)** will need to be extended to include an explanation of advanced driver assistance systems (ADAS), such as motorway assist or remote control parking. With remote control parking for example, the driver can be outside the vehicle using the remote control and will be relying on the driver assistance system.

Rule 150 will need to be updated further as and when more advanced automated systems are approved and become more widely available.

**Rule 160 (driving with both hands on the wheel)** will need to be amended to cater for situations such as remote control parking where it will be impossible for the driver to have their hands on the steering wheel as they can be outside the vehicle.

**Rule 126 (enabling platooning)** will need to be kept under review. If platooning is to be introduced into the Highway Code (once the technology is ready), it could be introduced as an extension of the Highway Code providing a separate rule for vehicles specifically fitted with ‘vehicle to vehicle’ V2V communication systems.

Relaxing Rule 126 prematurely may lead to drivers of vehicles without V2V system failing to leave enough stopping distances between them and the vehicle in front, thereby causing more accidents.

### **Construction and Use Regulations**

Maintaining active monitoring by the driver, together with the ability for the driver to instantly override any autonomous systems, must remain essential safety features. Nevertheless, the following Regulations will need clarifying:

- ***Regulation 104 (position to control vehicle)*** - the ‘driver’ must be within sight of the vehicle when utilizing any remote control features at all times. As the technology progresses towards providing wholly autonomous parking systems, it may be possible to safely control a vehicle remotely via a hand-held device (via the use of onboard cameras and sensors/monitors), thereby relaxing the requirement.
- ***Regulation 107 (switching off engine)*** - the driver must be within sight of the vehicle when they switch off the engine. The requirement should remain for the driver to ensure that:
  - (a) the handbrake is applied
  - (b) the vehicle is out of gear (or in park mode)
  - (c) it is safe to start the engine
  - (d) the vehicle is not within a garage or similar enclosed area.Manufacturing specifications must also require an engine to cut out if a driver has turned on the engine remotely but not taken control within a limited period (two-three minutes).
- ***Regulation 110 (use of hand-held mobile devices)*** - to ensure full engagement in the driving task, the Regulation should be clear that only the driver can use a single hand-held device and the device must be being used solely for controlling the vehicle remotely.

***Regulation 109 (motorway assist)*** - it would be inappropriate to consider relaxation of Regulation 109 at this stage. Research has confirmed that drivers who divide their attention are significantly increasing the risk of a crash. Given the early stages of this technology, it is imperative that drivers remain focused on the task of driving at all times whilst using ADAS and semi-autonomous systems. The suggested requirement for the driver/user to ‘touch wheel’ at regular intervals, such as every three minutes, and the possibility of sudden hand-back of control to the driver should be a minimum requirement.

**Question 14: What, if any, ethical issues need to be addressed in the substitution of human judgment in the control of vehicles by algorithms and Artificial Intelligence?**

No response.

***Wider governance***

**Question 15: What does the proposed Modern Transport Bill need to deliver?**

The Bill (expected early 2017) is intended to encourage investment in driverless cars and ensure insurance is available to users of such vehicles. It is our understanding that the Bill

will include new laws/amend domestic regulation to make the UK ready to pioneer driverless cars by summer 2017, to include:

- Clarification of criminal and civil liabilities in the event of an automated vehicle being in a collision (which would otherwise be dealt with on a case by case basis by the courts).
- Consideration of whether a higher standard of 'driving' should be demanded of vehicles operating in an automated mode than would be expected of a conventional driver.
- Possible changes to the MOT test to check that automation technology is maintained correctly.
- Potential revisions to the Highway Code to accommodate the automated vehicle technology.
- Exploration of how the existing regulatory framework may be developed to ensure automated vehicle technologies are protected from cyber threats.

While the Government and business are both eager to get driverless cars on the road (and manufacturers are innovating to stay competitive), insurers have called on Government to amend legislation proportionality. We share that view.

We await the Government's response to the CCAV consultation (expected by the end of 2016). The members of the House of Lords Committee also need time to consider the responses to this Call for Evidence and put forward their representations to Government.

The Bill must set out a detailed legislative framework against a realistic timetable to ensure that insurers, manufacturers and drivers have sufficient time to adapt and prepare. Careful drafting is key to this developing area, by addressing crucial areas such as insurance cover provision, thereby avoiding unintended consequences of new laws

**Question 16: How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

No response. This question needs to be addressed by those in relevant sectors.

**Question 17: Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

No response.

**Question 18: What are the implications of exit from the EU for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

With reference to Question 13, the UK Government will need to amend the Road Traffic Act 1988 to extend compulsory motor insurance to include product liability. It aims to do this by summer 2017.

The UK Government will also need to be alive to the dynamics presented by the desire for global co-operation – something that may be brought into sharp focus by the prospect of Brexit.

Amending the Vienna Convention on Road Traffic 1968 is a relevant plank to achieving such co-operation. As the UK signed but did not ratify the Convention, it is not bound by it (seen as a competitive advantage). However, for those member states that did both sign and ratify the Convention, it will require approval by the United Nations. The current timescale for achieving this is not clear. It must also be remembered that the UK is a signatory to and ratified the Geneva Convention on Road Traffic 1949 (Geneva Convention). The UK is therefore bound by Article 8 of the Geneva Convention, and similar updating of these provisions will be essential. Whilst the Vienna Convention has been partly amended to keep up with current work in this field, similar attempts to apply the same change to the Geneva Convention failed in March 2016. The contracting parties simply did not respond for reasons that are not clear.

Given the UK Government's statement that it would like to see international legislation amended by the end of 2018, it is imperative that the Government reviews the overarching international regulatory obligations that exist and considers now the extent to which domestic legislation will need to reflect any change in the obligations placed on the UK post-Brexit.

Post Brexit, the UK has the opportunity to play a greater role in the development of international regulation in this field. The UK has the expertise and should not be afraid to contribute more widely and directly at the international level, rather than working through the European Commission.

*26 October 2016*

## Keoghs LLP – Written evidence (AUV0014)

### INTRODUCTION

Keoghs is the only top 50 law firm to focus exclusively on handling and defending both mainstream and specialist insurance claims. We offer an end-to-end claims service to insurers, public sector bodies and self-insured companies which includes pre-litigation, litigation and costs negotiation activities. Keoghs acts for eight out of the top ten UK general insurers, and with almost 1,200 dedicated staff, is a recognised leader in its field.

Keoghs has been closely engaged with the Government's work on the advancement of driverless vehicles; we agree that the enabling of these technologies represent huge opportunities for the UK.

Keoghs welcome the opportunity to engage with the House of Lords Science and Technology Committee's ("the Committee") inquiry into the future uses of driverless cars in the UK. In particular, we think that the following considerations are of utmost importance:

- **Clarity around liability:** there needs to be a clear demarcation point as to when liability attaches to a driver and when it attaches to the owner/manufacturer;
- **Regulation for insurance cover based on type:** i.e. requirement for vehicle liability insurance cover to be regulated by vehicle type and specification; and
- **Data sharing:** there must be availability of the data set specifically in relation to when the driver was in full control or merely "in the loop", so that a third party can identify the correct defendant to a claim.

Given our interest and expertise, the comments in our submission relate to insurance matters, particularly the following question posed by the Committee: "*Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?*"

### THE REGULATORY FRAMEWORK

A review of the regulatory framework is important. The first regulatory review (which concluded in February 2015) demonstrated that testing of Automated Vehicle Technologies (AVT) in the UK was possible and this led to the publication of a Code of Practice to allow testers to comply with current laws. It is now necessary to review and amend our domestic regulations to allow UK citizens and businesses to take advantage of Advanced Driver Assistance Systems (ADAS) and AVT as they become approved and available. But before doing so, it is vitally important to understand the legal issues that arise from the use of ADAS and AVT and the circumstances in which they arise.

### **Current position**

Currently, liability to third parties injured or who suffer damage to property is as follows:-

#### (1) The negligent user

Where the driver of a vehicle drives it so that it causes injury or damage to property then they will be liable in tort for that injury/damage. The compulsory risks insurance covers this liability.

**(2) Owner/supplier/manufacturer of a defective automated vehicle**

If a vehicle causes injury or damage to property due to a defect then there could be a liability on the part of the owner, supplier or manufacturer. For example:

- If the defect was caused by a failure by the owner to maintain the vehicle then the owner could be liable in tort. The compulsory risks insurance covers this and the RTA provides a right of recovery for the insurer and a right to reject first party claims.
- If the failure was caused by a manufacturing defect then the manufacturer or supplier could be liable under the Consumer Protection Act 1987 but only to the individual consumer.

The Road Traffic Act 1988 already requires compulsory insurance for the negligent user of vehicle on a road or public place and it is an offence to allow a vehicle to be used without that insurance. There is a mature market for providing that insurance and a mechanism to protect those who suffer injury or damage to property from uninsured vehicles (the Uninsured Drivers Agreement and Untraced Drivers Agreement). There are practical difficulties in extending the existing arrangements in relation to the use of vehicles to protect the public from injury or damage to property caused by ADAS, AVT and automated vehicles.

**Our preferred model**

Our preferred model would be to make the owners and the manufacturer of the vehicle jointly liable for any injury, loss or damage to property caused by the vehicle irrespective of whether a driver was in or out of the loop. The Road Traffic Act could then be amended to compel the owners of automated vehicles to have compulsory insurance in place in relation to any liability for injury or damage to property caused by the vehicle. This would require owners of vehicles to take out “vehicle liability insurance” to meet such claims. It is important that the following aspects are considered:

- To enable third parties to pursue claims against the appropriate defendant, there needs to be a clear demarcation point as to when liability attaches to a driver and when it attaches to the owner/manufacturer.
- The requirement for vehicle liability insurance cover should be regulated by vehicle type and specification so that it is easily identifiable when purchasing new or second hand vehicles. This should be recorded by the DVLA as a new type of vehicle with a requirement to provide insurance details of the owner to the MID.
- There is a need to make the data set available to all of the parties specifically in relation to when the driver was in full control or merely “in the loop” so that the third party could identify the correct defendant to a claim.
- Where the driver was not in full control then there is a need to make the data set available specifically in relation to the attitude of the vehicle in the period up to and including the incident which is alleged to have caused injury loss or damage.

Once the vehicle liability claims had been met, it would be open to the insurer to pursue recovery of their outlay from the manufacturer.

There should be a step by step rolling programme of regulatory review. We recognise that the regulatory solutions that will enable future technology such as fully automated driverless cars may stifle progress and prevent UK citizens and businesses from taking advantage of them as they become approved and available. There needs to be positive engagement with innovators to identify technologies and vehicles systems as they begin to emerge to allow them to be tested and approved and made available.

**Should we only consider technologies that are likely to come to the UK market in the next 2-4 years?**

The ADAS and AVT that currently exist and those that are expected to reach the market in the next 2 to 4 years are primarily assistance systems. They require a driver to be in the loop which brings with it a risk of a lack of understanding, distraction and abuse by the driver.

But they also include technologies which go well beyond merely providing assistance. They include systems that are capable now of being used on normal roads such as the Mercedes, Volvo and Tesla systems. The current technologies are able to provide a driver with the ability to undertake non-driving tasks whilst on long journeys. There is significant competition between manufacturers to be first to market with new and improved technology and we are likely to see technology that provides an automated driving capability in all but name within 2-4 years.

We need to start now on the groundwork of considering and defining appropriate construction regulations for automated vehicles. The system technology will only increase in complexity and increase the time and resource needed to define the appropriate regulations.

We do not want to be in a position whereby the technology exists but cannot be used for want of appropriate regulation. If UK PLC is to become the leader in these technologies then the pace of regulatory reform needs to match the rate of technological advancement that is anticipated.

**LEGISLATION**

We should amend road vehicle compulsory insurance primary legislation in Part 6 of the Road Traffic Act 1988 to include liability for automated vehicles. However, we would caution against calling it “product liability”, as it is not “product liability” in its true sense.

The current primary legislation works on the basis of compelling motorists to insure against compulsory risks to third parties. This allows victims of road traffic accidents to be compensated fairly and quickly. The introduction of ADAS and AVT (“the system”) creates a situation where liability rests either with the engaged driver or with the manufacturer of the system. This is a blocker to third parties being compensated fairly and quickly because:

- They do not have control of the evidence that will assist them in determining where liability rests.
- They may have to seek compensation from the system manufacturer rather than an engaged driver.

This will cause friction over who or what caused the accident and result in victims being delayed or denied their compensation unnecessarily.

### **Necessary amendments**

The Road Traffic Act 1988 needs to be amended to address:

- Liability: i.e. make the owners and manufacturers of vehicles jointly liable for any injury, loss or damage to property caused by the vehicle irrespective of whether a driver was in or out of the loop.
- Compulsory insurance: i.e. compel the owners and manufacturers of automated vehicles to insure against claims for injury, loss or damage to property caused by the vehicle. This “vehicle liability insurance” will then meet third party claims.

ADAS and AVT are currently designed to be driver aids and not to replace the driver. There is a need to make a clear demarcation of liability from driver to owner so that a third party knows who the correct defendant is. There is no doubt that accidents will occur as a result of the misuse of AVT but that is not an issue which should prevent innocent third parties from being compensated or being covered by “vehicle liability insurance”. The insurer can then decide as to whether to pursue recovery as against the “in the loop driver” or the manufacturer depending upon whether the abuse of AVT caused the accident or the AVT.

### **INSURANCE**

There are a number of changes to the insurance framework that should be considered to support the use of AVT.

### **Classification**

There is a pressing need to implement a system for classifying automated vehicles to the extent that they can be easily identified when purchasing a new or second hand vehicle as requiring “vehicle liability insurance”. Manufacturers should be required to provide automation type specification upon registration of new vehicles and those upgrading vehicles with automation should be required to register the type specification. Where the owner is different from the registered keeper, the owner needs to be required to provide insurance details of the owner to the Motor Insurance Database (MID).

This will allow insurers to rate vehicles in accordance with the different automated systems and technologies.

### **Definition of a standard data set**

It is important to have a definition of a standard data set of information:

- The standard information should include confirmation of whether the driver was in full control or in the loop. Where it is the latter then it should include details of the vehicle's movements in the period up to and including the incident which is alleged to have caused injury loss or damage together with the attitude adjustments brought about by the automated system.
- There needs to be regulation over the format of the data and detail of how it can be handled to ensure that a court would view it as an accurate, reliable and factual recording leaving no scope for error or complex technical challenges in claims.
- The data set should be recorded in a "black box" and the data set should be easily accessible to the police authorities when attending upon the scene of an accident.
- RTA Amendments: S172 of the RTA 1988 may need amending to allow for a request for details of whether the driver was in full control or driving in or out of the loop. S170 RTA 1988 should be amended to require the disclosure of the standard data set recorded in relation to the accident to any person having reasonable grounds to require disclosure of the data set.

### **Exclusion of liability**

There will be certain situations that arise that are, for obvious reasons, not taken into consideration by the current regime. These must be considered, and there must be clarity around the exclusion (or not) of liability. We set out some examples below:

- Where a driver attempts to circumvent the automated vehicle technology, or fails to maintain the automated vehicle technology, the insurer should be able to exclude liability to the driver but not to any third parties who are injured as a result. This will allow third parties to be compensated fairly and quickly and will allow insurers to recover their outlay from the driver similar to the statutory right that exists under Section 148(4) of the Road Traffic Act 1988. This is the current position and we do not see any reason to change it.
- In the event of 3rd party hacking of an automated vehicle, an insurer should not be able to exclude liability. This will allow third parties to be compensated fairly and quickly and will allow insurers to recover their outlay from the hacker in the same way that recovery can be sought from the driver of a stolen vehicle. The incidence of hacking is *prima facie* evidence that the vehicle is not fit for purpose giving rise to a right of recovery by the insurer against the manufacturer.
- With respect to automated vehicles, we believe that the public sector should be able to continue to self-insure but, where they choose to self-insure, they would then be required to step into the insurer's position in respect of product liability damages. This will allow victims to recover damages as fairly and quickly as if the claim were being met by an insurer.

### **COST CONSEQUENCES**

Our view is that the cost of any changes to accommodate AVT could be very significant unless they are appropriately managed. We say this with the following considerations in mind:

#### **Data**

- Management - there needs to be a defined set of data recorded in a standard format that covers the immediate run up to and aftermath of an incident. That data set needs to be recorded in a standard format and be readily accessible by the police authorities in attendance upon an accident.
- Format - there needs to be regulation over the format of the data and detail of how it can be handled to ensure that a court would view it as an accurate, reliable and factual recording leaving no scope for error or complex technical challenges in claims. It needs to be stored appropriately and be made accessible to any person having reasonable grounds to require disclosure.

Unless this is appropriately regulated, then the cost of recording, obtaining, interpreting, challenging and storing the data in relation to potentially hundreds of thousands of accidents each year could be very significant.

### **Underwriting considerations**

Underwriting and vehicle technology rating and experience modelling aspects may add to the cost of these changes. The underwriting teams will need to assess the risk presented by each vehicle type to determine the risk and policy rating.

### **IT Systems and engineering**

There would need to be an IT review to store and analyse disclosed data from accidents. There would need to be training and upskilling the engineering workforce in relation to estimating cost of and completion of repairs to automated vehicle technology.

### **What about the cost of AVT insurance products?**

Initially, we anticipate that the cost of AVT insurance products will be higher than for conventional vehicles. We are not in a position to say how much higher that may be but if the requirement for vehicle liability insurance applied to current vehicles with ADAS and AVT then the initial cost would be spread amongst many from the outset thereby reducing the difference between it and insurance for conventional vehicles. It is also likely to be higher because of the underwriting uncertainty over claims frequency and severity. It may also be because of the additional cover required for the “non-fault driver” claims and the additional (even if only perceived) risk of cyber-attack.

There are also costs that do not apply to conventional vehicles that will have to be factored into the price of AVT insurance products. These will include:

- The cost of data sharing/ownership: these costs are likely to be significant. We have outlined the relevant considerations (which will be accompanied by a corresponding cost) in our response above.
- The cost of vehicle repair: AVT vehicles are, by their very nature, more sophisticated machines than conventional motor vehicles. We can reasonably assume that in the event of vehicle damage, the cost of repair is likely to be higher - at least in the short term.
- The cost of vehicle service: AVT vehicles will need regular servicing just as conventional cars do. However, there will be additional requirements due to the increased capabilities of AVT vehicles. Servicing will, for example, probably require that the relevant software is kept up to date.

- The cost of credit hire: providing a customer with a like-for-like replacement in the event that they are unable to use their own vehicle will inevitably be higher, at least in the immediate future and until the purchase price of AVT vehicles decrease.

However, if as expected, the frequency of at-fault accidents (whether it be engaged driver, disengaged driver or system failure) reduces compared with vehicles without AVT then popularity of safer AVT vehicles will increase.

As more and more people opt for safer AVT vehicles, the costs of AVT insurance products is likely to decrease. This may cause an increase in the cost of insurance products on non-AVT vehicles which may be considered a higher risk.

We anticipate that the introduction of vehicles with AVT will have no initial effect upon insurance premiums of conventional vehicles. However, as the AVT vehicles become more popular and safer, the risk of non AVT vehicles may be considered higher and insurance premiums may increase.

Although we anticipate that there will be rigorous testing of AVT prior to it being made available to ameliorate the risk of system fault incidents, the current uncertainty around the demarcation point of liability together with the model that is used means that costs are difficult to quantify. Certainty around liability and data transparency will be key to keeping costs down. If liability remains unclear, the risk of litigation and the potential exposure will undoubtedly push up costs for insurers. Market economics dictates that it is almost inevitable that at least some of the cost will be passed onto the consumer. And unless data is regulated and access is managed then litigation is likely to follow causing further increases in cost.

*20 October 2016*

## **Professor David Lane CBE FREng FRSE – Written evidence (AUV0050)**

Lead Author of *UK RAS2020 Strategy*<sup>167</sup> (2014) and *Lloyds Register Foundation Foresight Review of Robotics and Autonomous Systems* (2016)<sup>168</sup>

Director, Edinburgh Centre for Robotics<sup>169</sup>

Professor of Autonomous Systems Engineering, Ocean Systems Laboratory, Heriot-Watt University<sup>170</sup>

### **IMPACTS AND BENEFITS**

#### **1. What are the potential applications for autonomous vehicles?**

Beyond self-driving cars, operation in warehouses for order fulfilment, unmanned underwater, aerial, surface platforms for inspection, maintenance and repair of infrastructure (asset integrity management, assurance and certification), assisted living devices for the elderly around the home, other domestic appliances for cleaning, cooking, gardening, agricultural systems for planting and harvesting, other forms of transport including rail and ship for people and goods. In practice, anything that moves, and in some cases things that currently don't (eg mobile table for carehome)

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

Benefits are increased safety and productivity, reductions in cost of operations, time to perform, energy used. Disadvantages are need for training and up-skilling of staff who use them – autonomy is all about the operator. No formal methods yet for assurance of autonomous systems, especially if learning features built in.

#### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Different in different sectors. They are already used routinely for operations at sea – defence, oil and gas inspection, marine survey, environmental science, so their role and benefit is clear. Amazon and Ocado order fulfilment are already largely using autonomous vehicles. However other markets are less advanced, for example performing physical intervention for asset integrity management or working and collaborating with people in domestic environments. Here there are still technical challenges to overcome, and therefore the extent of when and what of their envisaged uses has still to be established.

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<sup>167</sup> <https://connect.innovateuk.org/documents/2903012/16074728/RAS%20UK%20Strategy?version=1.0>

<sup>168</sup> <http://lrfoundation.org.uk/news/2016/foresight-review-of-robotics-and-autonomous-systems.aspx>

<sup>169</sup> <http://www.edinburgh-robotics.org/>

<sup>170</sup> <http://oceansystems-lab-heriotwatt.com/>

Nonetheless, the opportunity and potential impact is enormous, on a par with the revolutions of computers, aircraft and motorized transport.

#### **4. How much is known about public attitudes to autonomous vehicles?**

There have been several surveys at different times with different results.

- 4) Public attitudes towards robots, Special Eurobarometer 382, Sept 2012

Broadly speaking people are interested and intrigued, because of the immediate ways they understand how it will impact their lives (eg drive home from the pub, faster package deliveries with drones). However, they are also concerned about job losses and employment and there is a good deal of media hype on this. Some believe there is a hollowing out of middle class employment coming or here with uneven wealth distribution, others that this is no different to the introduction of looms, cars, or computers. Technology has always created more jobs than it took away:

<https://www.theguardian.com/business/2015/aug/17/technology-created-more-jobs-than-destroyed-140-years-data-census>

The public are starting to see the difference between the Hollywood version of the future and the reality of what's achievable now. However, they don't fully understand the limitations on the technology. Greater responsibility and informed-ness in journalistic reporting plus connection of economists and social scientists to engineers is helping to shape better informed messages.

Some useful texts on employment aspects:

- 5) Judy Wajcman (2015) Pressed for time: The acceleration of life in digital capitalism Chicago: University of Chicago Press:
- 6) Rinie van Est, Linda Kool (eds) Working on the robot society. Visions and insights from science and engineering concerning the relationship between technology and employment Rathenau Instituut. The Hague, Netherlands
- 7) Tobias Hüsing Werner B. Korte Eriona Dashja (2015) e-Skills in Europe trends and forecasts for the European ICT professional and digital leadership labour markets (2015-2020) empirica Working Paper November 2015
- 8) Graetz, G. and G. Michaels (2015). Robots and work, IZA Discussion Paper No. 8938.
- 9) Jäger, A., Moll, C. O. Som and C. Zanker (2015): Analysis of the impact of robotic systems on employment in the European Union, study prepared for the European Commission DG Communications Networks, Content & Technology, Fraunhofer ISI. 2015
- 10) Frey, C. and M. Osborne (2013): The future of employment: How susceptible are jobs to computerisation?, September 2013.
- 11) Georg Graetz and Guy Michaels (2015) Robots at work, London School of Economics Centre for Economic Performance CEP Discussion Paper No 1335

- 12) Positive impact of industrial robots on employment. International Federation of Robotics. Metra Martech (2013)
- 13) The effects of technology on employment and implications for public employment services, World Bank Group (May 2015)
- 14) C. Lindsay (2003) A century of labour market change - a summary of labour market conditions in the 20th Century 1900-2000. Labour Market Trends, March 2003, Office for National Statistics, UK
- 15) Martin Ford (2015). Rise of the robots: Technology and the threat of mass unemployment. London: OneWorld Publications.

## **5. What is the scale of the market opportunity for autonomous vehicles?**

Multi billion dollar cross sector, with trillions of dollars of consequent impact. McKinsey 2013 report is a much quoted source.

- 16) Disruptive technologies: Advances that will transform life, business, and the global economy. Mckinsey Global Institute, (May 2013)

The FT has run an excellent set of articles (Q2 2016) filled with data on investment levels, market sizes, global activity, unemployment data that broadly supports these positions and is worth consulting rather than repeating here<sup>171</sup>

## **CREATING AND ENABLING ENVIRONMENT**

### *Research and development*

## **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

No. We have made a start in self driving cars with demonstrations and public interaction in Milton Keynes and Greenwich. However we must do much more across different sectors and quickly to stay ahead of international competition. RAS2020 Strategy lays out the essential domains. Infrastructure test beds for asset integrity management (oil and gas, nuclear, buildings), other urban environments, carehomes, factories and more

<https://connect.innovateuk.org/documents/2903012/16074728/RAS%20UK%20Strategy>

## **7. Is the Government doing enough to fund research and development on autonomous vehicles and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

Government has made a promising start with CCAV and underpinning R&D through EPSRC with Centres for Doctoral Training and Capital investments. A concerted effort is now needed to build on this and enable the cross sector innovation pipelines for disruptive new

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<sup>171</sup> <http://www.ft.com/robot-week>

businesses with products and services to really get going in the UK. This requires co-ordination of stakeholders in industry, government, public bodies and research through a Leadership Council structure, echoing the success of the automotive council. Government as smart procurer and customer helping disruptive innovative companies to become established by working on requirements spiral eg in SBIR type arrangements – long term relationships emerge over many years. Innovation should be embedded in cluster around the main Centres where research is underway, and skilled people are – eg Bristol, Edinburgh, Oxford, Sheffield, Southampton, London. A conventional Catapult may not be the right answer for this translation activity.

**8. How effective are Innovate UK and the CCAV in this area?**

CCAV is young and so it is early to pass judgement. They are certainly creating activity and interest across the community. Innovate UK have made good progress supporting all. Increased connectivity in planning and acting alongside the research councils and engagement in getting large companies and Government departments to work through smart procurement are opportunities for iUK.

**9. Is the environment for small and medium sized enterprises (SMEs) working in this sector sufficiently enabling?**

Not yet. Access to investment at scale is lacking, with follow through, to take risk but develop \$billion valuation unicorn businesses. Industrial Strategy has the opportunity to signpost routes to growth, by connecting people and oiling the wheels

*Real world operation*

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

Digital infrastructure continually evolves and can continue to do so as autonomous platforms become more ubiquitous. Physical infrastructure can change (e.g. automated parking garages) but much need not – the vehicles are designed to operate in environments adjacent to humans.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

The typical path is a gradual transition of smart autonomous vehicle capability (eg obstacle avoidance, mission planning) to manned vehicles, reducing workload on the driver/operator, freeing them for other tasks, making them more productive. It also gains the operators trust, and de-risks the technology through extensive supervised field testing, ready for the transition to full autonomy mode. This is happening in the car and unmanned underwater vehicle industries. For mass adoption by the public this kind of in-field testing both of the technology and the people is essential. Autonomy is all about the operator.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

The cybersecurity industry has still to focus on this market and topic with the same vigour being applied to other ICT applications eg banking. This was a key finding in the Lloyds Register Foundation Foresight Review of Robotics and Autonomous Systems launched in October 2016

<http://lrfoundation.org.uk/news/2016/foresight-review-of-robotics-and-autonomous-systems.aspx>

The cybersecurity and RAS research and development communities need to work closely. Some scoping activity could identify the opportunities and the needs in this area, to secure network connected RAS against a variety of classes of intrusion. This may include the need for encryption and the design of efficient approaches, including the role of digital ledger technology for guaranteed transaction records. Such RAS could be publically offered in a hack challenge to test their security.

Ideally, RAS software will be developed to acceptable software integrity level standards, appropriate to the criticality of the application. This is not a cheap endeavor. Identifying and recommending cost-effective ways to do this will encourage adoption by developers and specification by customers. Allied to this is the embedding of fault detection and diagnosis as part of the RAS onboard health management, with acceptably low false alarm rates. Third party vendor software embedded as libraries should also be assured or at least firewalled and jacketed so that the RAS degrades gracefully, predictably and safely in the event of code and other errors.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

The certification and assurance industry could be revolutionised by these platforms – especially where the autonomy includes the ability to self-certify in real time during operations. Regulation about several things including use of cameras and other forms of data privacy could be necessary for public adoption and trust. Regulations on safe use of space (eg roads and airspace) and standards for performance and behaviour where multiple platforms are operating concurrently or even collaboratively will be required. Insurance and ownership models will change, no longer so personalised to an individual. Significant disruption in the insurance industry could ensue, following a more Swedish model, being offered by the manufacturer as part of the platform package. Fewer crashes make this economic and feasible

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

- Engineers alone should not be left to programme behaviours into robots that cross ethical boundaries. Nor can machines that learn be similarly empowered. Internationally agreed ethical standards for RAS are needed so that clear guidance and norms evolve,

for example for ‘no-win’ decision making. A culture of ethical concern should be encouraged across the international R&D community. This requires an international effort and the evolution of ethical counsels to provide the reference guidelines and standards. Efforts to develop these should involve engineers, social scientists, lawyers, ethicists, researchers, policy makers and journalists working closely.

Further reading on this :

- 17) Patrick Lin, Keith Abney and George A. Bekey (2012). Robot ethics: The ethical and social implications of robotics. Cambridge, MA: MIT Press.
- 18) Gary E. Marchant and Wendell Wallach (2015). Coordinating technology governance. Issues in Science and Technology. Summer 2015. Pages: 43-50.
- 19) Wendell Wallach and Colin Allen (2009). Moral machines: Teaching robots right from wrong. Oxford: Oxford University Press.
- 20) Nick Bostrom (2014). Superintelligence: Paths, dangers, strategies. Oxford: OUP.
- 21) Illah Nourbakhsh (2013). Robot futures. Cambridge, MA: MIT Press.

*Wider governance*

**15. What does the proposed Modern Transport Bill need to deliver?**

**16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?**

We will need more autonomous systems skills at all levels in the future, and more people who possess them and are passionate. Teachers need support to lay good foundations in schools, with examples such as Robokid offering good quality distance learning materials and access to maintained equipment.

<http://www.robokid.org.uk/>

Undergraduate, postgraduate, continued professional development and fellowships all continue to be needed. Secondments for RAS students and researchers into the assurance industry would also provide useful mutual transfer of knowledge and skills.

EPSRC have made a promising start establishing centers for doctoral training and making capital investments in several UK centers. These are generating technology and talent, but there is a requirement for continued expansion as markets and opportunities grow. Technician and modern apprenticeships will also become increasingly important – maintenance of these systems requires different skill sets, including software.

**17. Is the Government’s strategy and work in this area sufficiently wide reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

No. Government has only just scratched the surface. CCAV could be a good role model, and secondment of fast stream civil servants into it from all Government departments will help create other opportunities in other sectors. This has been the subject of discussion at Cabinet Office Horizon Scanning meetings with Heads of Depts and Chief Scientists pre-Brexit. Momentum should not be lost post Brexit, in fact quite the opposite if UK is to go it alone. In conjunction with a Leadership Council as part of the Industrial Strategy, Government as customer and regulator and supporter of research and innovation can stimulate the research base and the innovation pipeline to create new businesses across all sectors. These will be disruptive in products and services with autonomous vehicle technology, that will make UK more productive and competitive, and gain market share overseas for exports.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

EU research funds and research partnering are an important source of finance and more importantly, ideas in the development of these technologies. It also connects UK researchers and companies with those in Europe, in some cases large manufacturers who can become customers. Post Brexit, some mechanism for UK organizations to continue in new EU consortia and initiatives doing research and innovation is essential, without discrimination, and without a second funding review hurdle to overcome.

For the car industry, there are no very large manufacturers located in the UK, and post Brexit we may lose those we currently have from overseas (eg Nissan). We will have EU competition selling our smart software for autonomous navigation, planning and other services into these EU based manufacturers. We are less likely to win against European competition without close relations, as well as a competitive edge in technology and price.

*26 October 2016*

**Mr Eion MacDonald – Written evidence (AUV0002)**

- 1.** Great saving in care costs for disabled in country districts or towns.
- 2.** Many elderly or disabled persons are moved from their own homes to care facilities (institutionalised) due to inability to seek under their own mobility the usual food/small items of daily life, while they can actually cook. Sit alone in garden, talk to friends etc. With a ‘purpose to life’. Inability to shop, obtain necessities puts them into the ‘care environment’ of care homes or council care which is unrelenting in its degradation of ‘life’ as carer/care home does things to obtain swiftest possible ‘job’ without consideration that independent life could be done by person with slow steps.

An ageing population needs transport to keep independent living as long as possible. Autonomous cars /taxi for hire could restore a large bit of country living and avoid demise of villages and compaction into ‘towns’.

Shopping is the biggest thing, but users of cars cannot keep a country home when no bus service carer once per two days etc., but with an autonomous car without need to control / brake, use legs etc. would allow an extension of individual life at home.

This would reduce care budget and increase quality of life.

- 3.** I have seen a lot of Woman’s Institute members in our district ‘give up desire to live’ due to no independent mobility from home to market. My wife is a WI member.

For the disabled, an autonomous car coupled with wheelchair driver capability would reduce the inability to get to a work site, or other place.

There are benefits, but other road users would need to be trained to spot such cars and take appropriate actions, a sharp overtake and cut in could cause very rapid emergency braking with consequent collision by rear end smash into stopped car. Very difficult to model mathematically, as cut in is a very dangerous procedure but very common.

*16 September 2016*

## **Maritime Autonomous Systems (MAS) Council of the Society of Maritime Industries – Written evidence (AUV0015)**

*Please see Glossary at end for explanation of acronyms*

### **Impacts and benefits**

#### **1. What are the potential applications for autonomous vehicles?**

There are a wide range of applications for Maritime Autonomous Systems (MAS) above (UAV), on (USV) and beneath (UUV & ROV) the sea surface. This expanding market impinges on a wide range of maritime applications such as marine science and hydrographic survey, offshore resource exploitation, maritime transport and defence and maritime security operations. By way of example, but not exclusively, MAS impacts on oceanography, offshore oil/gas, offshore renewable energy, deep-sea mining, fishing and aquaculture and underwater asset management.

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

Unmanned Vessels are persistent; they can go to previously unattainable places in the world's oceans, seas and inland waters; they are significantly more cost effective than manned vessels in certain circumstances; they reduce risk to humans and are not subject to human weaknesses; they can relay real time data to control stations ashore or afloat. Autonomy is currently a complementary capability to manned systems; they could be vulnerable to cyber interference and ensuring devices are adequately protected is a current focus for system designers.

#### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

The maritime learning curve is exponential and the potential impact is highly significant. USV, UUV & ROV and UAV are all in current use but it is the dawn of a new era at sea. Whilst most current vessels are relatively small, major companies such as Rolls-Royce are investing very large sums into the development of large USV for future commercial use.

#### **4. How much is known about public attitudes to autonomous vehicles?**

There is a growing awareness of the potential for MAS. This spreads from academic institutions, through commercial R&D and production organisations, to owners and operators of both manned and unmanned vessels, as well as being a highly debated topic in all international and national bodies, notably the International Maritime Organisation (IMO). There have been several successful deployments of MAS which have generated significant and positive public interest, an example has been the MASSMO deployments organised by the National Oceanography Centre. The UK MAS Regulatory Working Group has published an industry led Code of Conduct\* for surface MAS to assist in the generation of best practice and to demonstrate a responsible approach to the development and utilisation of MAS technology.

A copy can be downloaded from <http://www.ukmarinealliance.co.uk/content/masrwg-code-conduct>

**5. What is the scale of the market opportunity for autonomous vehicles?**

A recent survey of market opportunities conducted by the MAS Council (a new interest group within the Society of Maritime Industries (SMI)) has identified the increasing number of UK companies engaged in MAS. This includes academic institutions, distributors, equipment and platform manufacturers, system integrators, service companies and naval architects. The survey suggests annual turnover in MAS applications is £200 million, of which around 25% is export related. This is expected to rise to £500 million by 2020. Estimates put the global market for MAS at \$136bn over the next 15 years. 500 people are currently working in the UK on MAS activities and this is expected to double in the short to medium term. Maritime opportunities were highlighted in the RAS 2020 Robotics and Autonomous Systems strategy paper but not covered in detail.

### **Creating an enabling environment**

#### *Research and development*

**6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

This is a new venture in the maritime environment and facilities are growing by the day but are not yet matching the rising demand being identified. Government initiatives at all levels certainly need to become broader and more ambitious. Currently only around 30% of the UK's seabed within the exclusive economic zone (EEZ) is mapped. The Department for Business, Innovation and Skills (now Business, Energy and Industrial Strategy) and Maritime & Coastguard Agency in partnership with The Crown Estate and Department for Environment, Food & Rural Affairs have produced a report examining the economic benefits of mapping the remaining 70% and it is recognised this could only be economically delivered by autonomy.\* A government sponsored project to undertake this work over, say, 10 years would encourage industry investment in the technologies required to deliver this and accelerate the industry's ambition with attendant export potential.

\*UK National Seabed Mapping Programme – Scoping Study dated 30 March 2016

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

Investment has already taken place through a joint Innovate UK/Dstl MAS competition (£5 million) and through a number of NERC programmes, particularly with the National Oceanography Centre. However, much more is needed in all areas from academic institutions through company R&D to the various companies producing all elements and systems required to maintain a UK lead in the international field and ensure the MAS industry reaches its full potential. Co-ordination is a vital part of success and no more so than with this emerging technology. The MAS Steering Group, the UK MAS Regulatory

Working Group and the newly formed MAS Council of SMI are working closely together to direct and address the full spread of requirements. Clear ministerial responsibilities are needed to ensure effective co-ordination across the spectrum.

**8. How effective are Innovate UK and the CCAV in this area?**

Innovate UK has been a driving force to date through its Robotics and Autonomous Systems Special Interest Group (RAS SIG) but CCAV has not yet made its mark in the maritime environment.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

The environment is right, but is not uniform across the UK being dependent on whether or not the LEP, say, identifies marine as a major economic generator, and it is questionable whether it is sufficiently enabling. This inquiry needs to explore in some detail what is being done and how UK industry can be supported in both the home and export markets.

*Real world operation*

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

There will be a need for a significant development of the infrastructure needed to support MAS. Autonomous vessels require secure and reliable communications in all bands and there will be a need to develop new facilities ashore (and afloat) which can control these vessels on a global basis and to exploit the data which they produce. As mentioned under question 6, if the government were to treat the mapping of the UK's EEZ (an 'Ordnance Survey' of the seabed) as a major infrastructure project, this could accelerate developments in MAS.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

This is a complex question as the answer varies when addressing the needs of the current, relatively small, surface vessels or identifying the needs of larger commercial shipping when these vessels become operational. The answer also varies for the more established underwater vessels (both UUV and ROV) and UAV working in support of maritime operations. Transformative change is not inevitable in the UK given the maturity of the existing solutions and aversion to risk. Autonomous vehicles are best exploited within a suitable system; a directed framework of operational studies will inform system and technology definition and so increase the probability of transformative change.

Technology roadmaps have been prepared which have identified the following key milestones:

- Supervised autonomy
- Information architecture standards
- Full individual autonomy
- Swarm autonomy

N.B. Please see the UK Marine Industries Technology Roadmap 2015

(<https://www.gov.uk/government/news/uk-marine-industries-alliance-unveils-updated-technology-roadmap>)

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

The effective management of marine data in the public domain is fragmented although there are major efforts to improve the situation. In terms of wider maritime operations, cost effective satellite capacity will be required across all maritime sectors to fully exploit the capabilities of autonomous vessels and devices as they traverse the oceans and help to increase the market adoption rate. Furthermore, this is where effective cybersecurity to protect the assets and their data will be essential and there is still much work to be done. Therefore, the inquiry must highlight that a fully co-ordinated and effective approach to data handling and movement, with increasing resilience and defence against cyber-attack, is one of the greatest challenges to maintain confidence in the technology's integrity. This must be made a priority for government policy and funding.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

There will be a number of requirements for revisions in all these areas which are being addressed by the MASRWG. These will include updates to the four IMO Instruments (Collision Regulations, Marine Pollution, Safety of Life at Sea and Standards of Training, Certification and Watchkeeping for Seafarers), which are being co-ordinated through the Maritime & Coastguard Agency. An information paper has already been forwarded to IMO highlighting what the UK is doing and efforts are underway to build international consensus for the UK approach. A further paper will be raised to IMO for MSC.98 in 2017 to initiate the necessary revisions. Following publication of the Code of Conduct (see Q4 above), the MASRWG is preparing a Code of Practice for completion early in 2017. All relevant UK authorities and companies are engaged in this process, including classification societies and insurers.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

This aspect should not be underestimated in the maritime domain as with others, particularly in their command and control systems. Cultural change and full use of available technology are pivotal to the success of maritime autonomous vessels, as is the shift of emphasis for the requirement for experienced mariners both afloat and increasingly ashore. Whilst this may be seen as a potential roadblock, it should be emphasised that this is not the case. The inquiry could consider how risk tolerability and acceptance should be addressed to capitalise on the potential safety benefits offered by autonomous systems whilst not imposing overtly stringent requirements on the adoption of new technologies.

*Wider governance*

**15. What does the proposed Modern Transport Bill need to deliver?**

No comment at this stage.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

As with any emerging technology there is immense scope for students to start developing awareness and both skills and knowledge from the youngest age. There are requirements for young people to be part of the technology development and the operation of autonomous vessels. Input to schools and university curricula is at an early stage, as is the general motivation to become part of such an exciting world with the career opportunities it now presents. Government initiatives and incentives will be a welcome and essential part of this process. The development of MAS is a good example of where the modern engineer needs a wide scope of understanding covering mechanical, electrical and software skills.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

It is true to acknowledge that air and automotive vehicles currently attract the most publicity, both positive and negative. Many still believe that autonomous developments in the maritime world are still embryonic or have just not been exposed to it yet. This is not correct and therefore the strategy must be seen as not yet wide-ranging enough and increased emphasis on maritime issues is a real opportunity and crucial to the overall development of MAS.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

It is too soon to analyse the implications of exit from the EU although the maritime market is global. Whilst there may be short-term impacts in Europe, the maritime industry in the UK is sufficiently well balanced and advanced to withstand them from both technological and operational standpoints. It is essential that the UK keeps ahead of its competitors and is seen to be taking the lead in ensuring that autonomous vessels, and the systems which make them competitive and effective, can operate safely wherever there is a need across the world.

Maintaining the competitive edge in technology requires strong government engagement. EC funding through HORIZON 2020 has supported research and development on a range of MAS projects which have benefited UK based consortium members. Alternative funding sources will need to be established, post-Brexit, to avoid impacting on the UK's ability to stay at the forefront of technology in the sector.

21 October 2016

**GLOSSARY**

CCAV	Centre for Connected and Autonomous Vehicles
Dstl	Defence Science and Technology Laboratory
EEZ	Exclusive economic zone

Maritime Autonomous Systems (MAS) Council of the Society of Maritime Industries –  
Written evidence (AUV0015)

IMO	International Maritime Organisation
LEP	Local Enterprise Partnership
MAS	Maritime Autonomous Systems
MAS RWG	Maritime Autonomous Systems Regulatory Working Group
MASSMO	Marine Autonomous Systems in Support of Marine Observations
MSC	Maritime Safety Committee of the IMO
NERC	Natural Environment Research Council
RAS SIG	Robotics and Autonomous Systems Special Interest Group
SMI	Society of Maritime Industries
UAV	Unmanned Air Vehicles
USV	Unmanned Surface Vehicles
UUV	Unmanned Underwater Vehicles
ROV	Remotely Operated Vehicles

Professor Natasha Merat, University of Leeds, Andy Graham, White Willow Consulting and Professor Sarah Sharples, University of Nottingham – Oral evidence (QQ 55-62)

**Professor Natasha Merat, University of Leeds, Andy Graham, White Willow Consulting and Professor Sarah Sharples, University of Nottingham – Oral evidence (QQ 55-62)**

[Transcript to be found under Professor Sarah Sharples, University of Nottingham](#)

**Professor Natasha Merat, Institute for Transport Studies (ITS), University of  
Leeds – Supplementary written evidence (AUV0092)**

Thanks again for the opportunity to provide oral evidence. I thought the discussions were great but I wanted to add a few more details to my evidence and also include a couple of interesting recent papers which I thought members might want to see, should they have the time.

1. In terms of pedestrians' understanding of automated vehicles (AVs), there is now some effort by manufacturers such as BMW, Volvo and Nissan (and surely others) to consider communicating their intentions, using lights and words etc. While these are currently prototypes, this area is one which has been largely ignored by research and proves to a very complicated topic, since cultural, regional and even within city differences in pedestrian and cyclists' behaviour is a very complex area for human drivers to understand – never mind the sensors and cameras of a AVs. Therefore, standards, i.e. what a green light means versus a blue light, are essential in this context.
2. I think one area currently absent in this field is understanding of the drivers' attention and state when AVs are active and what would happen if the AV has to hand back control. Some manufacturers have suggested a minimum risk manoeuvre, which involves the car coming to a safe and complete stop, but this is clearly very dependent on the road infrastructure (and quite dangerous, for example on the busy M1!). Should there then be some consideration of camera-based driver monitoring systems for future vehicles at SAE Level 3 and up? Of course there are data and privacy considerations to be taken into account.

I would like to highlight three articles which I believe will be useful to the committee – and my apologies if these have already been identified.

1. The NHTSA Automated Vehicle Policy document<sup>172</sup>
2. A recent Scientific American article by a colleague at UC Berkeley, which I think provides some thoughts on the realistic capabilities of AVs.<sup>173</sup>
3. An RCCO study on how “automated vehicles can influence urban form, congestion and infrastructure delivery”.<sup>174</sup> This paper was reported for Ontario, Canada. It is perhaps a little utopian, but then relays my thoughts on how in the UK, we could use these vehicles a little differently to others, if we consider their benefits, longer term. Although I do appreciate that regular changes in government makes this a challenging ambition!

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<sup>172</sup> <http://www.nhtsa.gov/nhtsa/av/index.html>

<sup>173</sup> <https://www.scientificamerican.com/article/what-self-driving-cars-will-really-look-like/>

<sup>174</sup> [http://rccao.com/research/files/RCCAO\\_Vehicle-Automation\\_OCT2016\\_WEB.pdf](http://rccao.com/research/files/RCCAO_Vehicle-Automation_OCT2016_WEB.pdf)

Professor Natasha Merat, Institute for Transport Studies (ITS), University of Leeds –  
Supplementary written evidence (AUV0092)

*Author: Professor Natasha Merat, Chair in Human Factors of Transport Systems, Leader,  
Human Factors and Safety Group, Institute for Transport Studies (ITS), University of Leeds*

*24 November 2016*

## Met Office – Written evidence (AUV0081)

### Introduction

1. The Met Office is the UK's National Meteorological Service, a Public Sector Research Establishment and an Executive Agency of the Department for Business, Energy and Industrial Strategy. We are responsible for monitoring and forecasting the weather and conducting scientific research to support, develop and improve these capabilities. In addition we host the Met Office Hadley Centre for Climate Science and Services, which delivers policy relevant climate science and advice.
2. The Met Office's interest in this inquiry is primarily focussed on two key areas, firstly the positive opportunity autonomous vehicles (AVs) present for the essential task of gathering observations, and secondly the importance of considering the potential for severe weather to interfere with AV sensors. Further research and testing is required in both these areas, and the technical expertise in the UK, coupled with the diverse and challenging weather conditions here make it an ideal location for testing these technologies.
3. It is in the context of these roles, responsibilities and interests that we reply to this call for evidence.

### Q1. What are the potential applications for autonomous vehicles?

4. Meteorological and oceanographic observations are an essential input to our modelling and underpin our ability to forecast the weather and future climate. Observations are also an essential part of verification of forecasts and analysis of current and past climate. AVs are likely to provide important platforms for observations in the future on land, on sea and in the air. Considering each of these domains in turn:-

#### Land: Autonomous Road Vehicles

5. In order to function, autonomous road vehicles will have suites of sensors as part of the standard equipment. The output from these sensors is likely to contain some (indirect) information about the prevailing weather conditions which is potentially a valuable source of information. In addition, there is the possibility of being able to enhance the standard sensor suite with more specific meteorological sensors. In a symbiotic relationship, data from autonomous vehicles could allow weather conditions to be analysed in greater detail; in turn improving weather forecasts and benefiting vehicle operation by assisting in the management and mitigation of weather related risks (see also response to Question 11 below). Ultimately this significant increase in data could lead to enhanced highways management during severe weather, better warnings and safer operating conditions for emergency services.

#### Sea: Autonomous Marine Vehicles

6. Obtaining observations from the seas around the UK is particularly challenging because of the cost of deploying traditional platforms such as ships and buoys and the often fixed nature of these platforms. AVs, such as wave gliders, offer the possibility of

greater coverage of observations at reduced cost. Subsurface AVs are of particular interest due to the scarcity of sub-surface observations in our shelf seas environment. There is also the possibility of directing observation platforms to locations where weather conditions are expected to evolve rapidly, or are otherwise important for the evolution of the forecast. Should these AVs prove comparable in accuracy to traditional observing methods, this increase in data could provide benefits to weather models and forecasts. In turn this could improve the decision making tools available to organisations such as the Coast Guard, increasing the safety of lives at sea.

**Air: Unmanned Aerial Vehicles (UAVs)**

7. UAVs for meteorological observation have been under development for several years with the aim of potentially supplementing meteorological data we currently have access to, such as that from manned commercial aircraft. Particular benefits from UAVs could come from the ability to investigate phenomenon or areas where observations are traditionally scarce. At present their use is largely confined to specific observation projects for scientific research and development. This is because the regulatory requirement for their operation to be fully supervised at all times has a large impact on the cost and benefit of operation of this type of platform. Should this requirement be relaxed in future, the use of autonomous vehicles for routine upper-air meteorological observation is likely to expand considerably; particularly as UAVs are an area where performance and costs of production and operation are rapidly improving.

**Q2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

8. From a Met Office perspective, autonomous vehicles on land, sea, and in the air offer the possibility of increasing the volume and/or scope of observational data. Of particular interest is the prospect of cost-effective data acquisition in some areas/environments where there has historically been a lack of alternative sensor platforms. This in turn could produce benefits in forecast accuracy and, ultimately, the critical decisions made by those who rely on weather and marine forecasts. As the UK is in the early stages of planning and testing AVs, we have the opportunity to design the systems in such a way as to deliver maximum additional benefit. This could be, for example, by encouraging an open data approach with standard, rather than proprietary, formats and access methods.
9. With regard to potential disadvantages, operation of all vehicles - manned or autonomous - are to some extent sensitive to the prevailing weather conditions, and the weather can present particular challenges for autonomous vehicle design and operation which will need to be considered (see answers to questions 6 and 11 below).
10. Finally, it is assumed that AVs will have a reliance on global satellite navigation systems such as GPS and from our position as the UK's Space Weather Operations Centre and space weather risk owner, we think it important to consider the risk posed to these systems by space weather events. During a reasonable worst case event, the GPS signal may be degraded or completely lost for 1-3 days. However there are also parts of the globe where GPS signals are interrupted on a daily basis due to space weather activity.

This potential risk should also be factored into planning and decision making around large scale deployment of AVs.

**Q6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

**Land**

11. The current generation of autonomous road vehicles rely upon lidars, radars and camera type sensors. It is our experience that all can suffer either degraded performance, or even misleading output, in specific severe weather conditions. Indeed severe weather issues are often cited as one of the key obstacles in the development and adoption of autonomous vehicles<sup>175</sup>. With this in mind, those involved in the test environment should consider reproducing weather conditions that are representative of the conditions likely to be encountered in future routine operation, including the extremes. This is so that any weather-related degradation in sensor or vehicle performance during tests can be properly understood. The UK has some of the most challenging and diverse weather conditions in Europe which makes it an ideal location for testing and developing the technologies.
12. It may also be important to be able to relate the weather conditions experienced during tests to the climatology<sup>176</sup> – not just the climatology of the test site but also different regions of the UK and the rest of the world. This will enable any test results relating to weather sensitivities to be readily translated to more widespread operation. The use of detailed meteorological observations should also be considered in the development of vehicle sensor suites.

**Sea**

13. The Met Office has provided support to several exercises involving the testing of unmanned vehicles in the marine environment, including those co-ordinated by the National Oceanographic Centre<sup>177</sup> and the Royal Navy's recent Exercise Unmanned Warrior<sup>178</sup>. These exercises have been ambitious and included the collection of additional environmental data, which is being used to validate and improve the models that inform oceanographic forecasts.

**Q11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

14. At this stage in their development, it is difficult to judge the future extent of weather sensitivities in autonomous road vehicle operation. However, it may be desirable to establish a strategy for the mitigation and management of weather-related risks associated with the routine operation of AVs, prior to their extensive deployment. Depending upon the scale of residual risks that are identified (which also depends upon

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<sup>175</sup> <https://www.endurancewarranty.com/learning-center/shoptalk/tech/self-driving-cars-bad-weather/>

<sup>176</sup> A historical record of weather which provides context to the current weather i.e. whether the conditions are normal or abnormal.

<sup>177</sup> <http://noc.ac.uk/>

<sup>178</sup> <http://www.royalnavy.mod.uk/news-and-latest-activity/operations/uk-home-waters/unmanned-warrior>

technical progress up to that point), a plan for the operational management of residual risks will then need to be developed and implemented.

## **Mills & Reeve LLP – Written evidence (AUV0035)**

### **INTRODUCTION**

This document is in response to the call for evidence in relation to Autonomous Vehicles issued by House of Lords Select Committee on Science and Technology in September 2016 (the “**Consultation Document**”).

Mills & Reeve is a national UK law firm with 117 partners and a total strength of around 900 staff operating from 6 offices including London, Manchester, Birmingham and Cambridge. Mills & Reeve was named as one of the top five UK law firms in the latest edition of industry “bible”, Chambers UK. This year more than 60 per cent of our service areas are ranked in Band 1, the highest percentage of any top law firm.

Mills & Reeve acts for a range of clients who have an interest in the development of driverless cars including automotive manufacturers and suppliers to automotive manufacturers and insurers. We advise a range of clients on issues relating to driverless cars and therefore have a close interest in seeing that a robust legal and regulatory framework is put in place.

For the purpose of this response, we have quoted relevant headings from the Consultation Document and have also repeated the questions asked.

### **IMPACTS AND BENEFITS**

#### **Question 1: What are the potential applications for autonomous vehicles?**

1. As indicated by the Consultation Document there are many potential applications for autonomous vehicles. These include:
  - Privately owned vehicles, used exclusively by their owners or made available through the sharing economy;
  - Public transport;
  - Private and shared taxi services;
  - Shared private use vehicles made available through commercial fleet services;
  - Transport provision for disabled, elderly or under-age users;
  - Freight transport;
  - Commercial, industrial and construction site movements;
  - Agricultural and horticultural activity.

2. This technology has the potential to transform transportation in almost every context.

#### **Question 2: What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

3. Potential user benefits include:
  - Improved safety profile gained through the removal of driver error together with machine learning and artificial intelligence;

- Potential for cost savings through shared use of private vehicles, use of fleet vehicles or driverless taxis;
  - Improved mobility for those currently unable to drive; and
  - Better use of time through ability to engage in other activities during journeys and reduced congestion.
4. Potential user disadvantages include:
    - Loss of personal privacy due to information sharing and service targeting;
    - Interference with the functioning of the vehicle as a result of hacking, computer malfunction etc;
    - Loss of the enjoyment of driving; and
    - Potential increase in journey length or frequency of journeys (due to spending time in the vehicle doing things other than driving) which could lead to increased congestion.
  5. While not affecting users the following benefits and disadvantages to society as a whole can also be identified.
  6. Potential societal benefits:
    - Reduction in emissions and congestion due to more efficient vehicle use;
    - Reduction in the overall fleet size as shared use vehicles become more readily available;
    - Reduction in the need to provide parking, particularly in urban centres, workplaces, etc.
    - Removal of the need to allow for rest periods for drivers in relation to public transport, freight, etc.
  7. Potential societal disadvantages:
    - Loss of employment for drivers; and
    - Increased burden on the state to provide and maintain adequate connected infrastructure, network capacity, etc.

**Question 3: How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

8. Much of the attention so far has been given to personal and freight transport. Testing of autonomous and semi-autonomous vehicles for personal transport is now being undertaken in several countries. Freight-related projects are also under way, such as the European Truck Platooning Challenge completed in April 2016.
9. While these projects are fairly widespread detailed data on testing results is not readily available due to the early stage of these projects and/or commercial confidentiality. We expect that data from the current UK testing programmes will be made publicly available as those trials progress.
10. One of the more advanced projects is the testing by Google Inc. of its self-driving car in the United States. A report published in January 2016 by Virginia Tech Transportation

Institution, funded by Google Inc. provided information about safety of that project to date. The report sought to compare published crash rates for Google's self-driving cars with recorded crash data in the United States. The authors identified inconsistent recording approaches between US states and an estimated frequency of unreported crashes of between 15.4% to 59.7% as complicating factors. Having adjusted for underreporting and for crash severity, the report found that crash rates for Google's self-driving car operated in autonomous mode were lower than current national crash rates.

11. However, the report acknowledged that the number of miles driven by the self-driving cars were low compared with national miles driven, giving rise to uncertainty in the statistics.
12. It is notable that after 2.3 million miles of which 1.3 million were in autonomous mode, Google's self-driving car had been involved in 16 crashes (11 with the car in autonomous mode).

[http://www.vtti.vt.edu/PDFs/Automated%20Vehicle%20Crash%20Rate%20Comparison%20Using%20Naturalistic%20Data\\_Final%20Report\\_20160107.pdf](http://www.vtti.vt.edu/PDFs/Automated%20Vehicle%20Crash%20Rate%20Comparison%20Using%20Naturalistic%20Data_Final%20Report_20160107.pdf)

**Question 4: How much is known about public attitudes to autonomous vehicles?**

13. While a number of surveys and polls have been carried out we are not aware of rigorously collected, statistically significant data that can provide a definitive picture of public attitudes to autonomous vehicles.
14. The results of any survey or poll should, in our view, be treated with significant caution as there is a lack of understanding regarding autonomous vehicles and therefore responses tend to be negative or cautious due to a healthy fear of the unknown.

**Question 5: What is the scale of the market opportunity for autonomous vehicles?**

15. No response.

**CREATING AN ENABLING ENVIRONMENT**

**RESEARCH AND DEVELOPMENT**

**Question 6: Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

16. No response.

**Question 7: Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

17. The Government is making an active and high-profile contribution to research and development in this area. Compared with other governments, the UK is notably encouraging and positive towards the development of driverless technology.

**Question 8: How effective are Innovate UK and the CCAV in this area?**

18. Both Innovate UK and CCAV have made impressive contributions to the debate and testing regime. The approach of enabling private sector activity is probably the most effective way to achieve progress.

**Question 9: Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

19. No response.

## **REAL WORLD OPERATION**

**General comments on the Government's approach to driverless technology**

20. We agree with the principle of responding to technological changes as they come to market. However, we consider that there are risks involved with the approach outlined in the Government's July 2016 consultation document "Pathway to Driverless Cars: Proposals to support advanced driver assistance systems and automated vehicle technologies".
21. With increasing degrees of automation drivers will increasingly come to rely on the technology within the vehicle to deal with both normal driving tasks and emergency situations. A gradual transition towards greater autonomy may lead drivers to place unwarranted reliance on vehicle systems with the result that they are not in reality "in-the-loop" when required to take action. Manufacturer instructions to drivers to maintain focus and be ready to take back control of the vehicle when required may be effective in some instances, but the following issues arise:
  - Reduced reaction time at low workloads and a resulting inability to regain sufficient control within a sufficiently short time period
  - Distraction while the vehicle is in autonomous mode
  - Loss of driving skills
22. As we explained in our response to the Government consultation carried out in August and September 2014, "Review of the legislative and regulatory framework for testing driverless cars" (available here <http://www.mills-reeve.com/files/uploads/Documents/PDF/Driverless-cars-consultation-Sep-2016.pdf>), we consider that the best way forward is to require the inclusion of autonomous critical event control systems within vehicles having more than a minimal degree of autonomous function.
23. Google is reported to have introduced a driverless vehicle without a steering wheel or pedals after having allowed its own employees to use test vehicles. Despite repeated warnings, after an initial period of monitoring, car users would relax and let the system take over. They would then become distracted and no longer actively monitor the vehicle. Google is then reported to have concluded that it was too risky to create a system relying on drivers to take back control in an emergency. We understand that Google concluded that it was safer not to let the human drivers retake control in an emergency situation.

[https://www.washingtonpost.com/local/trafficandcommuting/self-driving-cars-reach-a-fork-in-the-road-and-automakers-take-different-routes/2016/08/24/5cdeaba8-63d9-11e6-8b27-bb8ba39497a2\\_story.html](https://www.washingtonpost.com/local/trafficandcommuting/self-driving-cars-reach-a-fork-in-the-road-and-automakers-take-different-routes/2016/08/24/5cdeaba8-63d9-11e6-8b27-bb8ba39497a2_story.html)

24. This is supported by a recent Canadian public opinion survey carried out in May 2016 by the Traffic Injury Research Foundation (TIRF) in partnership with the Toyota Canada Foundation (TCF). Over 2,600 Canadian drivers responded to a poll that investigated driver knowledge, attitudes, and practices in relation to semi- and fully-autonomous vehicles. Of these, 16% strongly agreed that it would be unnecessary to pay attention to the road environment when using the self-driving feature of a semi-autonomous vehicle.

[http://www.tirf.ca/media/news\\_show.php?nid\\_id=201&lid=1](http://www.tirf.ca/media/news_show.php?nid_id=201&lid=1)

25. In our view, as increasing levels of automated driver assistance features are introduced, the autonomous emergency systems become increasingly critical such that they should be mandated in vehicles with increasing levels of automated driver assistance. For example, if a highway assist function is available on a vehicle, there should be a complementary autonomous emergency braking system which is capable of operating at all times and speeds that the highway assist function is in operation. Any limitations to the AEB system (for example if it only operates at speeds up to 110kph), should mean that the highway assist function is similarly limited (ie is only capable of functioning at speeds up to 110kph). Such an approach ensures that the increased risks identified above of the advanced driver assist functions are mitigated by the requirement to include complementary autonomous critical event control systems.

**Question 10: Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

26. No response.

**Question 11: How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

27. We refer to our general comments above. We consider that a gradual transition to fully-autonomous vehicles with incremental degrees of automation to be potentially dangerous. We consider that the question of autonomous critical event control in all vehicles with sophisticated driver assistance systems should be addressed at an early stage, with a requirement that suitable emergency systems be included in all such vehicles. To fall back on driver intervention in the event of an emergency is, in our view, unrealistic.

**Question 12: Does the Government have an effective approach on data and cybersecurity in this sector?**

28. The Government has begun to tackle the issues of data protection and cybersecurity in this sector, but these proposals are not yet at an advanced stage. However, general rules on the protection of personal data are already stringent and provide a suitable basis for development.

**Question 13: Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

29. We note from the Government's proposals set out the consultation document "Pathway to Driverless Cars: Proposals to support advanced driver assistance systems and automated vehicle technologies" that it plans to address a series of regulatory and insurance matters in the forthcoming Modern Transport Bill. We have provided our comments on those proposals in our response to that consultation (available here <http://www.mills-reeve.com/files/uploads/Documents/PDF/Driverless-cars-consultation-Sep-2016.pdf>). We consider the proposals to be generally sensible subject to our concerns highlighted above around the issue of autonomous critical event control.

**Question 14: What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

30. We consider that the ethical discussion around autonomous vehicles has been over-emphasised and is somewhat artificial. We discuss this in more detail in our briefing entitled "Why we should get used to the idea that self-driving cars will sometimes crash" (available here: <http://www.mills-reeve.com/files/Uploads/Documents/Autonomous-Vehicles-Article-Is-it-an-ethical-or-a-legal%20question.pdf>). While it is possible to imagine scenarios in which the self-driving car will make the "wrong" choice judged by human standards, overall the expected improvement in safety will provide a real, practical safety benefit to road users.

## **WIDER GOVERNANCE**

**Question 15: What does the proposed Modern Transport Bill need to deliver?**

31. We refer to our response to the Government consultation, "Pathway to Driverless Cars: Proposals to support advanced driver assistance systems and automated vehicle technologies". We are generally supportive of the proposals, with some reservations. In particular, we consider that more should be done in order to address the question of autonomous critical event control.

**Question 16: How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

32. No response.

**Question 17: Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

33. We consider that addressing individual and freight transport are the most pressing concerns given the advanced state of development and potential impact on public safety. Applications in other areas will be able to follow and benefit from the developments in these areas.

**Question 18: What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from**

**the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

34. The Government is at the forefront of the deployment and testing of autonomous vehicles. However, important initiatives at European Union level, such as the Platform for the Deployment of Cooperative Intelligent Transport Systems in the European Union (the C-ITS Platform), have the potential to offer a co-ordinated approach to addressing the technical and regulatory issues surrounding autonomous vehicles.
35. The C-ITS Platform has recommended that the European Commission co-operates with non-EU governments in order to promote international consistency. However, Brexit is likely to lead to the UK being able to exert significantly reduced influence over how these projects develop, with a risk that the UK will have to follow rules established by others in order to produce vehicles suitable for the European market.
36. At the same time, the UK may benefit from greater freedom to develop regulation to meet with national objectives, and may be able to move more swiftly towards adoption of autonomous vehicles.

*25 October 2016*

Milton Keynes Council, GATEway (Greenwich Automated Transport Environment) and Bristol driverless cars project – Oral evidence (QQ 31-39)

**Milton Keynes Council, GATEway (Greenwich Automated Transport Environment) and Bristol driverless cars project – Oral evidence (QQ 31-39)**

[Transcript to be found under GATEway \(Greenwich Automated Transport Environment\)](#)

## **Motorcycle Action Group (MAG) – Written evidence (AUV0073)**

*This responds to the questions set by the Committee from the point of view of the UK motorcycling community, which numbers approximately 1.5 million regular riders and about 5.5 million fully qualified riders. The Motorcycle Action Group (MAG) is the leading voice for motorcyclists in the UK and hopes it will be permitted to share its perspective in person at forthcoming hearings.*

### **1. What are the potential applications for autonomous vehicles?**

MAG sees the application of autonomous technology in the context of powered two wheelers as ‘on a scale’ largely stopping short of full autonomy. This is because, for many riders, the act of riding is itself an attractive benefit of motorcycling. Thus, improvements in safety and convenience are the key draws for riders.

Full autonomy for motorcycling would not generally be regarded as appealing to riders, though MAG recognizes that there may be specific applications for fully autonomous powered two wheelers on the grounds of economy, compactness and in terms of opening up the pleasures of riding to individuals who would not wish to commit themselves to the more traditional demands of motorcycling regarding skills and effort.

### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

Benefits include:

- a) added safety features, which reduce the risk of human error by the rider.
- b) Interactivity with other road users, which reduce the risk of collision through failure to see an approaching motorcycle.
- c) Reduced workload for the rider.
- d) The opportunity for non-motorcyclists to benefit from the economy, agility and enjoyment of motorcycling and scooter technology.

Disadvantages could include:

- a) The risk of human error as a result of increased reliance on automated systems, thereby creating secondary hazards of human failure to intervene when overriding the automatic systems could have prevented an accident.
- b) Any move to create separate traffic space for autonomous vehicles, thereby effectively demoting conventionally controlled vehicles in terms of their road status. This is a major concern for riders, who explicitly choose motorcycles as a manually controlled form of transport. The current strategy to create ‘hard segregation’ for bicycles has already had a detrimental effect on road space for powered two wheelers, increasing risk and congestion – and pollution as stationary and slow moving queuing has increased.

- c) Potential questions of liability in respect of whether the manufacturer or user of the vehicle is responsible. This could cause considerable stress in the legal system in the event of an accident involving a rider.
- d) A difference in the reaction times of autonomous vehicles and humans could cause accidents. For example, a human cannot brake as fast as the autonomous vehicle in front of them, and this leads to a rear end impact.
- e) Wrong interpretation of data by an autonomous vehicle, leading to an accident.
- f) Corruption of data or programme functions by faulty programming, systems failure or design.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

There is considerable data now available from various operators in the UK and abroad, including Google, Tesla and Otto, as well as other travel sectors such as commercial aviation. However, MAG believes little has been done to assess the interface specifically between autonomous vehicles and motorcycles, and this is an important element in understanding the actuarial risks associated with the new technology. MAG is also willing and eager to suggest certain tests and to participate in them in order to improve collective understanding of the interface between autonomous vehicles and motorcycles in the interests of safety and utility.

### **4. How much is known about public attitudes to autonomous vehicles?**

The Motorcycle Action Group has not conducted quantitative research on the question of rider attitudes towards autonomous vehicles. However, from a qualitative perspective, there is a consistent theme in terms of what bikers consider the key concerns regarding the new technology. These relate to rider safety and potential restrictions on road space for non-autonomous vehicles.

Motorcyclists are supportive of progress, as long as the risks and practical implications are fully understood and do not compromise existing road users. There is scope for a quantitative review of public attitudes – though, to get an authoritative viewpoint from people, consideration has to be given to the level of knowledge which currently exists amongst the population. This will change rapidly as autonomous systems become more prevalent, and the public becomes more informed. As such, a quantitative review needs to be very clear about its purpose.

### **5 What is the scale of the market opportunity for autonomous vehicles?**

MAG believes there is scope for partial application of autonomous technology in the powered two wheeler sector, where this delivers safety and convenience benefits. Most high value motorcycle engines are already immensely complex and rely on extremely advanced autonomous engine management systems. However, at the budget end of riding, where less wealthy citizens depend on their motorbike or scooter to keep commuting costs to an absolutely minimum, any new technology which significantly increases purchase or maintenance costs is unlikely to achieve much market penetration and will not be welcomed by this community of commuters.

## **Research and Development**

### **6 Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

No. The current research environment depends almost entirely on the private sector to take advantage of the enabling conditions which the Government has laudably generated in the UK. However, aspects of the technology that are not necessarily in manufacturers' interest to assess – such as the knock-on effects to other road space users - may currently not be receiving the attention they require. The interface between autonomous vehicles and powered two wheelers appears to fit into this category.

### **7 Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

It follows from the answer to question 6 that MAG believes areas of little commercial relevance to the private sector would benefit from dedicated, Government supported research – either through a mandate to the sector or through direct public investment.

MAG is aware that these questions are rightly being considered by the Centre for Connected and Autonomous Vehicles (CCAV). MAG has made a submission to its recent consultation on these matters. We are more than happy to supply a copy of MAG's response on request. We would invite the Government to work with interest groups such as MAG to ensure that nothing has been missed in the process of proving the new technology. The risk of not doing so could be a counterproductive increase in accidents - as a result of unintended consequences arising from insufficiently thought out use of the new technology, leading to problems between manually controlled and autonomously controlled vehicles.

### **8. How effective are Innovate UK and the CCAV in this area?**

MAG has not interacted directly with Innovate UK. However, the Motorcycle Action Group has worked extensively with the CCAV. We have found their approach very impressive. They are entirely open to engagement and suggestions. We regard their comprehensive approach to consultation is very much in line with promoting the responsible evolution of the new technology and its practical applications.

### **9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

MAG has not had direct experience in this regard. However, we suggest that the Motor Cycle Industry Association may be able to furnish the Committee with a more detailed perspective – though, as already stated, autonomous vehicle technology is at this stage less prevalent in the motorcycle sector than it is in the four wheel sector.

## **Real world operation**

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

There is one aspect of this question which is highly relevant to motorcycling – collision avoidance. If this can be improved through autonomous technology, then there are strong grounds to ensure a continuous, robust WiFi environment which ensures that outages will not endanger the general road using community. Obviously, as far as MAG is concerned, we are primarily concerned with motorcyclists: however, this must surely apply to all vehicles and pedestrians.

If there is any risk of outages preventing manual override or the general prevention of accidents, then the infrastructure must be reviewed and made robust. For example, MAG observes that latency could become a serious issue if the digital infrastructure is overloaded by very high data transfer requirements, on account of a large number of autonomous or semi-autonomous vehicles. This issue of sufficient data transfer is important and probably requires Government intervention, as it is an infrastructure project that transcends the needs of individual companies.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

The move must take into account the issues listed in the other answers provided by MAG. This would imply the following milestones must be met:

- i) Demonstrable evidence that the technology is as safe or safer than current modes of control of vehicles.
- ii) Empirical evidence that no user group, such as the motorcycling community, is especially compromised in terms of freedom to operate or in terms of safety.
- iii) Cybersecurity protocols are established up to an agreed and specified industry standard.
- iv) Clarity is achieved regarding liability.
- v) A route map is generated to ensure sufficient digital infrastructure exists to accommodate predicted volumes of autonomous vehicles.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

Not yet. MAG believes that this issue has been acknowledged by the CCAV. It is, nevertheless, necessary to ensure that the solutions are in place before mass roll out of human carrying vehicles, which will necessarily involve large quantities of kinetic energy and potentially act as lethal devices if the systems are breached by a malicious third party. Solutions already exist. They simply have to be implemented.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

The Motorcycle Action Group has provided an extensive answer to this question in a previous consultation by the CCAV. We are happy to provide these longer comments on

request. To summarise and for the sake of brevity, the key goal is to ensure that no ambiguity exists regarding liability. This has to be achieved because motorcyclists – and for that matter other road users - deserve fairness of treatment in the event on an accident. They cannot be expected to muster the resources to mount a legal challenge against, for example, a massive multinational firm which would potentially be motivated to invest a large amount in legal defence to avoid a precedent which could be immensely costly in terms of future liabilities.

It is perfectly possible that the existing regulatory framework regarding insurance is adequate, but this needs to be tested prior to mass scale use of the machines.

Separately, the regulatory structure as a whole must err on the side of caution. Other road users must be confident that the overall regulatory framework is balanced and does not solve problems of co-existence by just separating autonomous and non-autonomous traffic at the expense of more lost road space for existing conventional vehicle users.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

There are two ethical issues.

Firstly, if anyone is killed as a result of automated decision-making, who is morally – and thus legally – liable for it? For example, does the fault lie with the designer of the scheme, the specific programmer who wrote a faulty script or the individual who successfully ‘hacked’ into the system?

Secondly, if there is an accident while the autonomous vehicle is being operated and the user does not exercise some kind of manual override – perhaps because they are incapacitated, for example through drink - should the individual be exonerated from liability, or is there NEVER a situation whereby someone who could have taken control is excluded from liability in this scenario? As an addition to this latter point, should there be a specific waiver which is entered into formal records to say that some individuals are physically or mentally incapable of taking control of a vehicle, and that they are indeed excluded from liability? MAG is eager to discuss these matters with the Committee.

**Wider governance**

**15. What does the proposed Modern Transport Bill need to deliver?**

The Motorcycle Action Group believes that the Bill offers an opportunity to introduce ‘light touch’ legislation to address all the practical, legal and moral issues which autonomous (and connected) vehicles present. These issues are now becoming recognized, but the legislation must also be flexible enough to embrace future developments which cannot yet be conceived in specific terms, but which may be understood in principle. For example, the Bill needs to be framed so as NOT to promote segregating autonomous, connected and human-controlled traffic – a move which would reduce the overall flow of traffic and further increase congestion and pollution.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

MAG has no formal involvement with the UK education system in terms of promoting or requiring these skills. Familiarity with the principles of connected and autonomous vehicles are an important element in road planners' understanding and experience.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

MAG believes that it is not the Government's role to seek to innovate in this sector, except in as much as it may enable socially beneficial outcomes to accrue from the new technology. Government also needs to ensure that no negative consequences accrue as a result of these innovations.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

Again, MAG does not hold a particular view on this question, but believes that the Motor Cycle Industry Association may offer a candid perspective on behalf of the industry itself.

## **CONCLUSION**

The Motorcycle Action Group would request the opportunity to provide oral evidence to the Committee to assist with its considerations in a constructive context, and hopes that the Committee would be minded to make such an invitation.

*26 October 2016*

## National Oceanography Centre (NOC) – Written evidence (AUV0056)

### **Summary:**

The UK is a global leader in the development and deployment of Marine Autonomous Systems.

These systems are very well suited to a range of maritime activities including survey, sustained observations, patrol and monitoring, pollution response, pipeline inspection and a range of defence applications.

Marine Autonomous Systems offer considerable cost savings over the use of a ship with a human crew (particularly the long-range systems that do not require a ‘mother ship’), can be operated in hazardous waters or under ice without risk to life, and can be operated if necessary in large numbers. They do not yet have sufficient dexterity or artificial intelligence to carry out all of the operations of a ship with a human crew, but future advances will lead to constant improvement in capability.

There are considerable gaps in insurance, regulation and legislation in the UK and international maritime law that can present formidable challenges to ‘early adopters’ of this technology, but the user community is working together to produce Codes of Conduct and recommendations to international bodies.

There is potential for wealth creation from the development and use of Marine Autonomous Systems (including conversion of existing ships to autonomous operation) and there is also potential to grow the supporting insurance, licensing and training sectors.

Very few modifications are required to existing infrastructure.

### **Introduction**

Recognising that the main thrust of this inquiry concerns driverless land vehicles, the National Oceanography Centre submits for your consideration responses to the Committee’s questions that reflect the wider implications of autonomy in a marine context, as it is an area of science, engineering and technology where the UK is at the forefront of global developments and where we are recognised as leaders in the field.

There are many cross-cutting issues that are of equal concern to land, air and sea-based autonomous systems, including the legal regime under which they operate, licensing, insurance, and especially the need to avoid collision or interference with human-occupied vehicles.

The National Oceanography Centre is wholly owned by the Natural Environment Research Council [www.nerc.ac.uk](http://www.nerc.ac.uk) and is based at sites in Southampton and Liverpool. NOC is NERC’s centre of excellence for oceanographic sciences with a remit to provide leadership and national capability in the marine sciences from coast to deep ocean.

Since the late 1980s at our predecessor institution the Institute of Oceanographic Sciences Deacon Laboratory, through to today’s National Oceanography Centre, UK scientists and engineers have pioneered the design, construction and deployment of advanced Marine Autonomous Systems, surface and sub-surface, self-propelled or drifter, and we remain global leaders in the real-world application of autonomy, and the development of appropriate safe systems of work and governance mechanisms.

## Responses to Questions

### 1. What are the potential applications for autonomous vehicles? –

1.1 In the maritime context, autonomous vehicles (sub-surface or surface-based) have been deployed since the 1990s to perform a variety of duties including:

- Data acquisition for marine scientific research
- Fisheries research
- Defence applications
- Pollution monitoring
- Surveillance and reconnaissance
- Seabed survey
- Pipeline inspection
- Surveys in dangerous or hard-to-reach waters such as underneath ice caps or mid-winter storms.

Note that the marine user community is settling on the term '**Marine Autonomous Systems**' (MAS) to define the unmanned vehicles/platforms and free-roaming sensors that operate at sea, with subdivisions into surface (MAS-S) and underwater (MAS-U) types, and these terms will be used through the rest of this submission. The acronyms **AUV** (Autonomous Underwater Vehicle) and **USV** (Unmanned Surface Vehicle) are commonly used by the community.

1.2 In the near future it is reasonable to envision the everyday use of Marine Autonomous Systems of increasing size and sophistication to undertake duties that are currently performed by human occupied platforms such as workboats, cargo ships and warships, subject to updated marine safety legislation, licensing of operators, insurance cover, redundancy of systems, appropriate Rules of Engagement (for military users) and the level of on-board artificial intelligence. The carriage of passengers is far less likely in the short term due to safety requirements in case of emergency.

1.3 Small, relatively inexpensive Marine Autonomous Systems are particularly well-suited to tasks that require repeated observations of clearly defined parameters such as seawater physical and chemical properties, measurement of underwater sound, monitoring security or checking integrity of structures at sea over a sustained period. Having much lower operation costs than a research or survey-class vessel with crew, extended duration operations or a denser network of sampling become affordable, and would for example help the UK meet any obligations that arise from national, European and international marine environmental protection treaties, laws and conventions. For example, long-range Marine Autonomous Systems (Surface) could patrol Marine Protected Areas in British Overseas Territories at a small fraction of the cost of crewed vessels, particularly as endurance and reliability of systems improves, and through use in conjunction with satellite or aerial remote sensing.

1.4 Marine Autonomous Systems are excellent platforms for observations in hazardous or severely polluted waters and during extreme weather conditions where a conventional ship would have to seek shelter or heave-to until wave conditions subside.

1.5 For a surface vehicle, use without crew but *without* autonomy (i.e. by remote control from shore or mother ship) is relatively straightforward to implement, as ships have plenty of on-board power for communication systems, few weight or space restrictions, and compared with a land or air vehicles low velocities and some degree of flexibility in decision response time. Remote control of ships has been tested for specialised purposes such as mine clearance. Full size cargo ships could operate in the High Seas in autonomous or remote control mode, and receive a human crew as they approach coastal waters, marine protected areas, fragile ecosystems or more crowded waters.

1.6 Marine Autonomous Systems (Underwater) – widely known as AUVs within the industry, (for Autonomous Underwater Vehicles) are usually unable once submerged to use radio frequencies to maintain contact with a human operator and in most cases operate in fully-autonomous mode, requiring human intervention only at the start and end of a mission for deployment and recovery. It is possible to establish a data link with a vehicle once it is on the surface to update mission parameters or download low-bandwidth data, but for the majority of the time a Marine Autonomous System (Underwater) has to operate according to the pre-programmed mission subject to modification according to hazards or obstacles encountered and the level of artificial intelligence that is available.

1.7 As a consequence of having to operate without human intervention, Marine Autonomous Systems (Underwater) require sophisticated obstacle avoidance, reliable and redundant systems, the ability to self-diagnose faults and if necessary surface or return to base if a fault or low-power state is detected. In complex 3 dimensional environments such as underneath ice sheets that have a solid ‘lid’ above, the vehicles require skilled programming and sufficient artificial intelligence to navigate their way past obstacles that are not pre-determined on charts, and for military systems there are additional requirements for stealth and self-protection.

## **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

2.1 The greatest benefit from a maritime context is cost-saving compared to the use of a conventional ship with crew – though this is less so for short-range vehicles that still require a ‘mother ship’ for deployment, recovery and data download. Even short range Marine Autonomous Systems act as ‘force multipliers’ enabling a survey ship, research vessel or naval platform to gather data over a considerably increased area than it could do solo, or for the ship to ‘stand-off’ while the autonomous system carries out a hazardous task such as under-ice survey, or inspection of a wreck or hazardous object.

For long-range Marine Autonomous Systems, it can be possible to avoid the use of a ‘mother ship’ altogether, launching and recovering the vehicle from the shore, offering very considerable savings for long-term sustained observations in the marine environment by civilian, industry, research and defence users.

Due to the cost saving, the other major benefit that arises is the ability to increase the number of vehicles that can be deployed within the available budget. This increases density of observations and availability of data, and allows some level of redundancy if a system fails or is lost to natural hazards such as winter storm or entrapment in ice or fishing gear.

2.2 The National Oceanography Centre has already demonstrated the advantages of long range marine autonomy without a ‘mother ship’ with our Autosub Long Range vehicle, and with Marine Autonomous Systems (Surface) directly deployed from coastal locations such as the Isles of Scilly.

2.3 Smaller size than a conventional ship or submarine offers cost savings, but also enables a Marine Autonomous System to reach places and carry out tasks that are difficult for a full-size vessel, for example exploration of confined underwater spaces, operations in very shallow waters, operations in ultra-deep waters, and operations under ice. For defence users small size offers considerable benefits for systems that are used in a surveillance and reconnaissance role.

2.4 Drawbacks – There is still no full substitute for the human eyeball, brain and hands and until we have ‘true’ artificial intelligence, which may become available in coming decades, there will always be limitations to the tasks that can be assigned to Marine Autonomous Systems. The smaller platforms also have limited payload space, limited on-board energy compared with a ship, and are vulnerable to hijacking or theft by unscrupulous or criminal elements at sea.

2.5 Lacking complicated ‘manual handling’ systems limits the number of samples that could be taken and stored on board. There is no ability to repair even simple equipment failures such as a blocked pipe or water inlet, and for missions that need to interact with living creatures an autonomous system is far from capable of catching, retrieving and humanely analysing a fish – it will be many years before a robot can do such a thing, though with a sufficiently advanced telemetry system and virtual arms some tasks may be possible from a shore-based operator by remote control instead of autonomy.

2.6 Marine Autonomous Systems (Surface) can offer real-time video feed to human operators, but real-time communication is generally not available for underwater systems, unless the system is close to a parent vessel and ‘tethered’ by optical fibre or acoustic datalink.

### **3. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

3.1 Yes - the current national and international laws and customs of the sea did not evolve in the expectation that robots would one day roam the oceans, and there are substantial gaps - often an absence - of legislation regarding the use of Marine Autonomous Systems – see **3.9** below. For example when seeking advice from the UK’s Marine Management Organisation (MMO) as to whether we require a licence to deploy Marine Autonomous Systems, MMO staff have needed to make decisions through extrapolation of existing laws that apply to ships, and so have regarded our Autonomous Underwater Vehicles so far as ‘vessels’ – yet an autonomous ‘vessel’ has no bridge watch-keeper or lookout, cannot render assistance to a sailor in distress, may lack a Port of Registry and could potentially not carry any insurance.

3.2 NOC and our marine science partners have evolved safe systems of work that include

cooperation with the Marine and Coastguard Agency, Royal Navy and Hydrographic Office to issue Notices to Mariners, and liaison with fishermen and coastal communities in our areas of operation to educate the public. Basic actions include writing 'Harmless Scientific Instrument' in bold letters on the hull, the use of bright paintwork, flashing beacons and contact telephone numbers and email addresses so that if a vehicle is encountered by a marine or coastal user they can quickly confirm the non-hazardous nature and ownership of our vehicles.

3.3 In March 2016 the UK Marine Industries Alliance (MIA) launched the first industry Code of Conduct in respect of Marine Autonomous Systems (Surface), with the long term aim of establishing a pan-industry agreement in respect of the development, design, production and operation in advance of, and alongside the eventual establishment of governing regulations. It is a comprehensive Code of Conduct that covers industry responsibilities, health and safety, environment, product safety, design and construction, identification of the systems on the surface, assurance certification and authorisation for use, trade restrictions and export controls, operational responsibilities, regulatory and legislative compliance and training and development. The code can be viewed and downloaded at <http://asvglobal.com/wp-content/uploads/2016/03/UK-MIA-MAS-CoC-2016.pdf>

3.4 So far the lack of legislation has not substantially prevented the use of systems in a research context, and some potential military applications of Marine Autonomous Systems are by their very nature clandestine, but as the numbers, diversity of users, and especially the size of Marine Autonomous Systems increases, it can be expected that eventually a collision or other event will occur that endangers property and life, particularly if operators do not adhere to the recommendations of the Code of Conduct mentioned in 3.3.

3.5 As the sector grows, new or revised regulations are required to govern the safe operation of Marine Autonomous Systems (Surface) in particular – for submerged systems there are relatively few hazards to other users of sea space, except for operators of submarines or seabed equipment that could potentially be damaged by collision with one of the larger autonomous vehicles. However, conflict with fishing gear is a hazard, and larger vehicles could be of sufficient mass to endanger smaller classes of fishing vessel - for example Boeing's 2016 'Echo Voyager' AUV is 51 feet long and weighs 50 tons.

3.6 As the application of marine spatial planning continues to evolve across the world (e.g. in the UK the systems that are arising out of the Marine and Coastal Access Act (2009) and Marine (Scotland) Act 2010) there will be an opportunity to help ensure that autonomous underwater vehicles can be operated without fear of entanglement in fishing nets, which is the primary hazard currently faced by these systems, and to ensure that safe separation of operations can be carried out, for example by Marine Autonomous Systems engaged in survey work, marine science and environmental monitoring.

3.7 The UK's pioneering community of Marine Autonomous System users (who include the National Oceanography Centre, the Scottish Association for Marine Science, the Society of Maritime Industries, Royal Navy and manufacturers of marine autonomous systems) have helped place the UK in the global lead for autonomy at sea, and are well placed to work with the Marine Management Organisation, Marine Scotland, Ministry of Defence, Marine and

Coastguard Agency, Trinity House, Hydrographic Office and Marine Science Coordination Committee to help ensure that the UK has fit for purpose legislation and can liaise with international regulatory and marine science bodies to help our Best Practise become the industry standard across the world.

3.8 At International Bodies such as the Intergovernmental Oceanographic Commission of UNESCO and International Maritime Organisation the UK is seen as the ‘champion’ for Marine Autonomous Systems and is in position to help develop next-generation maritime legislation.

3.9 There is already some international experience in the global operation of Marine Autonomous Systems, mainly in the field of Marine Scientific Research. Since the 1990s Marine Autonomous Systems in the form of over 3000 ‘Argo’ floats (unguided small oceanographic instruments that drift freely on ocean currents, undulating between the surface and several thousand metres depth, collecting science data and transmitting to shore every few weeks when on the surface) have played a vital role in helping the international marine science community to advance their knowledge of the three dimensional structure of the global ocean, and its temperature, salinity and other parameters.

Argo operations that take place within the Exclusive Economic Zones (EEZ) of Sovereign States use the provisions of Part XIII (Marine Scientific Research) of the UN Convention on the Law of the Sea (see Article 247 of the Convention, assisted by IOC-UNESCO Resolution XX-6 and others).

Where floats (i.e. small Marine Autonomous Systems that drift on ocean currents or with the prevailing wind) are deployed in international waters, and begin to drift towards an EEZ, prior notifications are made to the relevant Sovereign State, because it is not possible to change the direction in which the float is travelling. A Sovereign State has the right to request that sensors on an Argo float are switched off while it transits their waters, or that data is not transferred to a public domain until they have reviewed the content. So far most countries have accepted the routine measurement of temperature, salinity and pressure within their EEZ without question but as more advanced sensors become available that measure biogeochemical and other parameters the situation becomes far more complex – a State can legitimately demand 6-months prior notice that a Marine Autonomous System is due to enter their waters, and has the right to refuse entry.

With a system that has a degree of control over navigation and the ability to regularly communicate with a shore base, these legal issues can be easily resolved and a diplomatic incident avoided, but a Marine Autonomous System that is submerged and out of contact, or has no propulsion system and is unable to navigate freely, or has suffered mechanical or communication system failure, may drift into waters without permission, and trigger undesired consequences. As Marine Autonomous Systems become commonplace, performing a wide range of tasks, new international legal instruments will be required to ensure safe and legal operation in both international waters, and within EEZs.

The UK, as a global hub of expertise in maritime and shipping law, is well-placed to play a

leading role in the development of new statutory and voluntary instruments.

3.10 In our experience the Marine Professional Bodies and Learned Societies the Institute of Marine Engineering, Science and Technology (IMarEST) and Society for Underwater Technology (SUT) have been valuable allies in helping to develop Marine Autonomous Systems, build links across the user community and propagate best practise in the safe and reliable use of these vehicles.

3.11 Clusters of users are beginning to emerge and share their experiences, conferences on use of Marine Autonomous Systems such as the NOC Marine Autonomy and Technology Showcase scheduled for 14-18 November 2016 are taking place, and a new NERC/EPSRC Centre for Doctoral Training in Next Generation Unmanned Systems Science will help ensure a supply of well-trained experts in the field.

3.12 Unlike a ship with a crew, there are no obligatory statutory requirements for people who deploy and operate Marine Autonomous Systems to be certified, licensed or qualified to an agreed international standard. Whilst such systems exist in small numbers, and are operated by expert specialist users this is not causing a problem, but as the number and physical size of systems and breadth of duties increases there will come a point where some form of licensing becomes a necessity for continued safe operation.

3.13 Insurance requirements are also not defined for Marine Autonomous Systems, though to date users who wish to do so have been able to obtain insurance cover from a specialist insurers based in London – in time this could develop into a significant market.

#### **4. What is the scale of the market opportunity for autonomous vehicles?**

It is hard to estimate how large the market for Marine Autonomous Systems will eventually be, but it is reasonable to assume it will be large enough to sustain a viable export-focussed industry.

Cargo ships are well-suited to at least partially autonomous operations, either as retrofit to existing ships or incorporated from the start with new designs. Such ships may operate as a convoy in company of a human-crewed mother ship, or autonomously.

Passenger vessels are unlikely to be fully autonomous, though as artificial intelligence systems mature the ship's 'mind' may eventually be intelligent enough to take over the day to day duties of sailing the vessel and looking after various services and functions.

Supporting services such as insurance, training and licensing of operators all offer potential as growth markets for the UK.

#### **5. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

Deployment of increasing numbers of Marine Autonomous Systems may require minor modifications to port and harbour facilities, particularly for large autonomous cargo vessels, to ensure safe docking without human intervention.

Fully autonomous underwater vehicles will benefit from seabed or moored refuelling and data download docking stations, and the provision of acoustic navigation grids that function in an underwater environment – this could be possible in certain applications such as patrol of a seabed carbon storage facility, monitoring the decommissioning of large-scale oil and gas infrastructure, or a fixed deep-sea aquaculture location.

Current satellite navigation systems are adequate for surface vehicles but are not available to submerged systems (because most radio frequencies cannot penetrate underwater) unless the vehicle or sensor has some form of datalink to the surface, such as a towed buoy.

*26 October 2016*

Acronyms used:

AUV	Autonomous Underwater Vehicle
EEZ	Exclusive Economic Zone of a Sovereign State
EPSRC	Engineering & Physical Sciences Research Council
IMarEST	Institute of Marine Engineering, Science & Technology
MAS	Marine Autonomous Systems
NERC	Natural Environment Research Council
NOC	National Oceanography Centre
SUT	Society for Underwater Technology
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Education, Scientific and Cultural Organisation
USV	Unmanned (or un-crewed) Surface Vehicle

## **The Nautical Institute – Written evidence (AUV0020)**

*Author: Captain John Lloyd, Chief Operating Officer, The Nautical Institute*

1. The Nautical Institute notes the Call for Evidence from the Select Committee and the accompanying paperwork associated with the inquiry into Autonomous vehicles. While many references are clearly directed to the road transport sector, passing reference is also made to the use of vehicles in extreme environments such as deep sea. This submission relates to considerations for seagoing autonomous vehicles.
2. Question 16 examines the capability of the UK's education system for delivering people with the right skills for the autonomous vehicles sector. In the case of the operation of autonomous marine vehicles The Nautical Institute believes there is a requirement for specialist skills to be developed further in this area. The context of the marine environment requires specific rules to be adhered to for all seagoing vessels and the application of these rules in the context of autonomous vehicles requires special attention. Autonomous marine vehicles will be sharing water space with manned vessels and a common understanding of concepts and capabilities is important.
3. The Nautical Institute is the world's leading membership body supporting those in control of seagoing craft. The Nautical Institute has extensive experience in the control of maritime qualifications required for the operation of some specialist vessels (those utilising Dynamic Positioning equipment). This experience extends to the auditing of educational and training institutions in the UK and overseas. Members of The Nautical Institute are well placed to provide specialist technical advice related to the operation of autonomous vehicles in the marine environment.
4. The Nautical Institute submits that a visible process of providing independent third party audits of training providers and the qualifications of personnel controlling autonomous seagoing vessels will do much to reassure the public about the quality and safety of such operations.

25 October 2016

## **Professor Paul Newman, University of Oxford – Written evidence (AUV0041)**

### **Impacts and benefits**

#### **1. What are the potential applications for autonomous vehicles?**

It is difficult to overstate the impact of vehicles that are able to move around and answer the key questions for autonomy ('Where am I?', 'What's around me?', 'What should I do next?') in ways that benefit us. However, a common mistake is to focus too narrowly on autonomous *cars*. They are important, and there will be a point in the future when they become generally available, but they are the 'stellar application' of autonomous vehicles and as such have special status. We should do ourselves the favour of thinking about 'all the things that move' and therefore have our mind's eye on every port, warehouse, hospital, post office, road and train station. Autonomous vehicles have a role to play in any setting where human beings are moving people or objects around.

It is also essential to consider all the applications of this technology, not just the applications of fully autonomous vehicles. Even before we achieve full autonomy, there are a very large number of advances that will become possible as a result of the progress we are making towards it. This point is subtle and often missed. In the near future we will see cars with 'Guardian Angel' autonomy: they will have the ability to take control for short periods of time in critical situations, such as when the vehicle is about to crash. Aspects of this technology are already in place; ABS systems, for example, allow the vehicle to moderate the negative effect of a driver braking too hard. Advances in autonomous vehicle technology have already made, and will continue to make, a very significant impact long before we achieve 'driverless cars'.

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

The question has to be answered with great care, because it depends what timescale we're thinking about. It is also important to approach it in terms of the sectors we're focusing on. It is easy to talk about the advantages of a world where autonomous vehicles are fully deployed – that utopian point sometime in the future where people will be able buy a car with no steering wheel which will safely drive them to any place at any time in any weather. The benefits of this are obvious and positive; for instance it will enable someone who is blind to visit family who live at the other end of the country, or enable someone to work while their car drives them to a meeting.

However, there is a stage before that. At an intermediate level of autonomy, we have not yet fully grasped what difference Mobility-as-a-Service could make in some of our bigger cities, where private ownership isn't so attractive. There is a lazy argument that this will revolutionise all transport so that no one owns their own car any more, but this is very unlikely: private and public are going to be blended for quite some time. In the meantime, Mobility-as-a-Service has the advantage of offering some fairly fine-grained

control on how vehicles flow and interact in our big cities.

Increased safety is significant benefit, because machines don't get distracted in the way that people do. Between 70% and 90% of car accidents are caused by human behaviour and error. The McKinsey Report into Disruptive Technologies 2013 estimates that by 2025, if autonomous vehicles prevent only 20% of driver-caused deaths from car accidents, 150,000 lives a year will be saved. Because autonomous vehicles can drive more efficiently, there is a potentially huge impact on CO<sub>2</sub> emissions, which could be reduced by as much as 300 million tons per year (equivalent to 50% of CO<sub>2</sub> emissions from current commercial aviation).

Advances in the use of autonomous technologies in warehousing have already changed the face of shopping and will continue to do so. We now have the ability to browse the entire world for thousands of products, made possible by new warehousing technologies. There is an enormous opportunity for the use of autonomous vehicles in agriculture – not just harvesting crops mechanically, but doing farming in a completely different way. For example, there is the potential for vehicles to 'see' and apply herbicide to just the growing buds of only the weeds, not the entire crop. There are also major advantages in sectors like security (such as the deployment of autonomous vehicles to defuse IEDs).

One risk is that developments may be pushed through artificially fast, so that people become 'spooked' by the technology. People will be concerned about loss of jobs. Of course there will be changes of employment because of these vehicles, but this is not necessarily a disadvantage and certainly not a reason not to continue to develop them. Technology has always led to employment changes, and it is hard to see how the deployment of autonomous vehicles will become some sort of tipping point for job losses.

Because we will have more vehicles that are able to operate with more autonomy, there will be new kinds of jobs, but it will be a very long time before robotics and automation replaces the need for a human. For example, a forklift driver over the next 30 years will encounter more autonomous forklifts, but that may just mean that each operator runs six forklifts instead of one. There will still be many scenarios in situations such as warehousing where human ingenuity, intuition and perception can solve a problem infinitely more quickly than a machine. The fact that the forklift is capable of driving itself to the other end of the warehouse enables the forklift operator to get on with tasks that really do require human-level skills. There are only a few corner cases in the field of autonomous vehicles where it is possible to perceive that there will be no human involvement at all, so it is more realistic to talk about changing jobs rather than losing them.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Rarely do we find a sector that isn't both terrified and desperately excited. A good analogy for the discussions we are having now about robotics and autonomous systems is the conversations we had 30 years ago about computing – for example, spreadsheets replacing card index boxes. We use different nouns, but it's effectively the same topic.

My view is that there are some sectors such as mining where people have not yet fully grasped the potential of autonomous vehicles, and that in other areas such as stevedoring there could be issues around the impact on the workforce. Heavily unionised sectors might be difficult places to implement technology like this, should we choose too, but personally I don't believe that the technology should be forced on people. It's a societal decision: I fully support the right of society to make those choices. I also believe strongly in giving society the opportunity to change the way it does things, rather than being forced – and ultimately the economy is what brings about this change.

#### **4. How much is known about public attitudes to autonomous vehicles?**

No comment for this question.

#### **5. What is the scale of the market opportunity for autonomous vehicles?**

It is huge, and hard to exaggerate. In the field of autonomous cars and trucks alone, the McKinsey Report 2013 estimates that the benefits provided by improved safety, time savings, productivity increases, and lower fuel consumption and emissions could have a total global economic impact of \$200 billion to \$1.9 trillion per year by 2025. This does not include autonomous vehicles in sectors such as warehousing or farming. In the UK, the Robotics and Autonomous Systems (RAS) Strategy document (June 2014) estimates that, over the next 20 years, the economic benefit in terms of national costs avoided thanks to the use of RAS in transportation will be in the order of £1 trillion. The market size of the Logistics and Transport Sector expected to be affected in the UK is £112 billion. This is not so surprising when you consider that we are talking about all the things that move.

#### **Creating an enabling environment**

#### **Research and development**

#### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

In my view, no. At the moment we are trying to make the leap from closing off a few pavements in Milton Keynes so that we can trial autonomous vehicles, to full-scale deployment in a city like London. The gap between these two scenarios is enormous; you can talk about 'the urban laboratory' and cite any city in the world, but you need to be able to control demonstration facilities more than that.

In between we need a facility that is essentially a real community where people live and others come to work, which has roads in it, and the need for transport, logistics and service robotics, but over which you can also exercise some degree of control. This would provide a space where very different kinds of trials could be run: from someone new to the field of autonomous vehicles who wants to 'have a practice', through to established groups who have a more ambitious plan to identify a service gap in the community that they might be able to fill.

Somewhere like Culham in Oxfordshire would provide the perfect opportunity to do this. It is a campus environment that is also a community, a place that has transport links to train stations and all sorts of other ‘real world’ detail, a place where insurance can work but where you can also control aspects of safety. There is an opportunity here for us to do something that the US isn’t doing. They have the MCity Test Facility in Michigan, which is a realistic environment but not a ‘real place’ in the sense that Culham is. Nobody without an interest in driverless cars goes to work in MCity. We need to be operating demonstration facilities in a place where some people are enthusiastic but others are sceptical, so that we can enable them to see the potential and the benefits.

One thing we absolutely must not do is just build open test tracks, because that is exactly *not* what a city is.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

I believe the Government is doing a very good job here. CCAV is excellent; it is staffed with extremely competent people who understand the issues and who are there to help in a good hands-on way. The Research Funding Councils have also done a good job in getting behind some of those mobility programmes.

The most important signal to give is this: autonomous vehicles are not a ‘problem’ you can throw a lot of money at in order to solve quickly. You can’t just fund it and see if it catches alight; you have to keep on starting fires so that the right people will come to the UK, start businesses and then stay in the UK because they see that there is opportunity here. You don’t need to spend billions doing this, but what you do need to have is a continual financial backing. This speaks to a strategy for this technology in the UK. If we invest in this area, continually, over the next decade, we could have the autonomous vehicle equivalent of Silicon Valley here in the UK.

There is a need for a ‘sticky’ science policy in this area. The Government has done an excellent good job in starting CCAV and the Intelligent Mobility Fund, and what needs to happen now is for us to stick at it. We should not be distracted by Google or Apple announcing that they are getting into autonomous vehicle technology. That would be akin to telling Dell not to start a computer company because IBM exists. We have the same brains trust here as the US does, and what we need to do is build a culture of sticking at robotics and autonomous systems. That is something that government singularly can do.

Government should not become preoccupied with legislation; so far it has done a very good job of using a light touch. It should also stay well away from trying to do industry standards, which would be too restrictive and time-wasting. While people are still figuring out how to do things, standards would only inhibit the rapid pace of change. Standards will happen eventually, but it’s not the place to spend money at the moment.

**8. How effective are Innovate UK and the CCAV in this area?**

Across the board, I think that all the agencies involved in this area want to get it right. Innovate UK deserve a lot of credit for the efforts they have made, especially in view of how long it has taken to get some of the initiatives going.

However, I think there are difficulties at Innovate UK about the pace at which this is happening. Their desire to do the right thing isn't in question, but the detail of how things are administered is sometimes orthogonal to what is needed. Innovate UK needs to be totally committed to autonomous vehicles, again with a 'sticky' policy to make a sovereign capability in autonomy in the UK. They need to understand that long-term, recurrent funding is a very important role for them to have. I believe that Innovate UK's enthusiasm and excitement about autonomous vehicles will enable them to fix this.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

No comment for this question.

**Real world operation**

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

The key word here is 'require'. It is possible that in future there will be business or wealth generation opportunities that may induce changes to infrastructure. But these changes should not be seen as a *precursor* of autonomy; that would be disastrous, and the wrong role for Government. There are vehicles already in existence, such as Google cars, which prove that dedicated infrastructure is not needed.

There are situations in which infrastructure can usefully be considered as part of the planning process. So for example in China, when building roads for new cities, they are now putting in the equivalent of cycle lanes for Mobility-as-a-Service. If you were building a new Olympic Park, you could imagine putting areas aside for the autonomous mobility systems which will move people around the park. But there is absolutely no requirement to dig trenches alongside all existing roads and lay wires and sensors to control autonomous vehicles. For a long time to come, we will be able to do this job very effectively using the 4G phone network and the internet – and we have already built those.

Some aspects of infrastructure will be undoubtedly be useful, but that is not the same as saying that they are required, and their development will be regulated by the market and by factors such as insurance, not by Government.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

The key events that need to happen are social and economic. In terms of technical advances, development is relatively smooth, without noticeable revolutions. As with computing, the technology is continuously getting a little bit better all the time. But with regards to the social acceptance of autonomous vehicles, there are discrete steps that we will need to go through.

On the technical side, it is important not to take the attitude that deployment has to wait until we have a ‘finished product’. Of course there is still a lot of technical development that has yet to happen before we have a car with no steering wheel, but we can start to deploy the technology that we have now. Asking ‘when will I have a driverless car?’ is a bit like asking ‘When will I have a computer?’ It is not something that will ever be ‘finished’ in that sense.

In terms of management of risk, I think commercial factors will manage the process. Insurance is an important way to deal with some of these risks – insurance is all about risk, after all – and the conventional model is likely to be changed completely by the move to autonomous vehicles. For example, there might be the potential for autonomous cars to bid automatically for insurance cover for individual components of a journey (such as risk at a particular junction). The insurers are then directly assessing the safety of the vehicles at any point. I don’t think it will be possible to completely ‘prove’ safety before vehicles are deployed; I think it is something that will be assessed and measured during deployment using tools such as insurance.

Social milestones, however, are the critical ones. Initially there was elation and anticipation about autonomous vehicles, and now there is more uncertainty; we need to work towards public acceptance and trust. This is something that Government can definitely assist with; as part of its leadership role in society, it needs to help deliver the messages about this technology and what it can do.

One very important milestone is how we manage the first ‘big crash’ involving autonomous vehicles, because there will be one. In advance of that event we need a sensible, pragmatic conversation that there are inevitably going to be accidents. As a society, every time we build something new, unexpected things happen. That is not to say that we’re not being unbelievably diligent engineers, but we do need a narrative that says there will be new, but on the whole fewer, accidents. If for some reason that turns out not to be true, the economy will not tolerate it, and there will be no driverless cars.

A complicating factor is that the focus of much of the excitement – the car – is an article that has a ridiculous amount of influence over how we define ourselves. We also have a completely unrealistic expectation of the provision of service in these vehicles; we are totally intolerant of them going wrong. For this reason it is even more important that we understand driverless cars in the wider context of all the machines that might move for us. It is why warehouses and ports may be the first places where we see the deployment of this technology, because they are already considered a kind of ‘at risk’ situation, and also because people don’t have their personal esteem attached to forklifts in the way that they do to cars.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

No comment for this question.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

No. It would be best to leave it as it is, without regulation, and let developments happen for a while.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

There is an attitude that autonomous vehicles are ‘thinking machines’ capable of making moral choices, and this is not remotely true. Many situations arise in which physics dictates that someone or something is going to get hit by a vehicle. This is not the fault of the machine.

However, if we are building machines that are capable of making split-second assessments of these situations, then we need to unpick what is actually going on and discharge some of the tension around these vehicles being ethical agents. We need a discussion about how we want those machines to act. Do we want the outcome to be random? If the choice is between hitting an adult and hitting a toddler, do we want the vehicle to save the child? Do we sacrifice two passengers in the car to protect five pedestrians? This may sound calculating, but we make exactly these sort of calculations already for insurance purposes. These decisions will be made by humans; the car is then, in fact, only making an ‘ethical’ decision that has been programmed into it by people. It could be very beneficial; we could have situations in which better decisions are made, because machines (unlike humans) will not panic.

An advantage of this capability is that autonomous vehicles will be able to replay the accident so that we can assess whether the machine did what the software told it to do, and whether the outcome was reasonable. This will provide auditable evidence that we have not previously been able to access.

This is not really Government’s responsibility, but there needs to be a changing of the narrative around these driverless cars to address the question of who gets the blame when the car malfunctions in some way. It is essentially no different from using a tool that proves defective; if it fails once that’s bad luck, but if there are multiple failures – for example all the tyres in all autonomous cars start blowing out – then it’s a quality control issue and needs to be treated as such.

There may be social and economic issues that need to be addressed here, too. A recent paper in Science, ‘The social dilemma of autonomous vehicles’, found that ‘even though participants approve of autonomous vehicles that might sacrifice passengers to save others, respondents would prefer not to ride in such vehicles’. This poses a conundrum for

companies who want to sell cars.

### **Wider governance**

#### **15. What does the proposed Modern Transport Bill need to deliver?**

No comment for this question.

#### **16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

An honest answer would be ‘terrible’. This does not just apply to autonomous vehicles; it applies to the whole field of information engineering. In the UK we are not even close to imagining what we need to do to teach people to code properly. For 20 years we have confused ‘computing’ with ‘using the font selection dialogue box’. Of course people need to be able to use computers, but they need to understand what computing is as well. It’s like teaching writing without reading – half of the skillset is missing, and we wouldn’t think that was acceptable in any other subject.

I cannot overstate the importance of this: we need about 10,000 more engineers a year. We need to plough money into universities to teach information engineering, data engineering and software. Our future economy is not going to be about bending pieces of metal or shaping plastic; it’s going to be about making weightless software. The scaling you can reach through software engineering is huge. The example I would use here is Windows: a small number of people wrote the original operating system, but everybody in the world uses it. In terms of information engineering, we could be the nation that drives the revolution if we get the education aspect right.

Teachers at all stages of education need to be skilled up to think that software and computing, rather than the use of computers, is vital. I would like to see coding included as a core skill for SATS. Government singularly can effect this kind of change and singularly has the responsibility for this.

#### **17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

No, and this is understandable. The work on autonomous vehicles started with a kernel in CCAV, but what we need to do now is to grow the CCAV model to extend across all of Government to encompass BEIS, Transport, Defra, the MoD, DEC and the Home Office. All these Departments will be encountering ethical, efficiency, technological and social problems that relate to robotics. Imagine how many billions could have been saved 35 years ago in relation to computing if there had been a group that cut across all Departments to advise on how to navigate the changes, instead of every department having its own response. In retrospect, we would probably have played it differently. There is a similar opportunity now to get on the front foot with autonomous vehicles.

- 18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

No comment for this question.

*26 October 2016*

## Orbit City Lab– Written evidence (AUV0003)

1. My name is James Niles, I am the President, and Chief Innovation Officer of Orbit City Lab located in New York, NY USA. I would like to thank The House of Lords Science and Technology Committee for allowing me the opportunity to provide written evidence concerning autonomous vehicles. I would like to address questions 2, 3, and 13 with the following evidence.
2. It seems as if we all are “kids in a candy store” when it comes to the latest technology, and with autonomous vehicles, it is no different; we all want to peek inside the candy jar. For 99.9% of the public, the major benefits are safety improvement, road accident reductions, multi-tasking allowance, traffic lessening, or insurance reductions. Major concerns, which have been the focus of government agencies around the world, are vehicle safety issues, cyber security or data collection (privacy).
3. While safety, cyber, and privacy are important concerns, I want to talk about the proverbial elephant in the room that very few people are talking about but could potentially have a global impact if not addressed. This is the concern that autonomous vehicles could be used as a weapon (drone on wheels) which is very different from a cyber-attack. The House of Lords Science and Technology Select Committee needs to require that all autonomous vehicles have sensors installed inside the vehicle to perform a “sniff” test for hazardous/wmd material, and once detected, disable certain features of the autonomous vehicle.
4. It is not just I who believes that autonomous vehicles could be used a weapon, but perhaps more importantly several United States federal agencies and NATO believes it as well, yet no regulations have been implemented in any countries yet. An article that was published in 2014 makes reference to an internal Executive Analytic Report produced by the U.S Federal Bureau of Investigation that states the following on autonomous vehicles: “Autonomy will improve driving safety and make mobility more efficient, but will also open up greater possibilities for dual use applications and ways for a car to be more of a potential lethal weapon than it is today.”
5. Most recently, NATO's deputy assistant secretary general for emerging security threats stated that “terrorist organizations are already working on creating their own autonomous vehicles to be used as a weapon”. Just how much effort do you think it would take for a group or individual to use an autonomous taxi as a weapon? Every major infrastructure around the world will now be less secured as the possibility of a bad actor using an autonomous vehicle as a weapon has increase dramatically.
6. For the most part, the concern that an autonomous vehicle could be used as a weapon has gone unnoticed by the public and probably by the majority of the government officials. In 2014 when the first article came out only a few other articles picked up and re-reported the finding. One article even argued against autonomous

vehicles being used as a weapon because of the high price to acquire a vehicle and that would lead terrorist group/individuals to look for a cheaper approach. Given that on-demand autonomous taxi services will most likely be the introduction for the everyday consumer, this disproves the “too expensive” logic. Furthermore, having autonomous vehicles at airports, hotels, events, and roaming the streets increases the possibility that an attack could happen anywhere, all under the guise of transporting a person from one location to another.

7. Aside from the safety, cyber, and privacy concerns mentioned previously, we need to look at mitigation for autonomous vehicles. The mitigation process aims to reduce the consequence of an incident by identifying best practices as well as codes or standards that make transportation infrastructure more resilient. Mitigation activities can include building to standards that enhance resilience, identifying risks, ensuring additional protection measures are applied to reduce vulnerabilities, and taking actions to reduce the consequence of incidents that may occur. Mitigation activities are arguably best applied in the planning stage instead of an afterthought or after an incident. Properly applied mitigation efforts can reduce the vulnerability to, or consequence of, an incident while making response and recovery efforts easier.
8. Keep in mind that just because you solve the cyber security concerns, does not mean that you have solved the issue of someone using an autonomous vehicle as a weapon. You could have the safest vehicle, the highest cyber security, and the tightest control of privacy data and still be wide open for bad actors to load the vehicle up with explosives, punch in coordinates, shut the door, and send the vehicle to its’ destination. All allowed as the current regulations have no requirement to prevent or mitigate the possibility of someone using the vehicle as a weapon.
9. Over the last couple of months, there have been numerous hearings from the intelligence communities worldwide; the major theme is not “if” something will happen but “when”. In today’s society, we need to be prepared, protect and mitigate risk against all possibilities regardless if it is from a single person or a group that may have intentions of causing harm or destruction. Country leaders from around the world look to each other for guidance on security and technology issues. Let us not make a bad decision that will have a rippling effect throughout the world.
10. Autonomous vehicles is a multi-billion dollar industry with numerous automotive and technology companies involved. Autonomous vehicles, parked in our garages, driveways, or as on-demand services such as autonomous taxis, create numerous possibilities, both good and bad. Automotive and technology companies would like to have fewer regulations and be able to freely develop and ask for exemption on regulations when it is in their best interest. However, security and protection should not be avoided or exempt just to allow faster to market so a few extra dollars can be made – the autonomous vehicle industry should not be allowed to avoid regulations or achieve exemptions when it comes to security of the homeland.
11. In closing, if The House of Lords Science and Technology Committee do not require that autonomous vehicles have sensors to sniff out hazardous materials and then

disable autonomous features once detected, you might as well start working on the speech that you will have to give to the world the day after an incident happens. Having to retrofit the vehicles after an incident, means an incident was successful. While a regulation will not eliminate all future terrorist attacks, there is no need to freely provide the opportunity to someone when in fact a reasonable mitigation solution is available.

12. The 9/11 Commission concluded that the greatest problem that lead to the attacks on 9/11 was “failure of imagination” on the government’s part. Let us fast forward our imagination down the road one, two or five years and think about how big of an impact that The House of Lords Science and Technology Committee decision to either implement or ignore a policy/regulation can have. Let’s not think back on today’s evidence and ask ourselves, “What-if....”.

*16 September 2016*

## **PA Consulting Group – Written evidence (AUV0008)**

### **The journey to successful connected autonomous vehicles**

Connected and autonomous vehicles (CAV) are not just part of an imagined future street scene; they are here today on our roads in a growing number of pilot projects. And connected and autonomous technologies are increasingly prevalent in new production vehicles. However for fully CAVs to operate on our streets there are a number of issues and questions that still need to be addressed. So what are these issues and whose responsibility is it to find the answers?

### **The automotive sector**

For the automotive industry, the development of autonomous vehicles represents massive disruption to a well-established market. New challengers with new ideas, new expertise and new intellectual property are on the scene. They are making huge investments to get the technology to work. But the sector has yet to develop a meaningful CAV business model or models. This means understanding what advantages a connected, driverless vehicle can offer consumers over a conventional vehicle or a taxi service. The sector needs to work out if people will move away from vehicle ownership and leasing to renting a CAV for a specific trip and if we will move to a system where mobility becomes a service we purchase like any other. A service type model would have huge implications for the manufacturers – they would no longer sell vehicles to end-users, rather they would either sell mobility or would sell to intermediaries (who would then sell on mobility). That is a very different business model, with very different revenue streams, and would require very different relationships with their customers.

### **The insurance industry**

Insurers too will need to change their current model. As over 90% of motor collisions are due to driver error, the introduction of CAVs would be expected to cut the number of crashes. Indeed, there are 20% fewer collisions involving cars fitted with emergency braking systems.

That means it is likely that insurers will move away from insuring the driver to insuring the use of the vehicle – effectively product liability. Volvo has already announced that it will accept full liability for collisions involving its driverless cars and other manufacturers are expected to follow suit. In theory this simple solution makes a lot of sense. However there are still potential complexities. This includes determining what to do with vehicles that are out of warranty and therefore not in the mechanical state envisaged when designed. This could mean that CAVs will be unusable or uninsurable after, say, three years or they could need substantial refits to enable the manufacturer to accept on-going liability.

### **Highways authorities**

The development of CAVs requires not only the right vehicle technology but the right infrastructure to support that technology. So highways authorities have the very real challenge of building and maintaining the infrastructure for the vehicles of today which will also be fit for the future. If they do not take account of the operational requirements of CAVs, infrastructure that is currently being built may need rework in the medium term to allow them to operate to their full potential. A very simple example is road markings – removing these may help reduce vehicle speeds however they will also reduce the benefit of vehicle lane detection systems (and hence reduce their potential safety benefits).

### **The regulators**

It is clear that Government has a huge part to play in developing an effective operating framework for CAVs. By not ratifying the Vienna Convention on Road Traffic, the UK has been able to create a supportive environment for the development and testing of connected and autonomous vehicle technologies. However, for CAVs to be widely adopted, existing regulations governing how vehicles are used and maintained will need changed. This is likely to involve modifications to the MOT test to check roadworthiness (to include software updates) and the Highway Code. The challenge for the regulators is whether they try and steer the market (building a legislative environment into which manufacturers can develop vehicles and a working business model) or respond to it (amending the legislative environment in response to development/events).

### **Police**

Whilst the widespread adoption of CAVs has the potential to drastically reduce the number of collisions, they also could create a number of very real policing challenges. For example how do police stop and redirect autonomous vehicles (for example up a one way street to avoid an incident)? And how can CAVs clear the highway to respond to an emergency vehicle? Operators will also need to ensure that vehicle connectivity (vehicle to vehicle, infrastructure and to highways authorities) is not used to create widespread disruption. And on a more immediate level, what investigating capabilities will the police need to deal with collisions involving CAVs?

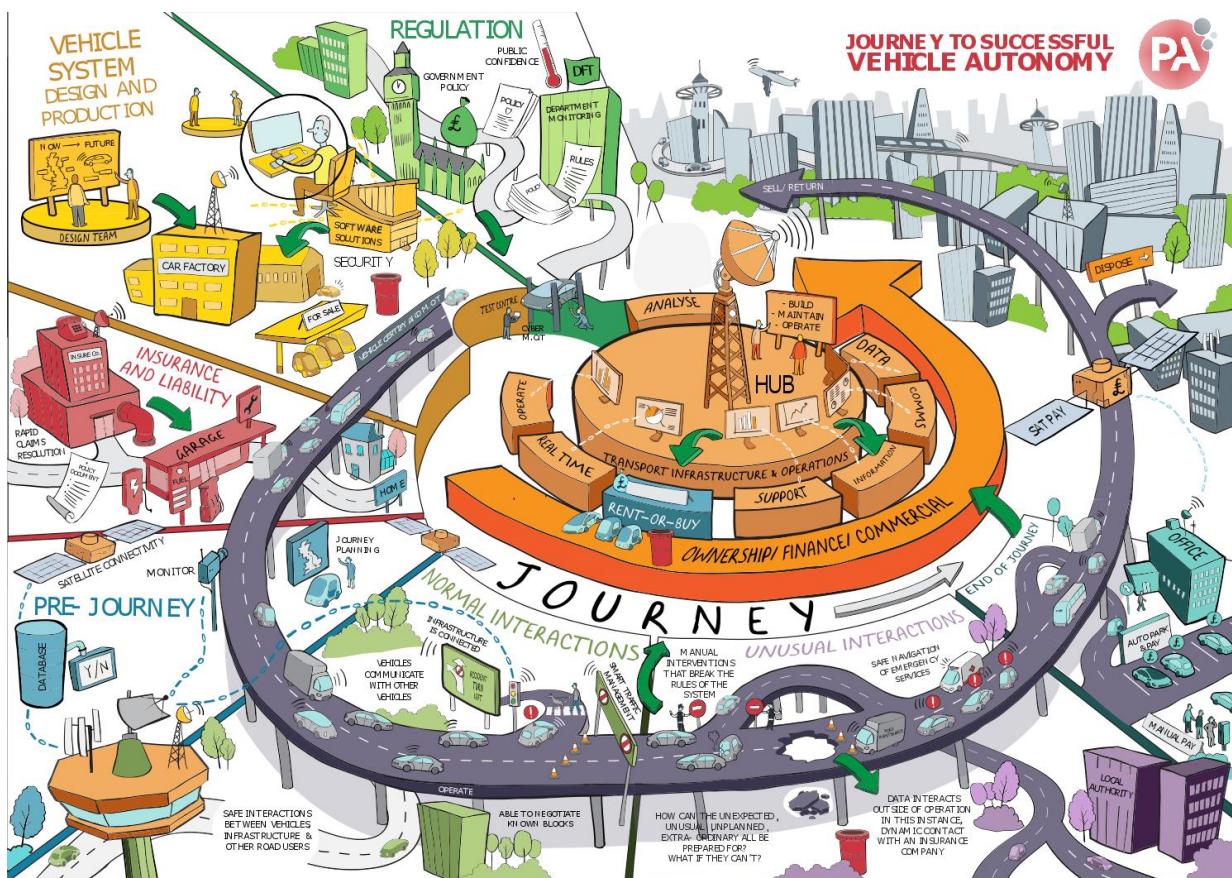
### **Users of CAVs**

CAVs present a huge potential to increase the safety of individuals' journeys, shorten journey times, increase the productivity of travellers and allow unprecedented shifts in working patterns and resulting improvements in work-life balance. However, these benefits come with costs; placing reliance on the safety of the underpinning vehicle technology, entrusting personal data to an unproven set of systems, and the surrender of personal vehicle control. So a key challenge, while technology and systems are in their infancy, will be to convince users of the advantages of CAVs and so create a market for them.

### **An emerging system of systems**

As technology and testing develop it will be easier to bridge the credibility gap with potential users. But there are still a number of significant challenges that need to be overcome for

CAVs to operate effectively. The most significant of these relates to the very inter-connectivity of these challenges – the solution for each will have an impact on the other areas in a way that is very new for the automotive sector. In order to clarify these interconnections and show how the inter-relationships can be managed, PA has developed a visual representation of the different factors which will affect the successful development of CAVs (see below).



The picture clearly shows that getting CAVs on the road as a viable and attractive option will be complex. There will be multiple solutions, for example covering different types of CAV user (e.g. commercial vs private). It also underlines that insurers, manufacturers, regulators will all have to work together to create a new world of collaboration and interconnection.

These complexities clearly illustrate that making CAVs a reality is not just a technological or even a commercial challenge but a political, social and cultural one too, and that understanding the inter-dependencies between them is going to require careful and focused attention in the coming years. The potential prize is significant but more work is needed to map out the route to get us there.

24 September 2016

**PA Consulting Group, Highways England and RAC Foundation – Oral evidence  
(QQ 48-54)**

[Transcript to be found under Highways England](#)

## **Peak Power – Written evidence (AUV0043)**

### **Executive Summary**

Peak Power is a group of transport users and stakeholders who live in rural communities and work in the major cities of the North and South West. Planned reduction in rural bus services combined with increasing congestion within, and leading into, urban areas triggered our interest in identifying the problems with modern public/private transport and the potential solutions. As research by Leeds University and KPMG shows, buses are essential to the rural economy, education health and social welfare of rural communities. Cuts in bus services may reduce running costs, yet as our own and Leeds research shows, a small investment of 10% will create 1,000s of jobs and other benefits.

Peak Power is a group of expert stakeholders who possess the experience, insight, and capability to act as 'Intelligent Client' for government and industry. As we search for alternative transport solutions we have through observation, analysis, and evidence, formulated a set of thoughts on AVs specifically, which we have captured to provide the basis of this submission to the House of Lords. A summary of the key points from our appraisal and this submission are as follows:

- The strategic impact and long term benefits of AVs on the economy, environment, and society is seriously underestimated by UK government and potential suppliers;
- There is a concern current UK AV development and introduction roadmaps/timescales are being held back by automotive industry thinking and starved of funding given a government priority for big infrastructure projects;
- The global reality appears to be that a new generation of global digital businesses are better placed, more highly motivated, and further along the growth curve in the development and exploitation of AV technology;
- UK AV strategy and development lacks cutting edge ambition, well behind international rivals, limited by vision and regulation, influenced and guided by a narrow public sector and a small pool of expertise in traditional auto industry and technology;
- The UK is seriously under resourced, we need to look to other sectors for transferable skills and expertise, we also need to increase spend (R&D), train tech capability, and identify niche opportunities and smart tactics to take market leadership and deliver most impact globally;
- AVs are part of an integrated transport system and massive transformation programme, there is little evidence this is understood and being acted upon by government or industry.

### **Response to House of Lords Autonomous Vehicle Select Committee**

#### **Impacts and benefits:**

##### **1. What are the potential applications for Autonomous Vehicles (AVs)?**

Air, water, and land based transportation of goods and people. The modes receiving most public interest, research, investment and political/legal attention are land based, with the main applications being:

- To reduce personal transport costs activities e.g. through shared use rather than single ownership/occupancy;
- Providing transport for those unable to drive on health or age-related grounds;
- Opening up urban and rural community use areas, including commuting, school runs, access to health services, economic hubs such as retail centres, entertainment;
- Substitute for cut backs in rural bus services;
- Light and heavy freight movement and home deliveries.

Please note: we consider connection essential to AVs. AVs are one component in a physical and digitally integrated transport system, where vehicles are the point of service delivery to the public (other components and processes inc maintenance, storage etc). The digital components are familiar to a traditional IT architecture and processes including communications networks, enterprise master planning/scheduling and operations control, data management, Apps development etc.

## **2. What are the potential user benefits and disadvantages from the deployment of Autonomous Vehicles?**

- Significantly lower running costs from adoption of shared AVs – Barclays estimated (2015) that use of a shared AV would reduce running costs by 56% and use of pooled AVs would reduce running costs by 82%;
- Safer transport as a pedestrian, passenger, and driver of other (conventional) vehicles – guidance and accident detection systems outperform human capabilities, especially if vehicles communicate with each other (V2V) effectively enabling “seeing” around corners and over the brows of hills, etc. As a consequence of the lower accident rates, insurance costs are likely to fall markedly;
- Reduced numbers of vehicles on the roads (Barclays estimate that a single shared AV can potentially replace 18 conventional cars and the efficiency gains from pooled AVs will be even higher). The common view is each AV will be used more than today’s conventional cars are, generating a greater return on the capital and environmental cost of producing a vehicle. This should enable reduced congestion, less ‘clustered’ urban and suburban landscapes, removal of ugly car parks which will make way for much needed housing;
- Optimised networks as AVs collect and pool ‘big data’ for the better planning and use of transport infrastructure – master scheduling, operational control etc;
- Lower environmental impact in operational use as more efficient driving and reduced congestion improve air quality.

The main disadvantages to adoption of shared AVs will be felt by an older demographic who associate vehicles with ownership, status, and as a means of storing personal belongings. These are major barriers to transition and transformation of transport and transport services.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Hard evidence on the impact of AVs across road use sectors is limited. However, research conducted mainly in the USA, suggests that introduction of AVs will have most impact on:

- Commercial vehicles (avoidance of driver maximum duty times);
- Legal and regulatory frameworks will require review and amendment to create an operational environment acceptable (i.e. safe) for AV users and travelling public;
- Taxis and buses (the driver tends to be the single largest cost);
- Virtual elimination of second vehicles in households (apart from a minority who own a luxury/performance/classic car as a hobby/status symbol);
- Marked (estimates vary) reduction in annual vehicle sales, leading to a transformation of car dealership (sales and service) networks;
- Higher annual mileage by AVs leading to shorter vehicle life (forecast AV life is 3.5 years c.f. 14 years for today's conventional fleet). This should lead to better air quality as only younger vehicles, fully compliant with current emission standards are on the road. However, the loss of older vehicles will lead to the demise of car repairers, dealers, motor factors etc. who base their businesses on servicing older fleets;
- The combination of lower vehicle sales, less complexity, reduced supply chains, and shorter vehicle lives (helps the industry) will have a dramatic impact on the business models of vehicle manufacturers, potentially reducing their influence post-transformation meaning they could well be a key block pre-transformation;
- As the key characteristics of vehicles move towards their electronics and data networks, the role of infrastructure providers (Google, Apple?) will increase;
- As fewer individuals possess their own car, the importance of ride-sharing entities will increase. Transportation-as-a-service (TaaS) is likely to become a significant industry in its own right, subsuming today's car rental, bus and taxi sectors;
- The vehicle insurance industry will have to develop products that cater for AVs. This should not be too much of a hurdle for the industry as it has recently adapted to user-based insurance drawing on vehicle telematics data.

### **4. How much is known about public attitudes to autonomous vehicles?**

There is a significant body of research and data concerning traditional vehicle performance, human/machine interface, and environmental impacts. Only just recently has Goldsmiths complete a 'sense tested' study to find out how our senses and emotional responses respond to various stimuli. There is little or no research into what the public know about AVs, the benefits, and how likely they are to want to use AV's. Setting up collaborative focus groups 'Intelligent Clients' to consider use cases will provide high quality feedback on public attitudes, knowledge, and perceptions of AVs to more accurately guide government and private sector investment.

The existing UK AV demonstrators are anticipated to provide insight and feedback; however the restricted operational (urban) and use limit the value of these; whereas a rural test programme offers much greater benefit across all use cases. A further consideration in evaluation of public attitudes is that like many successful innovations,

AVs extend beyond the knowledge horizons of consultation group, who may well discount the value and benefits without proper understanding and vision. The ‘intelligent Client’ role should therefore be able to brief, filter and moderate inputs/outputs of both providers and users of AV technologies and services.

## 5. What is the scale of market opportunity for autonomous vehicles?

An integrated transport strategy with a properly formulated masterplan would reduce the numbers of vehicles on the roads by at least a 50% of the current UK 30m, possibly by 70%. This would occur through shared commuter use, phased with school runs, health care trips, and economic/leisure trips during the remaining part of the day.

There are multiple challenges for AVs in achieving the replacement/displacement target of circa 15m, these include:

- Sharing space and operation (spatial interaction between human guided and computer guided machines) during a transition period;
- Overcoming the myopia of the teams currently leading the trials and introduction, which are focussed on urban areas, observation shows these areas are already well served by public transport - they offer least AV benefits compared to rural users;
- The annual UK figure for new car sales/registrations is approx 2.2m based on historic methods of marketing/sales and vehicle product introductions it will take 15 years+ to replace all 30m vehicles. To accelerate transition an introduction strategy/plan will need to be carefully thought through to deliver 50% in 10 years or less;
- This is a massive change programme comparable to reversing the side of the road on which we drive. So far the public is vaguely aware and interested in AVs, however a poorly thought through and executed introduction plan could well turn public and manufacturers (AVs will halve UK sales and decimate the supply chain) against the change.

The critical importance of data networking, computing, navigation and sensor technologies demand common standards internationally, or at least regionally. We have already seen this in the software and telecoms industries, which may have national players, but the standards are formulated at a global level. The greatest AV opportunity is international, one for which the UK post Brexit should be targeting, yet we are ill prepared to capitalise upon. This is a function of:

- Under resourced for R&D and manufacturing compared to future global competition – Google, Apple, Uber etc;
- A tendency toward an inward looking mentality, specifically in manufacturing based industries, rather than taking an ambitious international global perspective;
- Test and development programmes that fall well short of other global facilities/capabilities e.g. US Pittsburg, (even though there has been significant investment in Horiba/MIRA recently);
- Programmes are academic/technology led rather than market led by innovative product marketers from the technology sector, as opposed to manufacturing/vehicle industries.

## Creating an enabling environment

## Research and development

### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

The demo facilities in MK, Bristol, Greenwich appear to be technology based, aimed at creating public awareness rather than being planned, coordinated set of programmes that deliver a credible and useful transport service. There are several shortcomings with these facilities, specifically:

- Of the main UK manufacturers/tech only Ford and JLR are involved (via Autodrive), Nissan, Toyota, Honda, BMW, VW/Audi and GM are not represented;
- In several of the cases the AV demonstrators are providing a show case for overseas, rather than UK capabilities;
- The demonstrators have failed to identify and engage key players with need for AVs and investment capability;
- Whilst in reality there are likely to be multiple AV suppliers, the demonstration, or test programme, needs to provide a properly structured environment to test and approve systems, interoperability etc;
- Facilities are focussed on urban areas, with relatively little attention given to the opportunities (bus cutbacks) and challenges placed on AVs in rural areas (for example heavy snow which can hide road edges and markings, is much more likely in rural areas);
- At the most fundamental AV demo capabilities don't appear to map to specific use cases – they appear generalised and of limited benefit which may damage the case for AVs.

### **7. Is the government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

Given the resources the US technology players, and European/Japanese car manufacturers are investing in the area (e.g. 10's \$ billions), through differential resource analysis (DRA) it's difficult to see how the UK is going to address the opportunity and come out ahead. There needs to be a coordinated programme of all stakeholders, with government playing a key role in bringing the parties together, coupled to targeted seed investment in specialist areas e.g. guidance systems algorithms, usability capabilities, master scheduling etc.

R&D funding should be directed at representative environments where AVs meet a specific need, where there are clear use cases and benefits, which the public recognise and relate to.

As part of a coordinated plan of action, leverage and incentive should also be applied to bringing onboard supplementary, and potential, technology partners e.g. mapping and satellite communications companies to further accelerate the development of UK capability. This will require the coordination and management of cross sector, multidisciplinary teams, a capability not generally required, or associated, with

government departments – therefore, given what is at stake, suitable programme expertise and facilitation skills set should be sourced elsewhere.

**8. How effective are InnovateUK and the CCAV in this area?**

Clearly these organisations have helped move the agenda forward. However the nature of the opportunities and competition requires a different creative and entrepreneurial mindset in terms of strategic thinking, market delivery, technology, time to market, integrated (not intelligent) transport etc etc. There is no evidence of real success to date, or indication these organisations have appreciated the strategic long term value of AVs to UK industry, UK economy, and the ‘winner takes all’ urgency to the opportunity.

There is a real concern that the context of AVs is not understood by not only these organisations but other key government departments. It appears that AVs are being considered as a transport/motor industry issue only. In reality, the implications affect virtually every Government department, from the challenge of integrating multi-modal transportation (such as AVs getting people to from HS2 stations), to health and social care (AVs providing greater independence for the elderly), financial services (insurance industry and fleet management industries etc).

It is essential AVs are part of an integrated plan and delivery programme, to which the Transport Catapult, InnovateUK, and CAV are essential contributors, but should not be the principal drivers.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

The scale of the opportunity and size of task is best suited to large corporate players. However the problem is they don't always have the specialist expertise, or necessarily offer an attractive environment in which innovation can flourish. SME's can, and will supply, technical and business/programme capabilities, however they will require support from government (contacts, endorsement, funding) and large UK corporates (contracts).

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

Absolutely (both). AVs may be autonomous but they do not operate in isolation, they need data and navigation networks to operate. Modern communication systems are data-hungry and there is an ever increasing demand for band-width, these needs to be shared not just between AVs, but also with their occupants who are likely to demand high-speed access to the internet, especially as many of them will no longer be actively driving and will want to work, play, surf etc. Digital services are an area where the UK can take ownership and leadership. To function fully AVs will also need to be integrated with the infrastructure for purposes of optimised movement planning and operational management. Smart motorways will be required to extend across the road network, the most obvious complementary partner technology will be IT and communications network providers.

To re-iterate the point, AVs are essentially a component of a national transport transformation programme, the difficulty of introducing AV's is similar in scale and difficulty to changing from driving on the left to the right.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

Firstly we need people with the passion and vision to direct and deliver transformational change- these are needed at all levels, representing all stakeholders, and they need to work together with clarity of vision to a common purpose and agenda (otherwise it'll be like merging the 1960s/1970s British car industry all over again – foreign ownership/management is possibly a key enabler.....). This then becomes a 'big bet' transition programme with the key milestones:

- 'Go' or 'No Go' decision on a plan constructed from engagement of all stakeholders;
- Coordinated (International supplier) trial across urban and rural catchments – interoperability, safety, trip performance key criteria and measures;
- Public communications roll-out – Brexit means we'd better get moving on AVs if we don't want to be left behind;
- Align UK supply chain – corporate and specialist SME capabilities;
- Smart transport Infrastructure upgraded along heavily used e.g. key trunk routes;
- Business case tested and benefits assessed – proven realisation of the value of the technology;
- Target and work with key enabling groups/organisations to roll-out at scale.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

No comment – though recent Internet of Things(IoT) /webcam DNS attacks show this is essential.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

The operator/supplier of shared use AVs will need to take on legal liability and insurance cover the same as any other public operators e.g. taxi or bus company. Given the fail safe systems of AVs and consequently lower accident rates per millions of miles covered insurance premiums could be expected to fall significantly. However, the liability implications of any systemic faults could be far-reaching and may outweigh some of the accident-rate reduction savings. The UK insurance industry is already actively participating in programmes such as VENTURER and Autodrive (AXA), GATEWay (RSA Insurance) and Lloyds is currently interested in assessing the risks associated with autonomous features.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

The complicated moral dilemmas are well documented and were first considered in the 'trolley problems' introduced as a thought experiment by British philosopher Philippa Foot in 1967. British design engineers and legal teams could well take the global lead in defining a code of practice to govern AVs in all scenarios and eventualities.

**15. What does the proposed Modern Transport Bill need to deliver?**

- An unrestrictive framework to encourage innovation across all transport infrastructure and transport modes;
- Engagement - providing products services and solutions across a wide cross section of industries;
- A set of investment priorities to in parallel develop any required 'smart' infrastructure;
- Change in the people and products servicing the needs of transport users - a change in mindset, perspective, approach to solutions etc;
- A series of innovative solutions that maximise benefits, not only to the economy, but socially to the consumer;
- A technical architecture to control the roll-out and integration of different AV solutions – creating an 'open' architecture;
- Protection for the consumer and UK AV industry from one player dominating the market so restricting long term technical development, and increasing costs.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

We need an educational system that engages at all stages from the young pre STEM through to graduate (the education system tends to focus on preparing young graduate engineers) and mature engineers. We need the expertise and skills to develop businesses, market, service AVs, and support the wider IT and data communications networks.

A big challenge will be convincing a wide demographic as to the benefits and usability of AVs technology. We therefore need mature marketers and engineers, who can listen, note, and design AV's that meet with universal appeal and acceptance. However, AVs are much more than just an engineering challenge. They could herald a societal change as large as that triggered by the internal combustion engine replacing early EVs and horses. As mentioned in Q3, AVs can transform entire industries, not just vehicle manufacturing.

There is also a huge issue regards lack of courses to produce skilled labour capable of maintaining and fixing AVs. Traditional main, and independent, dealers are already stretched in their capability to understand and fix in-vehicle electronics. A set of dedicated training courses is required aligned with the needs of AVs, the students for which may come from early school leavers, or transferable industries/skills e.g. IT and home electrics, from across a wide range of demographics (sex, age immaterial to aptitude and motivation).

**17. Is the Governments strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

- Government strategy and work needs to consider AVs in the round as one component in the circular economy to embrace other technologies e.g. EVs and traffic control systems, as part of an integrated transport solution;

- The government should be assisting with wayfinding and taking an active funding role, to help inform and seed the AV industry, with the emphasis on differentiation with the aim of global leadership in selected technologies, knowledge areas, and use case niches;
- There is no clarity that AVs are being considered in more than road surface transport – a use-case based approach such as light freight would include surface and AV air e.g. drones;
- The government has set up complementary technology networks e.g. aerospace and satellite, these now need to be focused and brought onboard through intelligent clients (reqts and use cases) and visionary entrepreneurial individual contributions.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

Based on publicly available information (information from companies such as JLR will be commercially sensitive) - implications of Brexit are assessed as high risk and in the negative (we require a concerted European partner programme to protect interests and compete globally).

For the reasons outlined above (US and global competition), specific actions to support and protect the AV opportunities is required immediately and on an ongoing basis for the foreseeable future – at least 8 years ahead. The UK, alone among EU states is not a signatory to the 1968 Vienna Convention on Road Traffic and thus may be able to introduce legislation fostering AV usage more rapidly than other EU members can. However, this advantage is not unique to the UK as the US, China and Japan are also not bound by the Vienna Convention. It should also be noted that Sweden, Germany, France, Belgium and the Netherlands are all actively engaged in AV research and finding ways to incorporate AVs into their legislative frameworks.

The size of the UK vehicle market is insufficient by itself to sustain high-volume car manufacturing, exports are vital to the health of the UK industry. In the short-term avoidance of tariff-barriers is essential, but in the longer term ensuring compliance via EU Directive 2007/46 /EC (and its successors) is probably even more important. The UK government needs to derive a strategy to ensure that the research conducted by UK companies and institutions will be compatible with the regulatory standards in force in our major export markets. This challenge is exacerbated by the UK's likely absence from the negotiating table post Brexit.

The UK also needs to consider how it can maintain participation in the large number of international research projects relating either directly to AVs (such as CityMobil2 or the ERTRAC Automated Driving Road Map) or indirectly such as the UK's continuing participation in the Galileo satellite navigation system which will provide enhanced navigation data for AVs. Currently participation is only guaranteed within the timescales of Horizon 2020, but as the development of AV technology and infrastructure is a 10 year + mega-project, a long term product and delivery roadmap is essential.

The UK, under the appropriate leadership and direction of a diverse set of experts and proven innovators (as outlined above), must now develop a coherent long-term AV strategy and development framework. The UK should seek out, and address, the most difficult challenges for AVs, recognising that this work will help define and deliver global transport for the next 100 years – ‘**establishing a successful platform for future generations of UK industries**’

*Co-authors: Alistair Forbes MBA, Programme Manager - Navigation and Geospatial Solutions*

*Nick Bromley BSc MBA, Consultant & Programme Manager - Mobility Technologies*

26 October 2016

## Mr John Philips – Written evidence (AUV0010)

*This is a personal vision from a UK individual who has no political or commercial allegiance.*

### Re-Thinking Transport Systems

- 1) A near future possibility for autonomous vehicles is the motorway ‘vehicle train’. This would revolutionise transportation within the UK.
- 2) Most if not all the technology already exists to create within or alongside the current motorway network an additional autonomous fast lane. This would allow for special vehicles to run close together at constant speed without driver intervention. Such a UK wide network would create significant benefits in economy, travel time, motorway capacity and fuel efficiency. Many of these efficiencies would feed directly into improving business productivity within the UK.
- 3) Like many such UK-wide innovations, this requires a strong lead from Government. If the UK took a longer term view of transport, energy and business growth, this type of leading innovation would create a vibrant economic sector for transportation and energy. For instance, the creation of a standard for such vehicles along with an implementation timescale would create a strong stimulus for business intervention. Couple such technology with hydrogen based vehicles (fuel cells) and a UK wide grid for hydrogen distribution would take the UK into a leading position in this new transport market. A hydrogen based distribution system would also allow our growing alternative power production systems (solar, wind et al) to economically feed into hydrogen production for off-peak energy storage.
- 4) It is likely that within 50 years or less the UK will have many autonomous vehicles based on hydrogen and, or electric vehicles. We need to start planning for such change and start creating new infrastructure to help it work in the way we want rather than allowing it to mushroom in an uncontrolled, unplanned mess that removes many of the longer term benefits. Just leaving it to corporations to cream of the short term profitable pieces will not do well for the UK. Let us have a planned, innovative approach and lead the world creating efficient business growth for the UK.

10 October 2016

## Pinsent Masons and PETRAS – Written evidence (AUV0055)

### INTRODUCTION

1.1 We wish to respond in particular to questions 12 and 13

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

- 1.2 We believe that it would be useful for the committee to understand some of the implications in relation to the **law on data privacy and security** with respect to Autonomous Vehicles. Pinsent Masons is actively advising clients on privacy and security issues relating to autonomous vehicles and also assisting the PETRAS Internet of Things Research Hub<sup>179</sup> in its work regarding autonomous vehicles which are considered "internet of things" objects. Our role is to assist in ensuring the law on data privacy and security is taken into account in the design for internet of things objects such as autonomous vehicles.
- 1.3 PETRAS is a consortium of nine leading UK universities which will work together over the next three years to explore critical issues in privacy, ethics, trust, reliability, acceptability, and security related to the internet of things. The PETRAS project was launched in January 2016 by the Minister of State for Culture and the Digital Economy<sup>180</sup>. Funding for the Hub includes a £9.8 million grant from the Engineering and Physical Sciences Research Council (EPSRC) which will be boosted by partner contributions to approximately £23 million in total. This project runs in collaboration with IoTUK.

### QUESTION 13

2 **13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

2.1 Autonomous and connected vehicles give rise to a number of legal issues. Below is an overview of some of the more significant areas that need to be considered<sup>181</sup>:

2.1.1 **Data "ownership" and data privacy issues**<sup>182</sup> – a large amount of personal data tends to be collected including from "black box" systems giving rise to

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<sup>179</sup> (<http://www.petrasHub.org/>). The PETRAS IoT Hub, is led by UCL and includes Imperial College London, Lancaster University, University of Oxford, University of Warwick, Cardiff University, University of Edinburgh, University of Southampton, and University of Surrey. There are over 50 private sector partners.

<sup>180</sup> <https://www.epsrc.ac.uk/news/events/news/iotresearchhub/>.

<sup>181</sup> See [Connected and Autonomous Cars: The Emerging Legal Challenges](#).

data protection issues and also potentially surveillance issues. Our focus in responding to the call for evidence relates to data privacy issues Business cases for autonomous vehicles may require means of monetization of data so the question of data ownership (outside the scope of privacy aspects) will need to be resolved.

- 2.1.2 **Road traffic laws:** Whilst the Vienna Convention on Road Traffic on an international level will require revision to accommodate for level 4 or 5 autonomy the same applies for national traffic laws as well.
- 2.1.3 **Liability** - who is liable in the case of an accident - manufacturer, driver, suppliers, software providers? For example is the general position that a software provider is not liable for some bugs sustainable in this context?
- 2.1.4 **Product liability** – presently in the EU there is strict liability for manufacturers if the product is unsafe so could this become a product liability insurance issue? How should over the air software updates be dealt with in this context where applied to the vehicle after them having been put on the market? We note that some manufacturers have publicly stated that they accept they are liable (e.g. Volvo).
- 2.1.5 **Criminal liability** could there be a direct liability for corporate manslaughter and secondary liability for example in relation to programmers (in the UK secondary liability is rather widely drawn)?
- 2.1.6 **Telecommunications regulation issues** – depending on the nature of the automated vehicle manufacturers may find themselves falling within telecommunications regulation (which can differ to a significant degree in jurisdictions within the EU).
- 2.1.7 **Health & safety issues** – these would arise where the vehicle is an employer's vehicle.

## 2.2 Legal issues with data privacy

- 2.2.1 Autonomous vehicles collect large amounts of data some of which will tend to identify the driver/ owner of the vehicle and driver behaviours. This is personal data and would presently in the UK be regulated by the Data Protection Act 1998<sup>183</sup> (to be superseded by the General Data Protection Regulation in May 2018<sup>184</sup>).

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<sup>182</sup> For a comprehensive overseas analysis of this issue see the paper produced by the Canadian data protection authority <https://fipa.bc.ca/connected-car-download/>.

<sup>183</sup> <http://www.legislation.gov.uk/ukpga/1998/29/contents>.

<sup>184</sup> <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R0679>.

2.2.2 If we take a simple specific use case<sup>185</sup>:

**Use case 1:**

**The autonomous vehicle needs to understand to a very accurate degree its position on the road in relation to other road users.**

2.2.3 There is an obvious basic operational and safety reason for this. The sort of information that will need to be collected will include:

- a) Location to an accurate degree
- b) Speed
- c) Location of other cars (third party information)
- d) Identify of car / owner / driver

### 2.3 Legal basis for collecting and processing personal data

2.3.1 The starting point for analysis from the point of view of assessing the legal issue in relation to privacy is: what is the legal basis for collecting and then processing the information? This is where the revisions to UK legislation or regulation might assist.

2.3.2 Data privacy legislation works by requiring that there be a lawful ground for processing personal data. The most obvious ground is consent of the individual who's data it is (the "data subject"). We have discussed the practical ways an individual might provide consent when entering their vehicle including in discussion with the Information Commissioners Office who are also considering this issue.

2.3.3 However in the simple use case above the consent would not be sufficient as (1) third party personal data is needed e.g. from "the car in front" and (2) it would not be workable for the owner/driver not to consent (the car could not safely work without the data).

2.3.4 There are other grounds that might be relevant such as:

- a) Contractual necessity
- b) Compliance with legal obligations
- c) Vital interests
- d) Public interests
- e) Legitimate interests

2.3.5 To provide for greater certainty about the way personal data might be permitted to be collected and processed in this context some UK legislation would assist.

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<sup>185</sup> We have been analysing this use case in collaboration with our PETRAS partners the University of Surrey Dr M. Dianati and Dr Jia Liu, Thales Group and TRL. <https://www.pettrashub.org/index.php/portfolio-item/privacy-and-trust-in-connected-autonomous-cars-and-smart-transport/>.

2.3.6 The General Data Protection Regulation provides that Member States may introduce additional lawful bases in relation to processing carried out for the purposes of complying with legal obligations ((b) above) or performing tasks in the public interest ((d) above). There may be some basis for providing for this in the context of (or it being provided for) by the EU Intelligent Transport Systems Directive 2010/40/40 (and supplementary Regulation 2015/962)<sup>186</sup>. However this does not seem to reflect all the use cases that we have been considering.

## 2.4 Data minimisation, anonymisation and privacy by design

- 2.4.1 In the context of use case 1, we have been considering, with our PETRAS partners at the University of Surrey, the privacy and security implications of "cooperative positioning". This concept relies on vehicles communicating with each other to determine location more accurately.
- 2.4.2 The research so far has explored the feasibility of technical measures that might minimise the need for personal data to be transmitted. There do appear to be some techniques that could be explored further (the research is at an early stage).
- 2.4.3 The need to develop ways to minimise collection of personal data, anonymise it where possible and to build in privacy by design are concepts that are required in principle by the General Data Protection Regulation.
- 2.4.4 This is an area that might benefit from further guidance (in terms of how a manufacturer might comply with these requirements) but not necessarily an area that requires further legislation or regulation. There may be a role for standards in this area, as well as in the area of information security which we discuss below. This is something we have discussed with BSI in the context of their Research Project on Connected and Autonomous Vehicles (CAV)<sup>187</sup>.

## 2.5 Insurance

- 2.5.1 Another use case we anticipate exploring with our PETRAS partners arises in the context of insurance:  
**Use case 2:**  
**The insurer of the connected vehicle needs to understand the conduct of the driver and other road users**

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<sup>186</sup> The Commission will issue a "Masterplan on the Interoperable Deployment of Cooperative Intelligent Transport Systems (C-ITS) across the EU" by the end of this year to continue efforts towards connected, cooperative and automated driving. [http://ec.europa.eu/transport/themes/its/road/action\\_plan/](http://ec.europa.eu/transport/themes/its/road/action_plan/).

<sup>187</sup> BSI are working with Transport Catapult and Innovate UK on this project. <https://ts.catapult.org.uk/>.

- 2.5.2 Some of the techniques in relation to data minimisation and anonymisation are unlikely to be feasible in this use case as, to be fully effective, the insurer is likely to want to know the identity of the insured driver.
- 2.5.3 Issues arise in relation to third party data in particular where consent is not a practical mechanism to provide a legal basis for processing. However third party data may be important to determine whether the third party was responsible for an accident or apparent "error" made by the driver of the connected vehicle.
- 2.5.4 This may be another area where legislation could provide a degree of certainty about what the legal basis would be for insurers collecting and using this data.

### 3     **QUESTION 12**

- 3.1 **12. Does the Government have an effective approach on data and cybersecurity in this sector?**
- 3.2 We think it worth noting that security is not just a technical issue, but also a legal issue as data privacy legislation requires (in broad terms) that appropriate technical and security measures are taken in relation to safeguarding personal data.
- 3.3 In use case 1, or more generally, a vehicle periodically broadcasts "Cooperative Awareness Messages" (information about a vehicle's position, velocity, acceleration, etc.) to its neighbour vehicles for the safety purpose. However these messages could be collected and processed for other purposes and by the other parties (e.g., law enforcement, insurance companies). Questions arise around what the appropriate security measures should be. In relation to third parties could they collect and process this data easily where these messages are broadcast into the networks? Could the neighbour vehicles use the data for other purposes (e.g. a law suit for divorce) in addition to collision avoidance?
- 3.4 The legal requirements relating to security are generally of a high level nature – and are designed to ensure that suitable measures are taken given the nature of the data collection and processing taking place. However this means that approaches to security vary between the different entities that need to handle the data in order to make a connected vehicle work (e.g. the manufacturer might have a different approach to transmission of data, to the relevant telecoms provider, or the relevant data processor). This is one of issues that appear to be giving rise to difficulties with interoperability (i.e. the ability for different links in the chain to work with each other).
- 3.5 Legislation is one option – particularly for example in relation to a manufacturer of a component part of the automated vehicle where that manufacturer does not in fact process data. That manufacturer has no legal responsibility under data protection or cyber security legislation. Once it has made and delivered the object it

can walk away, but the object may contain security flaws which impact on other parties related to the connected vehicle and third parties more generally. Security flaws in internet of things devices (of which automated and connected vehicles are an example) have been utilised by hackers to attack internet services more generally<sup>188</sup>.

- 3.6 Another option for providing clarity, which may be more appropriate where the broad legal obligation already applies, would be to assist with the development of standards – this is something we have discussed with the BSI. In this context we consider that an EU or international standard, developed in conjunction with regulatory authorities could assist in overcoming trust and interoperability barriers in relation to the development of connected and autonomous vehicles.

#### 4 CONCLUSION

- 4.1 This is a brief overview of some of the issues that we are examining with clients and along with our PETRAS partners. The projects are presently at an early stage. Should the committee be interested in hearing more about the progress of work we are doing with PETRAS we would be delighted to discuss this with them.

*26 October 2016*

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<sup>188</sup> See for example the recent Dyn Cyber attack that disrupted Paypal, twitter and spotify <http://www.reuters.com/article/us-usa-cyber-idUSKCN12L1ME>.

## **Pupils 2 Parliament – Written evidence (AUV0016)**

### **Driverless cars – where are we going?**

*Submission of pupils' views made by Dr Roger Morgan OBE*

#### **Introduction**

1. This submission is by Pupils 2 Parliament, a project to enable school pupils to consider and feed in their views to parliamentary, national government and national body public consultations and inquiries. The project has been approved by the Clerks of both Houses of Parliament to use the term 'Parliament' in its title.
2. Pupils 2 Parliament aims to bring the particular viewpoint of children and young people to those conducting inquiries and consultations – plus the uniquely fresh and often challenging analysis that children and young people bring to decisions and policies.
3. The project also aims to give school pupils the chance to learn about and consider key decisions being made by parliament, national government and public bodies, and genuinely to participate in democracy by feeding their views into real national decisionmaking.
4. Pupils' views are independently gathered through discussions with groups of pupils led by someone from Pupils 2 Parliament, using material from the relevant consultation or inquiry document to explain the issues. We specialise in putting the issues and questions even-handedly, without leading pupils in any way or suggesting any responses. All views come spontaneously from pupils, with no adult prompt.
5. This submission gives pupil views for the Committee's inquiry on autonomous vehicles. The information we gave and the questions we asked pupils were based on the Terms of Reference for the inquiry.
6. The submission contains all pupil views given, without selection, comment or addition. The views submitted are entirely pupils' own views, and nothing but pupils' views.
7. Views in this submission came from discussion with 51 pupils aged 9 to 10 at Belle-Vue Primary School, Stourbridge, West Midlands.

#### **The uses of driverless vehicles**

8. Pupils were asked to list the uses they could see for driverless cars and other sorts of autonomous vehicles – and to say what they saw as the good and bad things about them.
9. Uses for driverless cars were for elderly drivers who could switch their driverless car to take over if they felt tired, or their hands or legs were aching, for deaf or blind people to use, to be designed to use less fuel, to go for long journeys (for families, this meant that

parents could rest while the car drove itself, and for anyone it meant you could relax during journeys), to drive more safely and so reduce accidents and injuries such as whiplash, to carry pregnant women without having a steering wheel in front of them, as taxis that could be called more conveniently than usual taxis, and to allow the driver to switch to auto to sort out any problems with pets or other animals they were carrying.

10. A good point about driverless cars was that sensors should be able to ‘see’ further and more widely than the mirrors drivers use on ordinary cars. Their sensors should be able to detect traffic ahead before a human could and before you got to it.

11. Pupils also saw a valuable use for autonomous submarines to explore the sea at depths where the pressures would be dangerous for humans. They also saw a useful ability to control any sort of exploration vehicle remotely using gloves fitted with position sensors.

12. Pupils also gave some extra ideas. Mobility scooters could be made autonomic, to take elderly or disabled people where they wanted to go and home again. This would be good for people finding it hard to drive a scooter, or to remember the way for themselves. The sensors on a driverless car could gauge the speed of an approaching vehicle and work out what it might do if it registered that it was going too fast. Autonomic motor bikes could let riders ride at a more stable angle while the sensors watched the road ahead, and could perhaps be made to correct things if the rider was overbalancing. All driverless cars could be programmed to take their passengers to the nearest hospital in an emergency, wherever they are.

13. Bad things pupils saw in the development of driverless cars and autonomic vehicles were that people would still need to take driving tests in cars with a full set of controls, otherwise they would only be able to travel as passengers in driverless cars, the computer controls of a driverless car could end up taking you where you didn’t want to go, sensors could turn out to be worse than humans at seeing what is going on around the car (“maybe humans are better than sensors and may react quicker”), computers can miss things, and the computer might simply ‘make a mistake’ and cause the car to hit something. There was also concern about sensors getting damaged, with a broken sensor causing an accident. While a driverless taxi might be easy to call, someone might pay for one online and then without a human driver, someone else could steal their ride, or the taxi might not turn up at all once you had paid for it online.

14. Many were concerned that the computers in a driverless car or other autonomic vehicle could be hacked into. Or they could get a computer virus and become unreliable and unsafe. If you used the time the car was driving itself to eat and drink, there was the risk that spilling a drink might affect the car’s electronics. Finally, while you would probably need a password to give instructions to a driverless car, passwords are often found out, and electronic pads or mobile phones with control codes for the car could be taken.

15. Some were worried that driverless cars might not be good at finding their way through diversions and road blockages – “if you’re driving to the airport and the road is blocked, it may not know where to go instead”. There was also a concern that driverless cars would turn out to be very expensive – and expensive to repair.

16. Many pupils were worried that in a driverless car, someone relaxing or sleeping could knock the controls and make the car wrongly sense the driver was taking control, or directly cause an accident. If this stopped the car suddenly, that could cause an accident by a vehicle behind running into it. There was also the concern that a child could accidentally start the car moving, or touch the controls.

17. Many others were worried that a driverless car could brake or change direction too sharply and hurt or injure its passengers.

18. Pupils had three concerns about the effects of driverless cars on human behaviour. Firstly, driverless cars could encourage more people to make more journeys, even very short ones, by car, and so stop getting exercise by walking. Secondly, they could encourage people to drink too much alcohol, thinking they could drink more because the car would take them home without them having to drive. Thirdly, passengers might be more likely to smoke in a driverless car than while they are driving.

#### **The pupils' vote on the future development of autonomous vehicles**

19. Once the pupils had discussed the uses, good things and bad things about autonomic vehicles, we asked them to vote on whether they were for, or against, the future development of lots of driverless vehicles.

20. Pupils were overall against the development of lots of driverless vehicles, by 40 votes to 11.

#### **What if pupils' families were to buy a driverless car?**

21. We then asked whether they would be really pleased if their own family was going to get a driverless car. This time, the vote was more balanced, but still more pupils voted that they would not be really pleased about their family getting a driverless car, by 27 votes to 23.

22. Pupils were not strongly keen on driverless vehicles – overall, they were against the development of lots of them, and the majority did not think they would be really pleased if their own family got one.

#### **The priority for the next autonomous vehicles**

23. We asked the group for proposals for the sort of driverless vehicle that the UK should develop first. We put these in order of priority by asking how many pupils supported each proposal. Here are the pupils' priorities in order:

- |           |  |
|-----------|--|
| 1st       | Drones to deliver medical supplies in rural countries (supported by 34 pupils) |
| 2nd       | Driverless cars for disabled people (supported by 33 pupils)                   |
| 3rd       | Driverless cars for elderly people (supported by 30 pupils)                    |
| 4th       | Autonomous leisure cruise boats (supported by 25 pupils)                       |
| Joint 5th | Driverless vehicles to carry families (supported by 22 pupils)                 |
| Joint 5th | Submarines for underwater exploration (supported by 22 pupils)                 |

7th Driverless coaches for transporting people (supported by 6 pupils).

24. The children's priorities for the development of autonomous vehicles, each supported by over half the pupils, were clearly drones for dropping medical supplies in rural countries, and driverless cars to carry disabled and elderly people.

#### **Interest in working in the autonomous vehicles industry**

25. The Select Committee is interested to know the likely supply of people to work in the autonomic vehicle industry in the future, so we asked the pupils how many of them would like to work on developing different sorts of autonomous vehicles in their own futures.

26. The majority of pupils (27 pupils) thought they would be interested in working in the autonomous vehicle industry in the future.

#### **Worries about hacking and autonomous vehicles**

27. The Committee has raised the issue of cyber security of autonomic vehicles, and this was something the pupils themselves raised in our discussion. We asked our 51 pupils how worried they were that driverless cars' computers might be hacked into.

28. Over half (33 pupils) were 'very' or 'a bit' worried about driverless cars' computers being hacked. 7 pupils were not worried about this at all.

29. The complete figures were 18 'very worried', 15 'a bit' worried, 11 'not really' worried, and 7 'not at all' worried.

#### **How safe should driverless cars have to be before they are used on UK roads?**

30. Lastly, we asked the children to think about how safe driverless cars should have to be, compared with humans driving cars, before being used on our roads. We had explained that around nine out of ten road accidents involve driver errors, and that driverless cars are expected to make far fewer errors than humans, and so be much safer. We wanted to test children's views on how much safer they should have to be in order to be allowed on the roads.

31. The children wanted driverless cars to prove themselves to be as near as they could possibly be to perfect safety before being allowed to use UK roads freely.

32. 37 out of the 51 pupils voted that driverless cars should have to be as near as they can to being perfectly safe before being used on the roads. 6 voted that they should be allowed on the roads once they had proved themselves safer than human drivers. Another 6 voted that they should be allowed on the roads once they had been proven as safe as human drivers. 2 voted that driverless cars should be allowed on the roads even while they were a bit less safe than human drivers, while they were being developed and because they were expected to get gradually safer as their design improved.

33. Pupils told us they voted the way they did because of the risks they still saw for driverless cars, such as their control computers being hacked into or getting a computer virus. Those risks needed to be got rid of first. They still saw the cars likely to fail sometimes

and cause accidents - which could kill people likely to be using them, including families or pregnant women. If driverless cars were so much better than humans, they needed to prove that there would be very little chance of an accident with them – “more humans can enjoy themselves then”.

34. The small number of pupils who voted that driverless cars should be allowed on the roads once they were found to be as safe as human drivers voted that way because using them on the roads would not increase road accidents, and that would be OK. Using driverless cars that had the same level of safety as human drivers was also OK because the cars should become safer with time; “should be the same because throughout the years it will get better, not worse”.

35. Those who thought that driverless cars should prove themselves safer than human drivers before being allowed on the roads gave two final quotes for this submission: “because they’re meant to be better than normal cars”; “if it’s not going to be safer, what’s the point of bringing it on the road?”.

36. I am grateful to the Head and staff of Belle-Vue School for letting me carry out this discussion with their pupils, especially grateful to the member of staff who worked hard to take notes of the pupils’ views, and above all I am grateful to the pupils themselves who gave their fresh thinking, views and ideas for this submission.

*23 October 2016*

## **RAC – Written evidence (AUV0011)**

*This response has been written by Nicholas Lyes, RAC Public Affairs Manager, on behalf of RAC Motoring Services*

### **About the RAC**

With more than eight million members, the RAC is the oldest and one of the UK's most progressive motoring organisations, providing services for both private and business motorists. As such, it is committed to making driving easier, safer, more affordable and more enjoyable for all road users.

The RAC, which employs more than 1,500 patrols, provides roadside assistance across the entire UK road network and as a result has significant insight into how the country's road networks are managed and maintained.

The RAC is separate from the RAC Foundation which is a transport policy and research organisation which explores the economic, mobility, safety and environmental issues relating to roads and their users.

The RAC website can be found at [www.rac.co.uk](http://www.rac.co.uk).

In September 2016, the RAC published its latest [Report on Motoring](#).

### **RAC Response**

#### **1. What are the potential applications for autonomous vehicles?**

1.1 Potentially, in the longer term, autonomous vehicles could address any application currently fulfilled by conventional vehicles with the exception of those journeys undertaken entirely or largely for the pleasure of driving. However, early applications are likely to include localised applications such as goods deliveries, taxi services and mobility services for the disabled, the elderly and others unable to drive themselves. It is also likely that longer distance journeys for commercial vehicles, where fuel savings from platooning offer the prospect of significant cost savings, are likely to be an early target.

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

2.1 Each year, The RAC publishes its Report on Motoring. Now in its 28<sup>th</sup> year, the Report is an extensive nationwide survey of a representative cross-section of UK motorists to find out what is on their mind and where their priorities on road policy lie. It informs Government and policy makers with considerable insight into the attitudes of the UK motorist and what is high on their agenda. Over the past 2 years, we have asked a series of questions to gather motoring opinion on the subject of driverless vehicles, and this year in particular we targeted specific aspects in line with the Government's priorities on the

matter. Our research found that most motorists (76%) do not expect driverless cars to become available to the public before the end of the current decade, while only half (49%) expect sales of new autonomous vehicles to outnumber those of conventional models by 2070.

2.2 The research also showed concerns about areas which are considered benefits by some policy makers. For example, 70% of respondents were concerned about the reliability of the software that driverless vehicles will use, with 66% admitting concerns that computer software of a driverless vehicle may be “hacked”.

2.3 There is also a suggestion that motorists may not be ready for driverless vehicles. A majority (63%) admitted that they are scared by the prospect of driverless cars on the road, whilst only one in four (25%) said they were looking forward to travelling in a driverless car (with 48% saying they weren’t). In addition, only 27% say they are excited by the thought of driverless cars on the road, as opposed to 35% who say they are not.

2.4 There is also concern that increasingly autonomous vehicles will begin to impact upon driving quality. 51% believe the new technologies will lead to complacency amongst drivers and potentially more accidents, although this is down from 59% in 2015. This is despite the contribution that driver error is known to make to casualty rates on today’s roads.

2.5 One in four drivers believe that driverless cars will reduce the number of traffic jams on the road, however a larger proportion (35%) disagreed.

2.6 There were, however, some positive findings in relation to mobility. 62% agreed that driverless cars will improve personal mobility for disabled or elderly drivers, an increase on the 52% who responded the same way when questioned in 2015.

2.7 The RAC believes that there are potentially many benefits for motorists from increasingly autonomous vehicles, and eventually fully driverless vehicles. These include safer roads through reduced road traffic accidents, reduced congestion through smoother traffic flow and increasingly intelligent technology. However, it appears this messaging is not understood by the majority of road users. There are also significant questions that need to be addressed on liability when fully autonomous vehicles are on our roads and we await with interest Government proposals which we understand will form part of the Modern Transport Bill. There is rightly an emphasis on ensuring that the UK is a technology leader and that the resulting vehicles are reliable and safe from cyber-attacks, we would urge policy makers to place equal emphasis on communicating the benefits that driverless vehicles will deliver for users and for society as a whole. We would also urge Government, manufacturers and developers to engage fully with the motoring public, including involving motorists in the pilot programmes, so that they gain confidence in the reliability and resilience of the technology.

**3. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

3.1 Progress towards fully autonomous vehicles is likely to be evolutionary, rather than revolutionary, and insurance and legislation needs to recognise that for a long time there will be a mix of vehicles on our roads with different levels of autonomy.

3.2 Where a fully or partially autonomous vehicle causes an accident then liability should reside with the vehicle manufacturer rather than with the user. However, to establish liability in such situations, it will be necessary to access the data stored by each of the vehicles involved in a collision. This raises issues of who owns the data and who has right of access to the data. We need to avoid a situation where product liability lies with the vehicle manufacturer but users of fully autonomous vehicles still need insurance to cover those situations where liability for a product failure cannot be established because one of the parties declines access to data stored by their vehicle.

3.3 It is also difficult to estimate how insurance premiums will be affected. It is expected that fully autonomous vehicles will be involved in far fewer accidents than today's vehicles and so in principle the cost of insurance will fall and much of the burden will shift from liability of a driver to product liability of the manufacturer. However, this is dependent on a robust regulatory framework that enables liabilities to be established.

3.3 Given the complexities of having separate strands of cover, amending Part 6 of the 1988 Road Traffic Act (as outlined in a recent Government consultation) to extend compulsory insurance requirements for automated vehicles to require the owner to ensure that there is an insurance policy in place that covers the manufacturers' and any other entities' product liability seems sensible. We believe this would be within a framework that the motorist is familiar with.

#### **4. What is the scale of the market opportunity for autonomous vehicles?**

4.1 The RAC is not in a position to answer this fully. However we urge those involved in the development of driverless vehicle technology to take note of the RAC's research on road user opinion as these opinions will invariably have implication on market opportunity and take-up.

#### **5. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

5.1 The RAC is not in a position to answer this fully. However we expect autonomous systems to place demands on the physical infrastructure. For example, some lane departure warning systems function by capturing images of painted white lane-demarcation markings. However, where these are faded, this could potentially compromise the effectiveness of the system. Going forward, therefore it will be necessary for highways and local authorities to recognise any more stringent demands placed on the physical infrastructure by autonomous vehicle technology when planning maintenance or developing improvement schemes.

## RAC Foundation – Written evidence (AUV0024)

### 1. Introduction

1.1 The RAC Foundation<sup>189</sup> is an independent transport policy and research organisation which explores the economic, mobility, safety and environmental issues relating to roads and their users. The Foundation carries out independent and authoritative research with which it promotes informed debate and advocates policy in the interests of responsible road users.

1.2 The Foundation welcomes the opportunity to give evidence on this important topic. Our comments relate specifically to road transport – including both the use of autonomous vehicles for road transport and the use of other types of autonomous vehicles that could have implications for road transport. We have set out some key considerations below before offering answers to the specific questions the Committee has posed.

1.3 The use of autonomous vehicles in the UK's demanding traffic environment is one of the most challenging of potential applications. Less challenging but still relevant applications for autonomous vehicles might include:

- environments hostile to human life and wellbeing;
- open environments which are easily navigated by robotic devices;
- tightly controlled environments where external intrusions are eliminated;
- environments which are too small to accommodate a human presence; and
- routine and repetitive operations not requiring a high level of operating skill.

1.4 Whilst driving a car on the public road might be regarded as engaging in a hostile environment, the arguments about convenience and efficiency are weighing at least as heavily as those for improving road safety in the debate about autonomous road vehicles thus far.

1.5 Meantime, the concept of the self-driving car has caught the public imagination and is attracting vast investment in the development of autonomous technology from traditional auto manufacturers and from technology companies. Given our success in attracting inward investment in the auto sector of late, it makes perfect sense for the Government to seek to attract this research and development activity to the UK as part of its broader industrial strategy.

### 2. The Foundation's general position on autonomous and driverless vehicles

2.1 The Foundation supports the introduction of aids to driving road vehicles where they:

- enable enhanced mobility, especially for those least well served by existing systems;
- reduce the risks of collisions between road vehicles and other vehicles, pedestrians and physical infrastructure;
- help to reduce fuel consumption, emissions and environmental nuisance;
- increase the effective capacity and reliability of the road system; and

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<sup>189</sup> For further information about the Foundation see <http://www.racfoundation.org/>.

- provide a less demanding and more enjoyable experience for road users.

Thus the Foundation sees the increased automation of road vehicle operation not as an end in itself - but as a means to increasing the safety, economy, efficiency and amenity of road transport. To achieve these benefits, we need to resolve a number of issues including the transition to autonomy and the nature of the business model (or models) under which autonomous vehicles will be made available.

#### *Background*

2.2 Over the last half century many innovations in automotive technology have improved the safety and economy of road vehicles<sup>190</sup> from servo assistance to anti-lock braking, electronic stability control and autonomous emergency braking. Engine and drive train efficiency has also improved substantially with small, often turbocharged, units supplanting larger engines without sacrificing performance yet sharply reducing fuel consumption and emissions. Often these are ‘optional extras’ in their early stages but soon become standard to the point that many drivers are not aware of their existence.

2.3 More recently technological innovations have been introduced which, to varying extents, change the driving task itself, (adaptive) cruise control, lane departure warning systems, (dynamic) GPS routing and intelligent parking assist are four examples. These mean that some tasks that had to be carried out by the driver are reduced or replaced. It is here that we see a potential ‘fault-line’ opening up in the path to full autonomy.

2.4 Whilst the developers of autonomous systems are making ambitious claims for the point at which their products will come to market, it is possible that the complexities of operating safely and efficiently in all traffic environments are such that operation without human control may only be possible in less demanding traffic environments such as on limited access roads, or on ‘closed’ elements of the network, such as motorways. The challenge then becomes one of managing the transition:

- between driverless vehicles and other traffic – with nearly 40 million driven vehicles on our roads (including bicycles) in this country alone driverless vehicles will need to be able to operate alongside driven vehicles for a considerable time as the vehicle park turns over.
- between the driver and the vehicle – who is in control? And can control be passed back and forth (as is the case in an aircraft autopilot system)?

#### *System and commercial architecture*

2.5 For the autonomous car to be brought into general use a number of issues will need to be satisfactorily addressed, many as set out in the Foundation’s response to the recent Centre for Connected and Autonomous Vehicles consultation on the Pathway to Driverless Cars: Proposals to support advanced driver assistance systems and automated vehicle technologies<sup>191</sup> including:

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<sup>190</sup> Bayliss 2008.

<sup>191</sup> RACF 2016.

- eliminating ambiguity of responsibility for vehicle control especially in transition between manual and autonomous operation;
- clarity of liability for damage caused by autonomous vehicles given the variety and complexity of detection, communication and control systems likely to be employed in their operation;
- how the interactions between autonomous vehicles and the general traffic stream will be managed;
- how autonomous vehicles will perform in complex traffic environments. Whilst platoon operation on motorways may well improve efficiency and capacity conservative autonomous vehicle operations in congested multi-purpose environments could result in sharp degradations of service levels and effective capacity;
- ethical questions about safety priorities in the event of a prospective collision; and
- robustness to IT failures and security risks such as ‘hacking’.

2.6 There are also unresolved questions about the overall architecture of a general autonomous regime. The present prototypes rely mainly on a combination of various ‘in vehicle’ detection systems along with GPS and GSM links. As numbers grow the viability and benefits of more advanced vehicle to infrastructure ( $V \leftrightarrow I$ ) and vehicle to vehicle ( $V \leftrightarrow V$ ) are likely to improve<sup>192</sup>.

2.7 A current example of the former would be traffic signals advising approaching vehicles of imminent green time to allow speeds to be regulated to avoid stopping; and of the second virtual linkages between platoons of trucks on motorways. Potentially more efficient architectures incorporating these facilities would require some measure of co-operation between vehicle manufacturers, telecoms providers, regulators and road operators. As yet there is little sign of this taking place and, variations in organisations’ objectives and commercial rivalries are likely to mean this would not be achieved overnight.

2.8 There are also questions about the commercial architecture of the autonomous vehicle market. Most of the descriptions of a future world of autonomous vehicles providing convenient, safe, efficient mobility for us all, without the need to worry about parking, are silent on the question of who, exactly will own and ‘operate’ the vehicle. Several models are possible, from an extension of the current, widely popular, leasehold contracts, under which a vehicle has a dedicated registered keeper, through to a form of minicab service, where users cease to own vehicles, instead booking them – and paying for them – by trip. Recognising that a variety of approaches might operate in parallel, it is hard, today, to be clear about the product that the individual motorist will be offered, and hence to form a view on the likely cost and affordability for individuals.

#### *The pathway to autonomy*

2.9 There can be little doubt that the pathway towards automated road vehicles will involve progressive introduction of driver assistance systems. Initially these have been passive (e.g. Anti-lock Braking Systems, Traction Control Systems and Electronic Stability

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<sup>192</sup> This has led to the use of Connected Autonomous Vehicle (CAV) rather than Autonomous Vehicle.

Controls), subsequently there has been a mushrooming of driver information systems (e.g. motorway Variable Message Signs, Satellite Navigation and Traffic Alerts) and now a range of active/semi-active systems are being deployed (e.g. Autonomous Emergency Braking, Adaptive Cruise Control and Parking Assist). This process of innovation seems set to continue with new applications appearing first on high value premium models but quickly cascading down to middle and utilitarian ranges.

2.10 There should be considerable safety benefits from innovations designed to make the task of driving easier. It has been argued by some observers that Advanced Driver Assistance Systems (ADAS) could bring safety benefits sooner and at a lower cost than fully autonomous operations – especially in light of concerns about their congestion impacts and security<sup>193</sup>. However their introduction will have to be carefully designed as the provision of information to the driver, even if intended to assist, can be distracting if not in the right form at the right time.

2.11 Furthermore, ambiguity over the extent of control required of the driver could, if not properly managed, introduce new forms of risks, in particular, where the driver is left with so little to do by way of controlling the vehicle that they are insufficiently alert when circumstances require the driver to take action. What is the driver realistically supposed to be doing on a motorway when the car is deciding for itself the speed to go at, when to brake, and when to turn the wheels to stay in lane? The less time a driver spends driving, the less we should expect them to *feel* in control.

2.12 The issue becomes starker as the borderline is crossed between driver-assistance into autonomous operation. The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) has defined vehicle automation as having five levels, which have become widely recognised as a possible 'road map' toward full autonomy:

**No-Automation (Level 0):** The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times.

**Function-specific Automation (Level 1):** Automation at this level involves one or more specific control functions. Examples include electronic stability control or pre-charged brakes, where the vehicle automatically assists with braking to enable the driver to regain control of the vehicle or stop faster than possible by acting alone.

**Combined Function Automation (Level 2):** This level involves automation of at least two primary control functions designed to work in unison to relieve the driver of control of those functions. An example of combined functions enabling a Level 2 system is adaptive cruise control in combination with lane centering.

**Limited Self-Driving Automation (Level 3):** Vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control. The driver is expected to be available for occasional control, but with sufficiently comfortable transition time. The Google car is an example of limited self-driving automation.

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<sup>193</sup> Sowman 2016.

**Full Self-Driving Automation (Level 4):** The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles.

2.13 We believe Level 3 is fraught with difficulty. The key is in defining what ‘sufficiently comfortable transition time’ means. Some descriptions of level 3 automation envisage the vehicle being able to cede control back to the driver where the circumstances it is encountering exceed its ability to interpret and manage them – potentially an imminent collision. But is it realistic to expect a driver to remain alert so as to regain control and act in the split seconds that count in such circumstances? A driver who has switched to autonomous mode and is catching up on e-mail or reading a book is unlikely to be able to re-take control. Indeed, many of the safety benefits claimed for autonomous operation stem from the ability of machines to sense and react more quickly than human drivers, as well as not being prone to human error.

2.14 Even outside emergency situations it is possible to envisage circumstances where a driver who has been reading or even sleeping for an extended period of motorway driving is not sufficiently awake and alert safely to retake control despite wishing to do so. Should the vehicle have the ability to deny the driver, possibly by reference to monitoring of the driver’s biometrics? Or should we only think of the control ‘baton’ being passed when a vehicle is stationary, thus the motorway driver wishing to retake control would need to instruct the vehicle to pull into a rest area and stop first?

2.15 In short, are we ready for a machine in which we are travelling not just to follow instructions, but to decide its own without the scope for a manual override?

### 3. Responses to Specific Questions

*What are the potential applications for autonomous vehicles?*

3.1 The environments where autonomous vehicles are most obviously suitable for deployment are briefly described in paragraph 1.2. But the full range of potential application is vast depending on the pace of development, sophistication and cost of the products coming to market.

*What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?*

3.2 Generally the potential benefits include:

- substituting machines for human beings in dangerous environments;
- accessing sites beyond the reach of human operated machines e.g. ‘silo’ parking;
- making vehicle operation safer by removing human error;
- enabling all vehicle occupants to engage in non-driving activities so releasing time for more productive uses and expanding the availability of personal mobility;
- increasing infrastructure capacity e.g. by reducing headways;

- better matching the supply of services to the demand for them; and
- reducing the dependence on costly and sometimes unreliable human operation.

3.3 These potential benefits will not automatically materialise:

- high levels of automation can be costly;
- there are many environments where the limited capabilities of autonomous operation are such that it will not be worth their development and deployment.

A critical issue for promoters of autonomous vehicles is to establish a clearer picture of how they could perform, at scale, in real world environments and what the economic, social and environmental consequences would be as well as how the technical problems would be dealt with. This is less about disadvantage and more about uncertainty.

*How much is known about the potential impact of deploying autonomous vehicles in different sectors?*

3.4 There has been interest in self driving passenger vehicles for some time and in 2004 the US Defence Advanced Research Projects Agency launched a competition for off road vehicles<sup>194</sup>. More recently there is a growing commercial interest in the prospect of an autonomous vehicle market with tremendous interest and investment from some of the largest technology and auto manufacturing companies<sup>195</sup>, with a reported 33 major companies working on autonomous road vehicles at present<sup>196</sup>. It appears that the design and development of autonomous road vehicles has already become a major civilian R&D activity<sup>197</sup>.

3.5 Real life trials of CAVs have been limited so far. Google has operated its autonomous cars for over 1½ million miles in a number of US cities<sup>198</sup> and the first stage of an automated taxi trial (6 vehicles in a 2½ mile radius zone) is underway in Singapore<sup>199</sup>. TESLA has been supplying its ‘autopilot’ technology in its cars since October 2014. This enables the driver to allow the car to ‘drive’ itself in certain traffic environments. The system steers, changes lane and controls speeds and braking and allows the driver to go ‘hands free’ whilst operational. This has not been without incident with at least two crashes and is almost certainly not yet suitable for operating in the wide range of conditions experienced in much everyday driving<sup>200</sup>. Here in the UK the Transport Catapult LUTZ project has recently demonstrated self-driving car operations (one vehicle) in Milton Keynes<sup>201</sup>.

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<sup>194</sup> DARPA 2008.

<sup>195</sup> See for example Audi 2015, BMW 2016, Daimler 2016, Google 2016, Nissan 2016a, Sage 2016, TESLA 2016 and Volvo 2016.

<sup>196</sup> CB Insights 2016, OICA 2016.

<sup>197</sup> ERTRAC 2015.

<sup>198</sup> Google 2016.

<sup>199</sup> The Verge 2016.

<sup>200</sup> Fortune 2016 see also Silver 2016.

<sup>201</sup> Moran 2016.

3.6 Truck platooning has been trialled in a European project<sup>202</sup> involving six manufacturers and twelve vehicle travelling on three motorway routes in norther Europe. This trial appears to have gone well and lessons are being learned for future development/deployment of this technology<sup>203</sup>. In the 2016 budget<sup>204</sup> the Chancellor of the Exchequer proposed that the UK Government will:

- conduct trials of driverless cars on the strategic road network by 2017;
- consult this summer on sweeping away regulatory barriers within this Parliament to enable autonomous vehicles on England's major roads;
- establish a £15 million 'connected corridor' from London to Dover to enable vehicles to communicate wirelessly with infrastructure and potentially other vehicles;
- carry out trials of truck platooning on the strategic road network; and
- start trials of comparative fuel price signs on the M5 between Bristol and Exeter by spring 2016 to drive fuel price competition and help motorists save money.

3.7 The M5 trial is underway<sup>205</sup> and the London to Dover 'connected corridor' is planned to start pilot operation in the summer of 2017<sup>206</sup>.

3.8 Whilst there is a great deal of activity in the development of Advanced Driver Assistance Systems (ADAS) and CAVs to date deployment has been very limited and mostly on a trial basis. Assessments of the impacts is therefore largely at a theoretical stage and there is no clear consensus of what these will be. Table 1 sets out one set of the potential impacts by Litman who is a respected transport analysts and without ant commercial interest in the technology.

3.9 The assessment assumes that the technologies will function adequately in a wide range of traffic conditions and any cost premia will not be so high as to prevent widespread take up of CAVs.

BENEFITS	COSTS/PROBLEMS
<i>Reduced driver stress.</i> Reduce the stress of driving and allow motorists to rest and work while traveling.	<i>Increases costs.</i> Requires additional vehicle equipment, services and maintenance, and possibly roadway infrastructure.
<i>Reduced driver costs.</i> Reduce costs of paid drivers for taxis and commercial transport.	<i>Additional risks.</i> May introduce new risks, such as system failures, be less safe under certain conditions, and encourage road users to take additional risks (offsetting behaviour).
<i>Mobility for non-drivers.</i> Provide independent mobility for non-drivers, and therefore reduce the need for motorists to	<i>Security and Privacy concerns.</i> May be used for criminal and terrorist activities (such as bomb delivery), vulnerable to information

<sup>202</sup> SARTRE 2013.

<sup>203</sup> European Truck Platooning 2016,

<sup>204</sup> HM Treasury 2016.

<sup>205</sup> Highways England 2016.

<sup>206</sup> DfT 2016a.

chauffeur non-drivers, and to subsidize public transit.	abuse (hacking), and features such as GPS tracking and data sharing may raise privacy concerns.
<i>Increased safety.</i> May reduce many common accident risks and therefore crash costs and insurance premiums. May reduce high-risk driving, such as when impaired.	<i>Induced vehicle travel and increased external costs.</i> By increasing travel convenience and affordability, autonomous vehicles may induce additional vehicle travel, increasing external costs of parking, crashes and pollution.
<i>Increased road capacity, reduced costs.</i> May allow platooning (vehicle groups traveling close together), narrower lanes, and reduced intersection stops, reducing congestion and roadway costs.	<i>Social equity concerns.</i> May have unfair impacts, for example, by reducing other modes' convenience and safety.
<i>More efficient parking, reduced costs.</i> Can drop off passengers and find a parking space, increasing motorist convenience and reducing total parking costs.	<i>Reduced employment and business activity.</i> Jobs for drivers should decline, and there may be less demand for vehicle repairs due to reduced crash rates.
<i>Increase fuel efficiency and reduce pollution.</i> May increase fuel efficiency and reduce pollution emissions.	<i>Misplaced planning emphasis.</i> Focusing on autonomous vehicle solutions may discourage communities from implementing conventional but cost-effective transport projects such as pedestrian and transit improvements, pricing reforms and other demand management strategies.
<i>Supports shared vehicles.</i> Could facilitate car-sharing (vehicle rental services that substitute for personal vehicle ownership), which can provide various savings.	

Figure 1: Autonomous Vehicle Potential Benefits and Costs

Source; Litman 2015.

*How much is known about public attitudes to autonomous vehicles?*

3.10 There have been a number of surveys of public attitudes towards driverless cars. However any findings must be subject to the caveat that few respondents have any direct experience of autonomous operation, and many will have little idea of how they would perform in practice. Subject to this qualification, these conclusions can be drawn from a number of recent surveys<sup>207</sup> some of which are of UK citizens whilst others include both UK and other people:

- a substantial proportion of respondents believe they would not want to use driverless cars as they enjoy driving;

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<sup>207</sup> AA,TSC 2015, DBIS 2014, Kyriakidis et al 2015, RAC 2015, RAC 2016, Shoettle & Slivak (2014) and Tennant et al 2016.

- there is a widespread feeling that autonomous road transport could significantly enhance the mobility and independence of those who were unable to drive (e.g. elderly, disabled and visually impaired people);
- driverless cars were seen by many as being potentially safer than manually driven cars although there were real concerns about hacking and other forms of abuse;
- there are social aspects to driving which driverless cars would not be able to integrate into;
- autonomous operation could reduce some costs e.g. for public transport operation by removing the need for professional drivers, but the picture was less clear for personal use – would there be a cost premium over ordinary road vehicles?
- Environmental impact could be reduced by automation but the availability of driverless vehicles could damage public transport services and prompt unwelcome lifestyle and land use patterns;
- some respondents thought that driverless cars should have segregated facilities to separate them from general traffic;
- some respondents did not see the development of driverless cars as a priority for the automotive industry.

A summary of the key points from these surveys is set out in Annex A.

*What is the scale of the market opportunity for autonomous vehicles?*

3.11 At any point in time the current car parc is a legacy of a history of introductions of new vehicles over many years. Looking at the market in Great Britain, taking the age distribution of the 2015 parc<sup>208</sup> it would take 7½ years for half the parc to be replaced with post 2015 vehicles, 11½ years for three quarters to be replaced by post 2015 vehicles and 14 years for 90% of the existing parc to be retired.

3.12 Figure 2 shows three hypothetical scenarios for the growth of Autonomous Cars (ACs) between now and 2050. In scenario A ACs start to appear in numbers in 2020 and develop rapidly such that by 2028 all new cars are autonomous. In scenario B ACs start to appear in numbers in 2022 and penetration builds up more slowly over the next thirteen years to 2035 when all new cars are autonomous. In scenario C AC growth starts in 2024 and builds up over 18 years. All three scenarios assume that eventually all cars will be capable of autonomous operation. In practice, unless excluded from their use on public roads, some drivers may choose to drive only partially autonomous vehicles and, even if all vehicles were capable of fully autonomous operation, some drivers may choose, if permitted, to drive them manually for part of the time. If only two out of three new cars were to be autonomous then the saturation level in figure 2 would be correspondingly lower (see faint dashed blue line).

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<sup>208</sup> DfT 2016c.

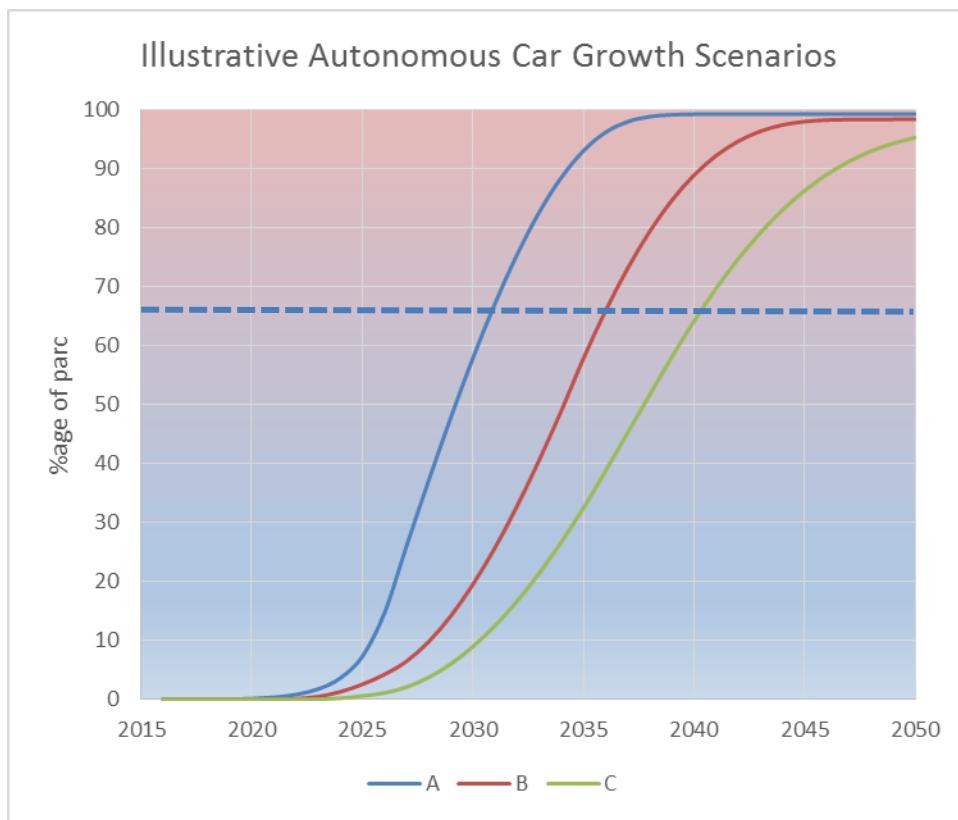


Figure 2: Illustrative autonomous car growth scenarios

3.13 Whilst these growth profile are purely illustrative they serve to show that on very bold assumptions about the penetration of autonomous cars into the market it would be 2030 before they became to dominant form of car transport and on more pessimistic/realistic assumptions (gradual take by only two thirds of drivers) this would not occur ‘till 2042. There are other more or less optimistic projections with one forecaster estimating 5½ million new CAVs globally in 2019<sup>209</sup> – equivalent to 7% of total car production and another, more sober prediction, giving between 40% and 45% CAV representation (globally) by 2050<sup>210</sup>.

3.14 But the automotive marketplace is a global business. If autonomous vehicles can be developed which do not rely on sophisticated state-run system architecture and pin-point accurate mapping, and can be produced at the right price, then the global market in developing economies could potentially be huge.

*Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious? Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?*

3.15 The trials and demonstrations of ADACs and CAVs is presently shared between a range of actors with the large automotive and technology companies playing the major part.

<sup>209</sup> Business Insider UK 2015, see also Lux 2014.

<sup>210</sup> Litman 2015

We welcome the establishment of the Centre for Connected and Autonomous Vehicles to span the policy interests of the Department for Transport and the Department for Business, Energy and Industrial Strategy and provide a single point of contact for Government interest in this issue. The CCAV framework to support the testing of automated vehicles on Britain's roads<sup>211</sup> has been recognised as a world-leading approach to describing and defining the framework that will need to be adopted, and to evolve over time, to allow for the development and deployment of autonomous vehicles on public roads.

3.16 The UK Government is also reasonably active in:

- part funding three trials to demonstrate autonomous road vehicles<sup>212</sup>;
- promoting lorry platooning trials; and
- providing tens of millions of pounds to research and develop new connected and autonomous vehicle technologies<sup>213</sup>.

3.17 The fact is that tens of millions of pounds of Government research funding has to be seen in the context of the hundreds of millions being invested directly by the automotive and technology companies. Where Government might usefully turn its R&D thinking towards are the areas of:

- exploring alternative system architectures for autonomous road vehicle operations in which V↔V and V↔I communications figure as well as the mainly vehicle-based systems that are presently receiving so much attention; and
- exploring the traffic performance of 'mixed' systems with manual, ADAS and CAV operations in different types of road environments from motorways to busy mixed use urban streets.

3.18 As this is a rapidly developing field it is essential that the Government keeps abreast of developments as they emerge and has the capacity to assess their public policy implications of these in a timely fashion. It should also regularly review the support it gives to industry and keep an open door to new collaborative and worthwhile funding opportunities.

*How effective are Innovate UK and the CCAV in this area?*

3.19 Innovate UK and the CCAV are together responsible for a number of activities in the field of autonomous road transport but at this early stage it is difficult to give an informed assessment of their effectiveness. It is welcome that the Government has established CCAV as a focal point and single 'portal' for those wishing to engage with Government, and to take the lead on those issues which fall to Government, such as amending the statutory framework to allow for safe autonomous operation. It will be important for CCAV to retain the overarching policy responsibility.

*Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?*

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<sup>211</sup> DfT 2015a &2015b, CACV 2016.

<sup>212</sup> TSC 2014, Venturer 2016, Gateway 2016.

<sup>213</sup> DBIS 2016 & DBEIS 2016

3.20 The questions about which technological mixes will prove successful, the presence of major players with deep pockets and the uncertainties of the regulatory environment mean that it is difficult for SMEs to take a solo lead in this area. However there are places for them in support of the Auto OEMs<sup>214</sup> and Tech companies, especially where there are established relationships. As far as the UK Government is concerned the streams 2, 3 & 4 of the CCAV/Innovate UK will fund feasibility studies and industrial research and development projects ranging in size from total costs of £250,000 to £5 million with projects lasting between 12 and 30 months. This offers opportunities well suited to SMEs either on their own or as part of larger consortia. The LUTZ project involves the Oxford Robotics Group which is a small team of systems and software engineers with a commercial arm and a medium sized division of an established advanced engineering company (RDM). Whilst the commercial risks will limit early involvement of most SMEs the government's involvement encourages SME participation.

*Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?*

3.21 This is an extremely difficult question to answer in any detail at this stage. Undoubtedly the general answer is 'yes', but 'what' and 'how' are much less clear. To some extent current autonomous systems rely on reading the features of their surrounding infrastructure; for example lane markings. If this continues then these will have to be maintained to a high standard and developed to cope with interference from adverse weather such as fog and snow. To the extent that CAVs and ADACs rely on reading road signs for their guidance then a consistent regime will be needed across the entire road system. Where there are large numbers of CAVs operating in close proximity there may be a need to increase the capacity and reliability of the mobile phone networks in the area. Similarly where GPS forms a part of a CAVs location/guidance system very high standards of reliability will be required.

3.22 If V↔V and V↔I communications figure in CAV operations then there will probably be a need to 'smarten' some aspects of the road infrastructure perhaps also replacing ANPR with electronic Automatic Vehicle Identification (AVI). The roles of these types of communication are, as yet, unknown and will depend of the overall systems architecture and protocols to be used for autonomous road transport operations.

3.23 The Foundation has commissioned research into the infrastructure implications arising from the introduction of autonomous vehicles which should be available in time to assist the Committee's deliberations.

*How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?*

3.24 The requirements for the widespread adoption of highly automated vehicles differ between ADAS and CAVs. Where the driver retains control – albeit with a substantial degree

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<sup>214</sup> Original Equipment Manufacturers.

of assistance from the car's ADAS – the overriding issue is the safe capability of the technology used. Where the requirement for manual control is removed other, more complex, issues arise. In this situation the highway operator/regulator will have to ensure that the CAV technology can operate safely, efficiently and with minimal environmental impacts in mixed traffic in defined traffic environments (e.g. motorways) or generally. This will require extensive proving of different types of CAV technology and evaluation of operations in a wide range of real life conditions. The trials so far are only early steps in this process.

3.25 Regulators will need to ensure that clear insurance arrangements are in place for CAVs and the rules of the road and CAV operation are consistent. If the introduction of CAV operations on a large scale require infrastructure changes then these will need to be introduced and this could be costly and take time. The mix of responsibilities for highways and traffic means that a central lead will be required to ensure all highway and traffic authorities act in concert. Where CAV use crosses jurisdictions ideally they should be uniformly of autonomous operating regimes between these or at least a capacity for safe adaptation when switching between jurisdictions (e.g. minor adaptations of UK vehicles when travelling on Continental European roads).

3.26 For the UK government the immediate milestones to be reached are the successful completion of the lorry platooning trials<sup>215</sup> and the recently started driverless car trials in Bristol<sup>216</sup>, Milton Keynes<sup>217</sup> and Greenwich<sup>218</sup>. Again however these are first steps and the progressive development of a policy and regulatory context for autonomous road vehicle operation will be needed. A start has already been made<sup>219</sup> but there is still a long way to go before a clear and comprehensive framework is achieved.

*Does the Government have an effective approach on data and cybersecurity in this sector?*

3.27 We do not have sight of Government activity in this area beyond noting that cybersecurity has been recognised as an important issue, but would expect cybersecurity to be explored directly and as an aspect of the trials that the Government is supporting.

*Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?*

3.28 These issues have been recently consulted upon by the Centre for Connected and Autonomous Vehicles<sup>220</sup> and the Foundation's response is at Annex B [not published].

*What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?*

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<sup>215</sup> Riccardo 2014.

<sup>216</sup> Venturer 2016.

<sup>217</sup> MKCitizen 2016.

<sup>218</sup> DBIS 2016.

<sup>219</sup> CACV 2016a.

<sup>220</sup> CACV 2016b.

3.29 This issue is addressed in paragraph 2.12 of the Foundations response to ‘Pathway to Driverless Cars<sup>221</sup>.

*What does the proposed Modern Transport Bill need to deliver?*

3.30 The Foundation has given its views in its response to the recent consultation on ‘Pathways to Driverless Cars’<sup>222</sup> set out in Annex B [not published].

*How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?*

3.31 The UK has a long tradition of excellence in science, technology and engineering and has many remarkable achievements in these areas to its credit. This is reflected in the excellence of the relevant professional and institutions. However its record in commercial exploitation and applications is less impressive. This is due to a range of factors one of which is the shortage of sufficient skilled professionals and technicians in these areas.

3.32 The UKCES Employer Skills survey showed that the science, research, engineering and technology professionals’ category (SOC sub-major group 21) had the highest ratio of Skills Shortage Vacancies of any of the 25 occupational sub-major groups<sup>223</sup>. A recent survey by the Confederation of British Industry (CBI) found that 44% of engineering, science and hi-tech firms reported difficulties in finding experienced recruits with the right STEM skills<sup>224</sup>.

3.33 So the answer to this question must be ‘not effective enough’.

*Is the Government’s strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?*

3.34 In its review of the need to strengthen the nation’s engineering skill base the 2013 review by Professor John Perkins<sup>225</sup> concluded that whilst a good deal was being done more was needed, in particular:

- the engineering community should work with Government to develop and promote new Level 2 and 3 qualifications that will create high-quality vocational routes for 16-19 year olds to enter engineering careers;
- the engineering community should work with employers to encourage and support provision of work experience for post-16 students, studying in colleges and schools.
- the engineering community, especially employers, should work with Government to develop additional Trailblazer Apprenticeships in engineering;
- Government should develop plans to boost diversity of engineering apprentices, building on the pilots and research commissioned by the Skills Funding Agency;

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<sup>221</sup> RACF 2016.

<sup>222</sup> Ibid.

<sup>223</sup> UKCES 2016.

<sup>224</sup> CBI 2016.

<sup>225</sup> DBIS 2013.

- Government should build on the UTC experience and seek to develop elite vocational provision for adults so that our people have the opportunity to learn the very latest techniques and approaches in a vocational setting;
- engineering employers should encourage their staff to share their skills and knowledge, for example, by participating in the Education and Teaching Foundation's Teach Too scheme;
- Government and the FE sector should encourage the application of learning technologies to extract maximum value from expert lecturers and the materials they produce, for example through Teach Too.

*What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?*

3.35 Until the terms of the UK's relationship with the European Union (EU), following its leaving, are clear and the new trading and co-operative relationships with other countries established it is very difficult to assess the implications for the automotive industry in the UK in general and its autonomous vehicle component in particular. In the short run these uncertainties are more likely to inhibit efforts by non-domestic players to promote the development of CAV activities in the UK than the reverse. In the long run there will be both opportunities and risks which will have to be carefully managed to ensure the UK realises its full potential in this area.

3.36 In the short term the Government must continue to play the positive roles it has already assumed in supporting the domestic development of autonomous vehicle technology and in creating a favourable environment for its safe and efficient introduction and deployment in the field. There are signs that the Government is alive to this issue and is seeking to ensure that the uncertainties of leaving the EU do not prejudice programmes by overseas based companies to develop autonomous road vehicle technology in the UK<sup>226</sup>.

3.37 UK representatives have long played a leading and influential role in the development of international vehicle standards e.g. in UN ECE committees, and it will help if this engagement is maintained and enhanced as new standards start to emerge for autonomous technologies.

25 October 2016

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<sup>226</sup> Nissan 2016b.

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## ANNEX A – ATTITUDE POINTS

### Catapult

39% would consider using driverless cars

Two thirds of progressive metropolites would consider using driverless cars

25% of petrolheads would consider using driverless cars

### Sciencewise

Only 18% of those surveyed said they thought driverless technology was an important avenue for car manufacturers to pursue, with 41% deeming it unimportant.

Providing freedom of movement for the elderly and disabled

Comfort, convenience and increased productivity

Increased safety

Easing congestion

Decreased cost

Environmental benefits

but

The system is vulnerable to abuse

The degree of control big business and governments could gain over people's lives

Safety.

Unwelcome changes to lifestyle

Waste of existing resources

Environmental concerns

### RAC 2015

A majority of motorists (52%) believe that driverless cars will benefit older and disabled drivers. But only a quarter (27%) expect driverless vehicles to make road travel safer.

### RAC 2016

There is widespread agreement that the driver-assistance technology used in existing vehicles is effective in making both cars and roads safer than in the past.

### AA

2016 – 72% said driverless cars have the potential to increase mobility and independence for those who otherwise may not be able to drive (elderly, blind, etc.)

2015 - Two thirds (65%) of respondents say that they 'enjoy driving too much to ever want a driverless car'.

Over half agree that 'driverless cars would have to be segregated' (56%) and that they 'wouldn't trust assurances that driverless cars were safe' (57%).

2013 - Two-thirds of AA members surveyed (65%) enjoy driving far too much to ever want a driverless car, and 56% wouldn't trust manufacturer or government assurances that driverless cars were safe.

12% of respondents can't wait for the day when they can buy a car that will drive itself, and almost a third (31%) would like UK laws to be changed so that trials can happen on our roads. This could be problematic because over half of AA members (57%) would want driverless cars to be segregated and drive only on dedicated roads or lanes.

### **Shoettle & Slivak**

The majority of respondents had previously heard of autonomous or self-driving vehicles, had a positive initial opinion of the technology, and had high expectations about the benefits of the technology.

However, the majority of respondents expressed high levels of concern about riding in self-driving vehicles, security issues related to self-driving vehicles, and self-driving vehicle not performing as well as actual drivers.

Respondents also expressed high levels of concern about vehicles without driver controls; self-driving vehicles moving while unoccupied; and self-driving commercial vehicles, busses, and taxis.

The majority of respondents expressed a desire to have this technology in their vehicle. However, a majority was also unwilling to pay extra for the technology; those who were willing to pay offered similar amounts in each country.

Females expressed higher levels of concern with self-driving vehicles than did males. Similarly, females were more cautious about their expectations concerning benefits from using self-driving vehicles.

### **Kyriakidis et al**

Results showed that respondents, on average, found manual driving the most enjoyable mode of driving. Responses were diverse: 22% of the respondents did not want to pay more than \$0 for a fully automated driving system, whereas 5% indicated they would be willing to pay more than \$30,000, and 33% indicated that fully automated driving would be highly enjoyable. 69% of respondents estimated that fully automated driving will reach a 50% market share between now and 2050. Respondents were found to be most concerned about software hacking/misuse, and were also concerned about legal issues and safety.

### **LSE/Goodyear**

This survey asked questions on 'comfort', 'openness', 'familiarity', 'perception' and 'Technological Optimism & Driver Sociability', from focus groups in four European countries and through a 12,000 respondent online survey in eleven European countries including the UK.

*Comfort* - 26% of respondents describe themselves as comfortable (either totally, very, or quite) with the idea of using an AV and 29% for driving alongside one. Conversely, 44% feel uncomfortable about using an AV, whilst 41% feel uncomfortable about driving alongside one.

*Openness* - Twice as many respondents agreed (43%) than disagreed (19%) that most accidents are caused by human error, so autonomous vehicles would be safer and machines don't have emotions so they might be better drivers than humans (37% v 21%) but 73% of respondents were concerned that autonomous vehicles could malfunction and that machines did not have the common sense needed to interact with human drivers.

*Familiarity* - When more thought was given to the comfort issue the respondents became more optimistic.

*Perception* - Respondents who already relied more on in-car technology are, on average, more open to AVs. So, while only 15% of respondents say that they regularly use cruise control, of these 61% are in the top half of the scale in terms of openness to AV. Nevertheless 70% thought that humans should be in control of their vehicles and 80% said it should have a steering wheel. 82% of respondents said they would probably or definitely prefer to keep aware of the road around them and only a few saying that they would sleep (19%) or watch a video (18%) if they didn't have to pay attention to the road.

*Technological Optimism and Driver Sociability* – ‘Sociable’ drivers tend to be less open to AVs as they enjoy a level of social interaction with other drivers they would not get with AVs and these folk are less technologically optimistic. ‘Combative’ drivers on the other hand tend to be more technologically optimistic and see AVs as easier to deal with than other drivers.

This study concluded that the majority of respondents remain concerned at the prospect of AVs, even if over a quarter of respondents are open to the arrival of AVs on our roads. When considering current levels of knowledge and experience of AV technology, it is to be hoped that greater familiarity will allay some of the concern.

But this research identifies a number of deep-seated reservations – to the willingness to give up control, to the reliability of AV technology and to AVs' ability to integrate in the “social space” that is the road. It is necessary to understand these reservations, rather than just assume that the public needs more information if AVs are to negotiate a place for themselves on the road.

Arguments that focus simply on promoting greater safety, lifestyle enhancements or economic efficiencies will not gain traction if AVs do not fit comfortably into the public's picture of what the road should be like for them to drive on.

**RAC Foundation, PA Consulting Group and Highways England – Oral evidence  
(QQ 48-54)**

[Transcript to be found under Highways England](#)

## **RazorSecure Limited – Written evidence (AUV0018)**

*Letter from Alexander Cowan, CEO, RazorSecure Limited*

1. We wish to respond to your “Call for Evidence” on Autonomous Vehicles. RazorSecure Limited is a business based around cyber security of mobile assets with a particular focus on the implications in the transport industry.
2. We are currently developing solutions in the aviation and rail industry, and we consider autonomous vehicles to be a significant future area for development in both cyber security and passenger safety. As such we would be happy to provide additional evidence as a specialist in cyber security for the transport industry.
3. I wish to respond to the following questions in respect to the call for evidence.

### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

4. As a son and step father, one of the key areas that I see autonomous vehicles being used are in increasing mobility of our population. Currently this area is being serviced by the taxi and private hire industry, however during peak times it is very difficult to get access to a driver, outside of big cities, without a pre-booking days in advance.
5. It is not just the passengers of autonomous vehicles that will see benefits from their adoption, but also the care givers, guardians and relatives of users without access to a traditional vehicle.
6. As the son of a pair of elderly parents, I see mobility as one of the true keys to their continuing independence. From visiting supermarkets to hospital appointments, having access to an autonomous vehicle would allow me to ensure they are able to maintain independence without disrupting my usual work hours and productivity.
7. As a step father to a young adult, I am often called upon to ensure my son is delivered to college, sports training and activities with friends. Having access to an autonomous vehicle would allow me to ensure he is delivered safely to the correct destination without the traditional disruption. Even though he has recently completed his driving test, given the current costs of car insurance it is prohibitively expensive to get him access to his own vehicle.

### **4. How much is known about public attitudes to autonomous vehicles?**

8. Security will be a key consideration in public attitudes towards autonomous vehicles. The Department for Transport has published papers on cyber-security in the rail industry (ref:

“Rail Cyber Security – Guidance for Industry”), and particularly around the multi-layered security approach required to ensure these vehicles are safe for public use.

9. With increasing adoption of autonomous vehicles, any incidents will be reported in the media and likely face extreme scrutiny. A significant cyber-attack could see the entire network of autonomous vehicles being taken offline. Therefore, it is key that the layered approach to security including firewalls, intrusion detection, encryption and software/hardware assurance is considered before mass adoption can occur.
10. This media scrutiny has already been occurring in California where incidents with the Google self-driving vehicles are analysed by the media who are flagging for any potential safety issue with the technology. Failure to address security and safety concerns, will erode public trust in the technology and undermine future adoption.

## **8. How effective are Innovate UK and the CCAV in this area?**

11. The CCAV scheme is a very positive step towards providing funding for projects within the UK. The commercial focus is admirable; however it is challenging for SMEs to access. RazorSecure spent considerable time investigating the CCAV2 scheme, but were unable to put together a consortium within the time frame to place a project bid.
12. The consortium requirement certainly places a lot of extra pressure in what is an already challenging area. While we can see the benefits in terms of greater engagement and higher chance of success, it was a deciding factor in us not continuing to invest time with that programme.

## **12. Does the Government have an effective approach on data and cybersecurity in this sector?**

13. It is important to recognise that future autonomous vehicles will be significantly different from the current private hire vehicles that are in use today. The environment that will exist will be more akin to a new form of mass public transportation and will rely heavily on the hardware and software manufacturers over the operators to ensure the safety and security.
14. Cyber security will be critically important and thus hardware and software manufacturers must be required to deliver updates to vehicles over their entire lifetime. This is a growing issue in the security industry, as devices are often only certified as secure when they are manufactured for the first time. This means that new security vulnerabilities may not be considered in the ongoing production of devices, and in the future vehicles.
15. In addition, it is important that hardware/software manufacturers and operators are required to put in place a multi-layered approach featuring techniques such as firewall, encryption, intrusion detection and active response even when not connected. Early

warning of attacks and breaches is key to ensure that they can be managed quickly and safely without compromising the availability of the technology.

16. The RazorSecure team has experience with cyber security in rail, aviation, space and defence. We would welcome the opportunity to help define the processes and standards and to create an environment for the UK to become a world-leader in safe and secure autonomous vehicles.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

17. For an effective, safe and secure mass deployment of autonomous vehicles, it is important that the correct regulation is put in place regarding cyber security.

18. These rules are currently being developed for other areas of critical national infrastructure, and it is important to recognise that a connected network of autonomous vehicles would represent a new form of mass public transportation.

19. In addition to the usual certification and assurances that are required to deliver a product to market, it is critical that manufacturers are required to support the product with security updates over the vehicle's lifetime.

20. In a recent security incident, a Tesla Motors vehicle was able to be hacked remotely and the hackers could activate the vehicles brakes while it was in motion (ref: "Team of hackers take remote control of Tesla Model S from 12 miles away" – The Guardian September 20th 2016). The vehicles were updated via an over-the-air update within days to close the exploit, but this relied on the hackers announcing the breach and also the manufacturer to provide a quick response.

21. It is therefore vital that manufacturers are required to implement a multi-layered approach focusing on security and early detection of breaches.

**15. What does the proposed Modern Transport Bill need to deliver?**

22. In the area of delivering "safe technology in the autonomous vehicles industry" (ref: The Queen's Speech 2016 – 18<sup>th</sup> May 2016), we would look for the Modern Transport Bill to deliver:

- A requirement cyber-security to be a key consideration in the health and safety of passengers
- A requirement for hardware and software manufacturers to deliver security updates for the lifetime of the vehicle
- A requirement for a multi-layered approach to cyber security in autonomous vehicles

## Research Councils UK (RCUK) – Written evidence (AUV0053)

### INTRODUCTION:

1. [Research Councils UK](#) (RCUK) is the strategic partnership of the UK's seven Research Councils. Our collective ambition is to ensure the UK remains the best place in the world to do research, innovate and grow business. Together, we annually invest £3 billion in research covering all disciplines and sectors to meet tomorrow's challenges today. We drive innovation through brokering partnerships, co-delivering research and innovation with over 2,500 businesses, and providing intelligence for policy making.
2. Between us, the Research Councils cover a wide spectrum of research activities in Robotics, Automation and Artificial Intelligence (RAAI)<sup>227</sup>:
  - The Biotechnology and Biological Sciences Research Council (BBSRC) investment in basic neuroscience and behavioural science contributes to underpinning, cutting-edge AI and robotics research. BBSRC has likewise invested in novel research into agricultural applications of autonomous vehicles.
  - The Engineering and Physical Sciences Research Council (EPSRC) investments include robotics, artificial intelligence (AI), other parts of computer science such as image and vision computing, verification and validation, smart sensing technology and its associated connectivity with the Internet of Things, autonomous manufacturing, healthcare technology, and intelligent mobility.
  - The Natural Environment Research Council (NERC) provides funding for environmental applications and development in robotics, automation and smart sensing to enable the capabilities of persistent presence, long deployment and remote environmental observing, especially for operation in hostile and in-accessible environments.
  - The Science and Technology Facilities Council (STFC) offers computational infrastructure and data intensive science capabilities to underpin the virtual testing, verification, and validation of connected and autonomous vehicle research and the technology evolution pathways into the market.
3. This evidence is submitted by RCUK and represents its independent views. It does not include, nor necessarily reflect the views of the Knowledge and Innovation Group in the Department for Business, Energy, and Industrial Strategy (BEIS). The submission is made on behalf of the Research Councils listed above.
4. RCUK's detailed response on the future of Robotics and Autonomous Systems (RAS) can be found in the House of Commons Science and Technology Select Committee Inquiry into Robotics and Artificial Intelligence submitted in April 2016.

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<sup>227</sup> RAS (Robotics and Autonomous Systems) and RAAI (Robotics, Automation and Artificial Intelligence) can be used interchangeably and capture the same breadth of opportunity. RAAI, however, provides a clearer descriptor of the component parts that integrate to create new products and solutions.

## EXECUTIVE SUMMARY

5. The Research Councils that compose RCUK work collaboratively with Innovate UK across the spectrum of research and innovation. The organisations are working collaboratively to build a proposition for integrated robotics, autonomy and AI investment in key areas, in particular health and social care; extreme and challenging environments; next generation manufacturing; and transport systems. It is important that future investments recognise the potential for cross-sector impact and do not focus on one area alone.
6. The applications for autonomous vehicles supported by the research councils ranges from passenger transport to marine exploration and agricultural production. With the enormous potential offered by autonomous vehicles and the wider, underpinning area of Robotics, Automation, and Artificial Intelligence (RAAI), greater Government coordination is needed to provide a focus for economic development.

### Question 1. What are the potential applications for autonomous vehicles?

7. There are clear applications for autonomous vehicles to provide transport for both passengers and goods, carry out inspection and monitoring of resources, and perform tasks in locations such as warehouses and hospitals. The EPSRC has funded a [£5 million project](#) in these specific applications of the technology, and an £11 million jointly funded programme of research with Jaguar Land Rover is currently investigating smart, connected control in autonomous vehicles. Beyond these areas, autonomous vehicles have the potential to revolutionise sectors as diverse as oceanic exploration and the agricultural industry.
8. For example, the Natural Environment Research Council (NERC) has invested close to £50 million in the last five years in Marine Autonomous Systems (MAS) developed from a scientific need to go further, faster and more effectively in the extreme and challenging environments that are pervasive in ocean research. Spinning out of this investment is a number of disruptive technologies for inspection and survey in extreme and challenging (hazardous) environments benefitting key industrial sectors such as: oil and gas; offshore renewables; nuclear; defence; aquaculture; and infrastructure systems.
9. Further applications of this technology cover numerous [sectors prioritised by Government](#): inspection of hydrocarbon infrastructure (potentially in ice-bound regions); offshore carbon capture and storage monitoring (including the North Sea); self-deploying met-ocean platforms for weather forecasting; efficacious monitoring of the UK marine environment for statutory obligations (including vast new Marine Protected Areas in UK Overseas Territories); sustainable exploration and exploitation of deep-sea resources; marine battle-space characterisation and security of strategic platforms.
10. Autonomous vehicles or systems that operate in an agriculture and farm environment will also have a major impact on the way food is produced and food systems research is

carried out. Advances in this technology have the potential to make agriculture significantly more efficient by reducing labour costs, enhancing sustainability due to timely and precise application of inputs, reducing greenhouse gas emissions and reducing soil compaction. This is acknowledged in the Government's [Agri-Tech Strategy for the UK](#), which sets out that agri-engineering can help to increase UK productivity through the wider adoption of best practice and help increase the UK's share of emerging markets by utilising the UK's strengths in precision agriculture, remote sensing technologies and robotic applications.

11. Advances in GPS, earth observation, image recognition and sensors will enable automation on farms, potentially changing farming practices. BBSRC has invested in some initial research towards such applications through Agri-Tech Strategy investments and other funding schemes.<sup>228</sup> Autonomous monitoring and harvesting of crops is one area of particular interest in agriculture. Vehicles under development include scout vehicles that can sow seeds, identify and kill weeds using lasers, and tell when the crop food is ready for harvesting.<sup>229</sup> BBSRC has also invested in unmanned aerial vehicle (UAV) technology for the collection of field data, which will give unique perspectives on crop growth and plant functioning, and will vastly extend capabilities for screening crops of different genetic background for performance, nutrition, stress, and pathogen and disease responses.<sup>230</sup>

**Question 7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

12. Supporting technological innovation and development that combine the UK's scientific strengths and business capabilities is a core part of the Government's industrial strategy approach. For example, the Government's funding of programmes such as the Centre for Connected and Autonomous Vehicles (CCAV), the Transport Systems Catapult, and competitions for projects in Intelligent Mobility is a sound start to stimulate research and development of autonomous vehicles.
13. However, greater support is needed for enabling research that will underpin the next generation of RAAI technologies across a range of sectors from energy to healthcare. Such technologies are "sector agnostic" and allow for the creation of technological foundation by de-risking the investments of the industries involved. This further investment would help meet existing industrial needs by accelerating the generation of knowledge and flow into the economy through targeted research and translation. A coordinated approach across RAAI will avoid the duplication of effort and enable the development of autonomous vehicles to be accelerated through innovation spillover from adjacent sectors.

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<sup>228</sup> Please see the feature on [Farms of the Future](#) for additional information.

<sup>229</sup> Examples of recent BBSRC-funded projects include [AUTOPIC](#) (Autonomous Strawberry Harvesting and Management Robot; £184k) and [3D Vision Assisted Robotic Harvesting of Broccoli](#) (£87k).

<sup>230</sup> The [Octocopter](#) is an example of BBSRC-funded UAV technology.

14. Robotics R&D spending alone is predicted to grow at a **Compound Annual Growth Rate** (CAGR) of more than 17 percent during the next four years spurred on by industrial demand for smarter systems and processes.<sup>231</sup> The UK has the potential to lead and increase its share in this global market through greater coordination of effort that draws together the UK's distributed excellence in research and innovation. Forming dedicated research and training hubs, alongside a targeted innovation and translation centre, in four key areas—health and social care; extreme and challenging environments; next generation manufacturing; and transport systems—is central to unlocking UK market growth in RAAI.

**Question 16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

15. The skills necessary to support the autonomous vehicle sector are in great demand across a wide-swathe of the technology industry: Amazon, Apple, Facebook, Google, IBM, Intel, Microsoft, and Uber are all recruiting post-doctoral students and academic staff experienced in robotics and artificial intelligence.<sup>232</sup>

16. To educate and train the next generation of skilled researchers and entrepreneurs, the EPSRC has three funding mechanisms: Centres for Doctoral Training (CDTs)<sup>233</sup>, Doctoral Training Partnerships (DTPs) with lead universities, and Industrial Cooperative Awards in Science and Technology (ICASE). At present, there are 253 students enrolled on programmes of relevance to robotics and artificial intelligence across all EPSRC-supported courses, with the primary method of training being via CDT. Each year of the 4-year CDT programme has between 10 and 20 students currently enrolled in each centre; based on recent application numbers, these Centres are oversubscribed for the number of places they are able to offer, some by as much as 14:1. More widely, the UK suffers from a shortage of engineers<sup>234</sup>, and skills growth is a key recommendation of the [UK RAS 2020 Robotics and Autonomous Systems strategy](#) (RAS2020 Strategy).

17. Enhancing the provision of the existing CDTs and establishing new centres is one way to bolster numbers in the short term. However, it is also necessary to look at the complete “people pipeline”, from primary school through to higher education to ensure that enough trained individuals are available to support both the current development of autonomous vehicles and a technology-enabled future. Further to this, it is also necessary to consider a wider cultural shift<sup>235</sup> to change the existing perception of

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<sup>231</sup> [Technavio Market Study, 27th July 2016](#)

<sup>232</sup> Gibney, E. 26 April 2016, “[AI talent grab sparks excitement and concern](#)”, *Nature*. See also “[Partnership on AI formed by Google, Facebook, Amazon, IBM and Microsoft](#)” in *The Guardian* (28 September 2016).

<sup>233</sup> The five CDTs of relevance to robotics and autonomous systems include: Autonomous Intelligent Machines and Systems (AIMS) in Oxford; Embedded Intelligence in Loughborough; Future Autonomous and Robotic Systems (FARSCOPE) in Bristol; Robotics and Autonomous Systems in Edinburgh; and Next Generation Unmanned Systems Science (NEXUSS) Centre for Doctoral Training in Southampton (jointly funded with NERC).

<sup>234</sup> 1 February 2016, “[Strong engineering industry hindered by skills shortage](#)”, *Institute of Mechanical Engineers*.

<sup>235</sup> 27 March 2015, “[Changing Engineering Perceptions Amongst Parents and Children](#)”, The Institution of Engineering and Technology.

engineers and technologists in the UK. Recent activities like the Festivals of Engineering held in [Wiltshire](#) and in [London](#), and the [UK-RAS Network's UK Robotics Week](#), are a step in the right direction, but a cohesive programme is necessary to secure skilled, engaged workers in the long-term.

**Question 17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

18. [The UK Landscape for Robotics and Autonomous Systems](#) (2015) and the [RAS2020 Strategy](#) (2014) highlight the full gamut of opportunities offered by RAS technologies, specifically through a focus on assets, clusters, challenges, coordination, and skills. This potential includes the UK's £60 billion nuclear decommissioning market, more precise and consistent medical interventions, enhanced productivity in sectors as diverse as manufacturing and agribusiness, as well as the social and economic benefits offered by autonomous vehicles on land, sea, and in the air.
19. The opportunities that are offered by both autonomous vehicles and wider underpinning technologies are vast. This complete landscape needs to be considered to avoid the creation of sector-specific silos that curtail discovery and innovation. There is a risk that developments in autonomous vehicles may be being overlooked in other sectors; greater cross-sector coordination and investment from Government would reduce this risk, increase impact and deliver multi-sector growth.
20. For example, investing in [fundamental research in autonomous vehicles](#) has led to inward investment from international companies and has created UK policy and regulation leadership in the area. This leadership has strengthened the international appeal of the UK's offer in autonomous vehicle development; however, there is scope to facilitate wider UK leadership across sectors such as healthcare and manufacturing through a coordinated Government endeavour.

26 October 2016

## Road Safety Markings Association (RSMA) – Written evidence (AUV0012)

1. The Road Safety Markings Association's submission to the Lords' inquiry is brief and, in line with the Committee's terms of reference, focuses on matters relating to the future uses of autonomous vehicles in the UK. This submission particularly relates to the 6th question around the changes to the physical infrastructure in the UK that will be required for the successful deployment of autonomous vehicles.
2. The Association's main concern is that current standards of road safety markings in particular are not actually being maintained and, where assistive or autonomous technology relies in part on road markings and signs, any failure of maintenance presents a real safety hazard.
3. By 2025, at least half the travel on Europe's roads will be in vehicles that to some extent can read the road ahead including markings and signs. A 2013 consultation paper by EuroRAP and EuroNCAP<sup>236</sup> refers to lane markings as "the rails for self-steering cars". Vehicles, like drivers, cannot function if basic road markings and signs are non-existent, non-compliant, worn out, obscured, inconsistent or confusing.
4. In the case of road safety markings, the Association's most recently-published survey<sup>237</sup> of lines on 7,000km of motorways, dual and single carriageways in England, Scotland and Wales shows that, despite a recognised Highways Agency (now Highways England) standard, and contractual obligations on behalf of main contractors, approximately half of road markings were inadequate.
5. LifeLines England, a report based on the survey carried out by the Road Safety Markings Association found that 52 per cent of markings on motorways, 42 per cent on dual carriageways, and 48 per cent on single carriageways all needed replacing immediately or needed to be scheduled for replacement. The survey also showed that just 16 per cent of markings on England's motorways and 13 per cent on single carriageways made the "excellent" grade.
6. The survey of roads managed by the Welsh Assembly found 63 per cent of road markings on motorways needed replacing immediately or needed to be scheduled for replacement, while only one per cent of motorway markings made the "excellent" grade; nearly half (48 per cent) of markings on dual carriageways needed replacing immediately or needed to be scheduled for replacement.
7. There is a lack of research in relation to Local Roads whether, major roads, urban or rural roads. It is expected that with significant budgetary constraints over the last 10

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<sup>1</sup> Roads That Cars Can Read: <http://www.eurorap.org/portfolio-items/roads-that-cars-can-read-a-consultation-paper/>

<sup>237</sup> The Road Safety Markings Association's LifeLines 2014 Report [www.comparethemarkings.com](http://www.comparethemarkings.com)

years, standards of road markings will be lower than on the more strategic networks referred to above.

- 8.** In the US, Tesla and Volvo have taken the California Transportation Department and City of Los Angeles officials to task over the poor quality of markings. This is because their machine vision detection technologies are highlighting that the road markings have been poorly installed, monitored and maintained.
- 9.** Numerous media articles have highlighted concerns that some vehicles with assistive, partially-autonomous or fully-autonomous technology depend on accurate reading of road markings. Vehicles with lane departure assistance systems use cameras on the car to track the positions of road markings and keep the vehicle in the centre of the lane, while sensors around the front, sides and rear of the car keep an eye on other vehicles. A recent report by Reuters claimed that the Tesla semi-autonomous vehicle refused to drive itself because of the poor quality road markings that were present (<http://www.reuters.com/article/us-autos-autonomous-infrastructure-insig-idUSKCN0WX131>).
- 10.** Road markings can wear away, and they can also disappear under snow. Modern laser-surveying sensor systems (called LIDARs, after light detection and ranging) may not be accurate in those conditions. LIDARS calculate distances by illuminating a target with laser light and measuring the time it takes for the light to bounce back to the source. Radar does much the same thing with radio waves. In cars, LIDARS and radars have an effective range of around 50 metres, but that can shrink significantly in rain or when objects are obscured by vehicles ahead. Even the most advanced vehicles travelling at motorway speeds can “see” only around a second and a half ahead.
- 11.** In the US The American Association of State Highway and Transportation Officials (ASSHTO) and the Society of Automotive Engineers have established a working group designed at developing guidance for agencies seeking to install and maintain road markings that meet the needs of machine vision systems. They are due to publish an initial report in May 2017.
- 12.** It is recommended that such a working group is established in the UK in order to:
  - a. work with industry in order understand the requirements of autonomous vehicle manufacturers, their trade bodies (e.g. SMMT), insurers, etc.;
  - b. identify and plan for future changes to Sector Scheme 7 and legislative requirements;
  - c. provide road marking industry input into road trials; and
  - d. act as a focal point for knowledge transfer between different parts of industry, infrastructure designers, Central and Local Government and Government Agencies.

**13.** It is considered that with appropriate funding, the RSMA would be well placed to establish and lead such a working group for the UK, given its specialist knowledge of the road marking industry, current practices, knowledge of the current condition of road markings and its current role as custodian of Sector Scheme 7.

**14. About the Road Safety Markings Association (RSMA)**

- a. RSMA is the largest specialist trade association in the highways sector, representing more than 90 per cent of the road-marking sector.
- b. The RSMA's activities emphasise quality, health & safety and training and it has invested substantially in these areas over the past decade, in order to help highways companies and organisations to drive up sector standards and deliver higher quality in a safer manner. It has a clear focus on setting standards for its members.
- c. The association has developed a large NVQ Assessment Centre, qualifying in excess of 800 road marking operatives and has been the first organisation to introduce specialist apprenticeships in the highways sector. The centre delivers or facilitates delivery of a wide range of NVQ and training solutions for roadmarking companies. As a result, 90 per cent of the operative workforce is qualified, and there is a clear career structure now in place for the industry for both management and operatives.
- d. RSMA is the only organisation which has carried out a condition survey of road markings on the Strategic Road Network in the UK and has been carrying it out every two years since 2001.
- e. The RSMA has, as an industry body, imposed standards on its sector and pushed up quality, improved training and defined specific health and safety best practice for the sector moving the sector away from inadequate and often inaccurate blanket health and safety policies.

*12 October 2016*

## **Rolls-Royce – Written evidence (AUV0083)**

### **Introduction**

Rolls-Royce designs, develops, manufactures and services integrated power systems for use in the air, on land and at sea. We are one of the world's leading producers of aero engines for large civil aircraft and corporate jets and the second largest provider of defence aero engines and services in the world. For land and sea markets, reciprocating engines and systems from Rolls-Royce are in marine, distributed energy, oil and gas, rail and off-highway vehicle applications. In nuclear, we have a strong instrumentation, product and service capability in both civil power and submarine propulsion.

In the UK Rolls-Royce employs c23,000 people, including 9,000 engineers – more than half of our global engineering resource - and 95%+ of our people are based outside London and the South East. Recent investments in the UK include new manufacturing facilities at Washington, Tyne & Wear and Rotherham; a new composite centre in Bristol; a new facility in Solihull will open next year; and we are re-developing our Derby campus.

This submission covers our interest in autonomy across marine and aerospace applications.

### **Marine**

Transport by water is the most energy-efficient means of moving cargo, equipment and people. Ships and shipping have a long history in the use of control systems and other technologies, including autopilots, dynamic positioning systems, automation and control, satellite communications and remotely operated subsea vehicles. The marine sector drives growth in the economy by enabling efficient transport. Whilst the recent reduction in oil prices has depressed the offshore oil and gas market, there has been increased activity in other areas of the marine industry.

Rolls-Royce is at the forefront of a drive towards introducing autonomous vessels within the marine sector, both in the UK and other countries. The promotion of autonomous ships for commercial operation was initiated only about two years ago when Rolls-Royce began to advocate the concept. In the past six months, practically all major marine technology suppliers have included remote operation and autonomy in their strategy (this has been made public through white papers etc.). The world's first autonomous ship ecosystems/forums have been established in Finland and Norway in September of this year, and the first test areas for autonomous operations have been established.

The parallel development of autonomous road vehicles, aircraft and marine vessels could result in advantageous synergies where there is overlap. Situational awareness (knowledge of the world around) is an area which has seen rapid development in the automotive sector which is benefiting the marine application.

### **1. What are the potential applications for autonomous vehicles?**

### **Marine**

There is potentially a wide range of applications of autonomous marine vessels, e.g. surface vessels, in particular, present a great potential for the autonomy across almost the complete spectrum of activities. Existing research and development has been centred on small research and monitoring vessels, for example for testing water quality. The vast majority of the current vessels are small (no larger than 20 metres in length), are generally deployed from another, larger, manned vessel, and have a limited range of operation.

For the greatest return, the future trend should be towards commercial operation of much larger vessel types beginning with vessels that operate in a local area such as a port, for example, autonomous tug boats or launches. Further progression is likely to include larger vessels within a single flag-state, for instance ferries, local cargo and container vessels, dredgers and anchor handlers. Ultimately, the aim would be to encompass the vast majority of new-build vessels including bulkers (i.e. ships carrying bulk cargo such as ore or coal), container carriers, tankers, roll-on-roll-off ferries, offshore supply vessels, yachts and super-yachts.

Finally, there may be applications which are made possible or economic by the use of autonomous vessels which have not been viable before and represent disruptive technology, for example, ‘swarms’ of vessels used for survey or coastal policing.

### **Aerospace**

There is a range of autonomous aerospace vehicle applications including Micro-UAVs (Unmanned Aerial Vehicles), to hand-held/launched ‘drones’, to small vehicle launched systems, and on to larger vehicles that require more significant infrastructure to operate. Rolls-Royce is currently only likely to provide propulsion and power systems for these larger vehicles and is involved in power and related systems on board larger (UAVs) that have a take-off weight in excess of 4 tonnes. Such UAVs have a range of military applications such as surveillance and reconnaissance (ranging from tactical UAVs, such as ‘Watchkeeper’ to high altitude long endurance UAVs such as Global Hawk), and the smaller of these applications have increasing appeal in the civil/security arena such as for road policing and border patrol for which long endurance operation is a distinct advantage.

Commercial applications of UAVs that exploit this advantage and will likely see further growth include pipe-line and power-line inspection for the oil/gas and electricity distribution, respectively. These applications fall under the ‘dull’ category of UAV suited tasks but further applications will facilitate tasks under the other oft cited categories of ‘dirty’ and ‘dangerous’, where human operation is best avoided. Emergency response in remote areas is one example where a UAV could be deployed to provide immediate assistance (e.g. search-and-rescue); to mitigate a crisis unfolding (e.g. fire-fighting); or to provide subsequent disaster relief (e.g. the delivery of humanitarian supplies). Future applications of UAVs could involve the transportation of significant payloads, both civilian and military, such as long distance air freight.

### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

### **Marine**

**Increased safety.** A large proportion of accidents at sea are attributable to human-error, e.g. non-rational behaviour; varying degrees of knowledge, competence and experience; different perceptions to safety and risk; limitations in human data processing capacity; skill degradation (e.g. automation and controls skills are more important in the future than mechanics); misinterpretation of data; unpredictability; vessel behaviour based on captain's personal characteristics; limited communication and logging of observations and decisions; fatigue and boredom. Therefore, by increasing automation and removing, or distancing, the human, it will be possible to reduce the number of accidents. At the same time, removing crew from vessels also means that fewer people will be present if an accident were to occur – taking people out of harm's way.

**Reduced crew costs.** Perhaps the most obvious benefit for vessels owners and operators is the reduction of costs associated with crewing vessels. The cost of crew is, in many cases, the highest per-voyage overhead facing a vessel operator. It is becoming increasingly difficult to recruit the younger generation to life at sea – months away from home, limited access to social media and possible hardships. This has contributed to the demand for trained and skilful crews outstripping the supply, resulting in rising costs and a shortage of competent officers and engineers. Autonomous operation would enable land-based operators and engineers to oversee the operations of a number of vessels and thereby increase the desirability to a new generation, and reduce the numbers required.

**Reduced capital cost for vessels.** Removing the crew from a vessel allows the vessel design to be simplified. All of the life-support functions can be removed, including accommodation, air-conditioning, heating, lifeboats, water, food, lighting and recreation facilities. This will lead to smaller vessels for the same load-carrying capacity, with much less equipment required on board.

**Increased efficiency of ships.** With the reduced size of the vessel, the efficiency for a given pay-load will be increased, since the energy required to move a vessel through the water is directly related to the dimensions. The design of the whole vessel can be optimised for efficient running. For example, the accommodation block on a vessel incurs a significant wind drag as the vessel moves along. With no crew and no accommodation block, the vessel could be designed to be more aerodynamically efficient. With no life-support systems, energy usage for air-conditioning, heating and lighting, among others, will not be required, reducing the energy efficiency further.

**Reduced emissions.** With increased efficiency of the vessel in terms of aerodynamics, dead-weight and operational dead-time, the amount of fuel used in the transport of goods and passengers will be reduced, leading not only to savings in cost, but also reductions in emissions of greenhouses gases such as carbon dioxide, as well as other pollutants such as sulphates and nitrates.

**Increased efficiency of transport operations.** Increasing the level of autonomy of the vessel is not limited to navigation. It is also possible, by digitally connecting the complete transport operation, to optimise loading, unloading, to integrate the movements and dockings of the vessel to its intended cargo and ultimately to optimise the complete logistics chain. The same technologies which will act as enablers for autonomous operation will allow the

maintenance of the vessels and its equipment to be optimised around its work. Leading to further efficiencies and reduced down-time.

**Technology spin-offs.** The development of technology required for full autonomy will have certain spin-off advantages which will increase the short-to-medium term benefits. For example, advances in situational awareness (i.e. detection and identification of other vessels, objects or obstructions around the autonomous vessel) required for computer control of a vessel will be used to improve the safety of manned-vessels by giving the captain, helmsman or pilot enhanced awareness. A further example is the automation of equipment on-board, including diagnostics of faults and self-repair, which will be required for autonomous operation, will be available for improved reliability on manned-vessels. Countries that participate in these developments by providing facilities such as digital ecosystems or test areas for autonomous vessels, will be able to reap the greatest rewards, including creation of high-tech jobs.

### **Potential disadvantages**

There are some disadvantages associated with autonomous vessels. Some are generally well-known risks: automation of manoeuvres and data communication via satellite including cybersecurity. For some risks, there is limited current knowledge, for example interaction between manned and unmanned ships, operations in harsh weather conditions and complex operating situations. There will also be risks that are currently unknown, some of which may have been identified in the automotive arena, but some which will be completely new.

One identified area to be addressed is that of cybersecurity, which represents a major risk as a single source of failure in unmanned shipping. It could cause several critical functions to fail to operate as intended. The level of autonomy impacts the type of cybersecurity arrangements required. Remote operation from a shore control centre typically requires the ship and the centre to be connected in real-time, whereas autonomy lets the vessel operate without active control from shore.

### **Aerospace**

The proliferation of small UAV suppliers is evidence of the numerous benefits and significant market access made available by their deployment and many of these benefits will apply to larger UAVs. The removal of the operator should result in the reduction in the scope for human error. As the extent of UAV on-board autonomy increases then lifecycle cost reductions will be realised from reduced operator presence and skill-level, and lighter, simplified UAV design without the need to accommodate the human operator. Furthermore, increasing autonomy will lend itself to 24/7 operation of UAVs.

Many factors will influence the more wide-spread use of UAVs such as cost, system reliability, robust control of system (e.g. reliable sense-and-avoid, ability to fly in cluttered environments, appropriate response to unexpected events); ability to fly with loss of GPS; emergency 'get home'/land ability. Most of these are being tackled to an extent by the larger more sophisticated systems (including military), and a lot of this would need to translate into the smaller systems, since they face the same issues.

A significant barrier to more wide-scale adoption of UAVs is a dearth of risk assessment approaches, design standards and means of validation/verification that are specifically tailored to assuring autonomy related technologies. This barrier results in a reluctance to trust in and accept broader UAV deployment by customers, operators and certification bodies.

## **5. What is the scale of the market opportunity for autonomous vehicles?**

### **Marine**

There are currently about 50,000 vessels in the international merchant trade, with a total crew of 1.2million seafarers. This worldwide merchant fleet generates approximately £400bn in freight charges per year. The market value for autonomous vessels can be calculated from these based on potential reductions in capital costs, manning costs and fuel costs. It is estimated that capital costs and manning costs are, on average, approximately 25% each of total running costs, and that fuel costs are approximately 15% of total running costs. Studies into the design of unmanned vessels have estimated that the capital spend on vessels could be reduced by around 20%, whilst a similar saving would be possible on the fuel costs. Finally, at least two-thirds reduction in spending on manning could be achieved by removing crew from ships and utilising experts in onshore control centres. Combining these figures, the total savings across the industry would be around 20% of the total, or £80bn per annum. A significant proportion of these potential savings should be available for exploitation in the provision of the vessels, equipment and services which provide the capabilities of autonomous operation.

Within the UK, opportunities exist in a number of areas, including research and development (R&D), manufacture and operations. With its long maritime history, seafaring tradition and number of institutions involved in maritime research, the UK is in a strong position to be at the forefront of autonomous R&D. Whilst shipbuilding is no longer a major industry within the UK, there is potential to supply high-tech solutions and intellectual property for use on future vessels. Remote and autonomous operation makes it possible to control vessels of any flag state from the UK. This has the potential to permit vessel management, fleet management and marine operations in the UK. However, there is also a threat that if other countries are able to provide the expertise they will be preferred to the UK. Those nations that provide early support, education and infrastructure are likely to succeed.

There is a huge potential for the use of autonomous marine vessels to revolutionise the marine and shipping industries. Some of the key benefits include:

- Increased safety by removing human errors and having fewer people at sea.
- Reduced cost of shipping by reducing manning costs, capital costs and increasing fuel efficiency.
- Fewer emissions since unmanned ships can be smaller and more efficient.
- Optimisation of fleets and cargo in a digitally connected operation.
- Creation of high-tech jobs in countries that take a lead in providing digital ecosystems and autonomous test areas.

The UK and Rolls-Royce are currently in the vanguard of efforts to make this come about, but other players are moving quickly. The UK has the potential to become a major player in the further development of autonomous vessels and could reap major benefits from early

adoption, with a huge potential market. Action from government and other UK institutions could greatly improve the effectiveness of UK development in order to harvest the greatest benefits. The current inquiry represents a welcome start to this process.

### **Aerospace**

Applications at the smaller end of the UAV market are likely to move beyond the military, initially into the security sector and then into the civilian sector; indeed the largest markets will most likely be civilian applications. Typical applications could be:

#### Security

- Border patrol
- Anti-smuggling (goods and people)

#### Day to day utility

- Motorway patrol / Road traffic accident
- Oil / gas pipeline surveillance
- Powerline surveillance / fault finding

#### Emergency utility

- Oil depot fire
- Mountain rescue
- Coastal patrol / rescue
- Oil / chemical spillage at sea
- Nuclear powerstation emergencies
- Floods
- Adverse weather / heavy snow

Larger UAVs are currently the domain of the military, with a greater emphasis on being able to operate in potentially hostile environments (e.g. Predator, Reaper) and at high altitude, long range (e.g. Global Hawk). The emphasis is more on the utility of such systems and less so on cost. The level of sophistication is increased with a greater likelihood of bespoke subsystems. The nature of propulsion and power for these platforms is for increasing requirements on power provision to the subsystems (e.g. surveillance sensors) with the associated challenge of managing the thermal environment within the platform. There may be some civil applications in areas such as earth observation where the intent would be for an observation platform/system that could be ‘on-station’ for very long periods of time. The future is quite likely to include combat UAVs in this class where the size is dictated by the ability to carry a payload over long distances.

UAV propulsion so far tends to be with existing engines (i.e. OTS – Off-The-Shelf), predominantly for cost reasons. However as the market demands more sophisticated systems then more bespoke solutions will become attractive, with technological advances such as hybridised power systems incorporating fuel cells, photovoltaics (i.e. solar cells) etc. With increasing autonomy, the requirement will grow beyond the provision of propulsion alone to intelligent on-board power management. The engine supplier’s scope of interest will thus broaden out to include for instance, demand monitoring and power distribution. Increasingly lengthy unmanned operation will demand increasingly reliable on-board systems along with assurance of this reliability. Indeed, the emphasis will likely shift towards

whole vehicle health management of integrated subsystems to include advanced condition monitoring; diagnostics/prognostics; and optimised maintenance and repair.

In the future, market leaders are likely to be those who can best integrate systems, both internally within the platform and into the wider infrastructure. Consideration also needs to be given to how these systems are operated; in the civilian field there are a lot of likely interested parties who could not afford to develop a system on their own, but may be more interested to be part of a consortium for both developing and operating a system. So there could be a future significant market opportunity to provide a service to those interested parties.

## **10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

### **Marine**

Autonomous vessels already in use, or in demonstration, are using existing infrastructure in order to make progress. However, the full benefits of autonomous vessels will not be realised without changes to digital and physical infrastructure. There are significant technical challenges associated with ensuring safe and robust operation of autonomous vessels which could benefit from governmental influence or intervention.

On the physical side, ports may need to provide changes to their infrastructure in order for fully autonomous vessels to operate. For example, the berthing and loading/unloading of a vessel with no crew may require specific equipment at the quayside not available at present. Such a provision may also help to speed up the whole port operation.

The ultimate aim for autonomous vessels is for them to share sea-space with manned vessels. There may, however, be a requirement in the near-term to separate autonomous and manned vessels in congested areas like ports. In either case, whether autonomous vessels are separated or not, there will be a requirement for changes to sea traffic management to enable the full benefits to be realised. This is likely to include the provision of information concerning the movement and intentions of vessels being made available for the use of others in the area. There are initiatives being trialled in a number of European ports to digitalise sea traffic management, support for these initiatives within the UK is highly desirable.

In order to navigate a vessel, it is vital to have an accurate measurement of the actual position on that vessel. The primary method for position measurement uses global navigation satellite systems (GNSS) such as the global positioning system (GPS). In order to ensure security, it is necessary to have alternatives to GNSS which use alternative technologies. Currently there are few alternatives, but infrastructure could be envisaged to provide ‘digital lighthouses’ for example as a backup for GNSS. This could be a further possible area for support from government agencies.

### **Naval applications**

The discussion to date has concentrated on commercial marine applications of autonomous vessels. There is a further potential benefit to the UK in the use of autonomous vessels in naval applications both surface and sub-surface. Development in autonomous airborne

vehicles (drones) has been highly publicised and has proved to be extremely beneficial in reducing costs, increasing flexibility and reducing the dangers for pilots and military personnel. Currently, naval ‘drone’ technology is behind that of the aerial theatre, but developments in this domain are moving forward steadily.

The Royal Navy, like most European navies, is preparing to introduce small (<12m) unmanned vessels deployed from existing platforms to conduct specialist tasks such as mine countermeasures, surveillance and fleet protection. ‘Unmanned Warrior’, a large scale, multi-environment, military demonstration of unmanned technology has just completed off the west coast of Scotland. It combined industry, academia and defence partners, including the US Navy, to explore the feasibility of increasing the use of unmanned and autonomous systems in delivering maritime capability. Modern combatant designs, such as the Royal Navy’s planned Type 26 frigate, are increasingly including ‘mission bays’ to house and deploy such unmanned vessels. The US Navy is probably the most advanced in this area, they have commissioned a 40-metre proof-of-concept unmanned vessel, Sea Hunter, which is intended for anti-submarine and mine-hunting activities. In the longer term they believe that this type of vessel could replace manned anti-submarine warfare frigates, reducing running costs from \$700,000/day to around \$20,000/day and costing a fraction of the price of a larger manned platform.

Engagements with USN and RN unmanned programme teams indicate that large scale introduction of fully autonomous technology for combatant platforms is a long way off. It is envisaged that the rapid maturing of full autonomy in the commercial sector will pull through into naval new-build programmes in the form of semi-autonomy; decision support computer systems that analyse and contextualise platform data and present the operator with recommended options are very likely be introduced. This would further reduce specialist on-board manpower and improve warfighting capabilities. The only restraints to such an introduction is the slow pace of new build programmes as warships designed for service in the 2020s will be too early for the autonomy revolution and retrofits to warships currently in service are unlikely to prove cost effective since autonomy needs to be considered and implemented at concept design stage.

Clearly, autonomous technology could dramatically improve the capabilities in the naval sector. The UK could be far more ambitious in utilising the advances in the commercial arena and ensure that the requirements for new warships are future-proofed, allowing for the introduction of semi-autonomy as it matures through the next few years.

### **Aerospace**

A more broad ranging deployment of UAVs will likely require infrastructure changes, the specifics of which will depend on the particular applications. A digital infrastructure is required that facilitates safe air traffic integration with robust remote command, control and communications that are both fault-tolerant and secure. Meanwhile, physical infrastructure such as dedicated runways or launch pads and associated facilities will likely be required to accommodate increasingly larger UAVs so as not to diminish the capacity of existing terminals for passenger and freight transport.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

There are many challenges that will need to be overcome before the widespread use of autonomous systems is realised:

- How do we demonstrate sufficient system reliability and integrity at platform/operation level (e.g. may need to incrementally demonstrate ‘in the field’)
- How can we build the public’s trust in an autonomous system
- How can we make the system sufficiently flexible to allow growth / upgrade
- What technological developments are essential
- How can the ability to communicate with the system be maintained at all times
- What other infrastructure needs to be put in place
- How can we ensure the security of the system (e.g. so it cannot be hijacked or compromised by external sources)
- How can we get developments out into the field more easily

These challenges are largely common to all such systems, whether in the air, sea or land domain. The difference will be the level of evidence needed to prove the system; air applications will be safety critical which will need a much higher level of integrity than in the land or sea domain, but in principle all will need to demonstrate an appropriate level of integrity for acceptance. Continued UK government support is pivotal to achieving the broader exploitation of UAVs such as state funding for technological development in low maturity areas and the engagement of public agencies such as the Civil Aviation Authority.

**Marine**

Autonomous shipping represents major challenges to the current regulatory framework. Autonomy means that there is a more pronounced major risk area of connectivity and cyber security on top of powering, propelling, steering and controlling a ship. Also, the importance of software development, validation, system reliability and functionality is increased. The legal liability and responsibility of system providers will increase with the introduction of more autonomous applications.

Much of the legislation on operation of marine vessels in the UK is based on the conventions issued by the International Maritime Organisation (IMO). For example, the International Convention for Safety of Life at Sea (SOLAS), the International Convention on Standards of Training, Certification and Watch-keeping for Seafarers ( STCW ) and the Convention on the International Regulations for Preventing Collisions at Sea (COLREG). The wording of these conventions, and of other legal instruments, relies heavily on the assumption that there is a crew on board, including a master. This leads to an ambiguous situation when considering autonomous vessels. Recently, some nations have given input to IMO 2018-2023 strategy to include aspects of unmanned shipping.

It is recognised that the international conventions would be unlikely to be altered in the short term. International rules evolve slowly due to the complex approval process by member states and the required minimum country adoption rate before new rules or amendments take place. Vessels operating within a single country can be exempted from international rules by the approval of a national authority. UK legislation could, and should,

be used to clarify the situation within UK coastal waters in order to accelerate development of autonomous vessels here. Other flag states are already addressing the issue of local legislation in order to try to foster further development.

Unmanned shipping represents a quantum leap in shipping as we know it. Therefore, a mere regulatory compliance is not a sufficient approach. It is recommended that the marine industry applies best practices from the aviation industry by implementing holistic safety management.

Insurance, liability and classification rules are also areas in which the introduction of autonomy represents largely uncharted waters. Recently, the trend has been towards probabilistic and goal-based rules that can be applied to novel applications. While this provides a possible upgrade path, it is yet to find credence with insurance companies.

### **Aerospace**

A comprehensive review of both the national and global position on insurance, regulation and legislation involving all relevant stakeholders is essential to establishing a shared understanding of the difficulties and barriers to a more broad ranging deployment of UAVs. Such a review is key to identifying proposed revisions and operational restrictions/limitations, and encouraging standards development, to facilitate more ambitious applications of UAVs than exist today. In the first instance, principles are required for the operation of increasingly larger UAVs and increasingly sophisticated roles. A position should then be developed on their safe integration to the airspace as it exists today in and amongst conventional air traffic.

*26 October 2016*

## Royal Aeronautical Society – Written evidence (AUV0077)

### 1. Executive Summary

- 1.1 There is an important distinction between automated and autonomous vehicles. The terms are often used interchangeably but incorrectly when describing current and future applications.
- 1.2 There already exists a wide range of automated capabilities within both civil and military aviation sectors, including space, with the likelihood of manned and unmanned aircraft systems becoming more autonomous with technological and regulatory advancement.
- 1.3 The scope of autonomous flight is more wide-ranging for aircraft than for cars as they are not restricted by existing physical infrastructure and because there is a wider range of designs and constructions of UAS, making it more challenging to predict the development path of the technology.
- 1.4 In the same way that a human driver will still likely be required to oversee the highly-automated operation of a car for the foreseeable future, a remote operator or team of operators are likely to remain a requirement for airborne vehicles. This is unlikely to raise any new ethical issues.
- 1.5 Increasing the application of automated and autonomous technology in manned and unmanned aircraft will not work in concept if it is simply designed to replace the human. Operational weaknesses, such as loss of situational awareness, develop if a human does not know what part they play in the overall system.
- 1.6 The hazards posed by the use of automated and autonomous UAS are similar to those posed by autonomous cars, but with significantly greater consequences when something goes wrong. Regulations in place to limit the freedom of UAS operators should, however, be reviewed and changed when technology advances.
- 1.7 The legislative and regulatory environment, as well as and airspace architecture, will also need to adapt in a risk-based way and incorporate UAS to maximise the sector's economic potential. The Government's planned UAS Strategy and Modern Transport Bill provides the ideal opportunity to resolve legislative and regulatory barriers to growth. Regrettably progress appears to have stalled after the EU referendum.
- 1.8 Trials have been laying the foundations for the regular sharing of the skies between manned and unmanned aviation. Despite the optimistic forecasts for growth, rethinking legislation and regulation to suite commercial applications of UAS is a challenging task. However, countries that are early adopters of UAS in controlled and unsegregated airspace could be well placed to capture the commercial and economic opportunities.

- 1.9 Government support should not focus on a few narrow commercial applications, particularly those based on imported technology as this will not help the UK industrial base to achieve its growth potential.
- 1.10 Automation and autonomy will be dependent on satellite systems, especially navigation. The Government's strategy should recognise the role of space technology in autonomy and must continue to support the UK's leading role in the space sector as a necessary element in delivering autonomy advances.
- 1.11 As with autonomous cars, there is a concern about the cyber vulnerability to automated and autonomous manned and unmanned aircraft systems. Systems need to be protected from hacking, for example to prohibit non-authorised operators from taking control, through the provision of high standards of systems resilience and regulation.
- 1.12 Without preventative action, Brexit will lead the UK's withdrawal EU-funded research and space programmes relevant to the development of autonomous technology.

## **2. About the Royal Aeronautical Society**

- 2.1 The Royal Aeronautical Society (the Society) is the world's only professional body dedicated to the entire aerospace community. Established in 1866 to further the art, science and engineering of aeronautics, the Society has been at the forefront of developments in aerospace ever since. The Society seeks to: i) promote the highest possible standards in aerospace disciplines; ii) provide specialist information and act as a central forum for the exchange of ideas; and iii) play a leading role in influencing opinion on aerospace matters.

## **3. What are the potential applications for autonomous vehicles?**

- 3.1 At the outset, it is important to clarify the distinction between automated and autonomous vehicles, as the terms are often used interchangeably but incorrectly. An automated vehicle is one that follows a series of pre-programmed commands but lacks the capacity for independent decision-making. If an automated system encounters a problem, it can only follow a script; it is not capable of devising its own solutions to effectively cope with demanding circumstances. An autonomous vehicle is given a task or mission, and is programmed to be able to take decisions intelligently on how it will perform that task without human intervention.
- 3.2 Systems where there is no active and direct human intervention across the various stages of a given decision-making process might appear to be autonomous but might just be highly automated with a human over-ride. The US Navy Office of Naval Research (used by SEAS DTC) provides a helpful explanation of the various levels of autonomy from human operation to full autonomy<sup>238</sup>.

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<sup>238</sup> Williams, R. *BAE Systems – Autonomous Capability Overview*. BAE Systems, Preston, Slides 5-6.

- 3.3 There already exists a wide range of automated capabilities within both civil and military aviation sectors, including automatic landing systems for use in poor weather, automated navigation, anti-collisions systems and engine controls. In the field of unmanned aircraft systems (UAS), automation is already underway in areas such as take-off and landing and navigation, with the likelihood that UAS will become more autonomous with technological and regulatory progress.
- 3.4 The development and application of increasingly automated and autonomous systems in civil and defence aviation, is advancing at a rapid pace because of the expected benefits the technology will yield, including efficiency, accuracy and enhanced safety of operations, while concurrently potentially reducing workload and training requirements and costs. Automated and/or autonomous aircraft systems could enable access to places that would otherwise be dangerous or impossible for human pilots to reach. Automated or autonomous systems can also replace roles that would be too repetitive or tedious for people to carry out for extended periods of time where high levels of focus would be required.
- 3.5 The interest and advancement of automated and autonomous aircraft systems and technology is driven in large part by the growth in civil and military UAS. UAS are expected to play a greater part in the future of aerospace and aviation owing to the promise of military capability enhancement and economic gains. Advances in artificial intelligence (AI) are creating new opportunities for UAS, creating new business models, modes of operation and innovation in the aerospace sector. Swarms of UAS able to share data, unmanned combat air vehicles (UCAV) that could react to and respond to pop-up threats, or UAS programmed with the accumulated knowledge of thousands of human pilots and able, even, to learn from mistakes to optimise performance, are all possible applications of greater autonomy in aviation.
- 3.6 There is an expectation that armed UAS, with the capability of responding to verbal and digital commands thanks to AI technology, may eventually evolve and become common place, even operating alongside human piloted aircraft. A US Air Force Research Laboratory funded project, ALPHA, is an AI system trained by an Air Force expert in air combat. In synthetic-based trials, the AI consistently bested human pilots – even when hampered by being given inferior aircraft.<sup>239</sup>
- 3.7 The scope of use of autonomous flight is more wide-ranging than for cars, particularly certain sizes and weights of UAS, as they are not limited by existing infrastructure, like roads. Unlike cars, UAS offer a wider variety in the way they are constructed and developed, which make it more challenging to predict the development path of the technology. The commercial availability of autonomous UAS is more difficult to foresee given the sheer number of opportunities, including Personal Air Transport (PAT), and current restrictions of operation in a multitude of civil and military environments due to safety, ethical and legal concerns. UAS (automated and

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<sup>239</sup> Gallagher, S. (2016) AI “pilot” bests human air combat experts in simulated dogfights. arsTechnica, USA

autonomous) technology raises a number of questions about the possibility of safe integration into a well-established, regulated airspace.

- 3.8 In the same way that a human driver would still be required to oversee the highly-automated operation of a car for the foreseeable future, a remote operator or team of operators is likely to remain a requirement for the operation of airborne vehicles. The term Remotely Piloted Aircraft Systems (RPAS)<sup>240</sup> is often preferred as a reminder that although these vehicles are unmanned, they still rely, to some extent at least, on ground-based operators.
- 3.9 Beyond terrestrial applications, autonomous vehicle technology has applications in the satellite and space exploration domain. Satellites operate as semi-autonomous vehicles in space. In this context, autonomy is typically applied to the management of on-board systems in order to achieve a high degree of resilience to external disturbances or equipment faults, while minimising dependence on human oversight. The expected growth of ‘mega-constellations’, consisting of many hundreds of satellites, places major demands on autonomy as a necessary element for maintaining effective control without an equivalent, uneconomic growth in ground-based oversight. Autonomous ground vehicles have a developing role in robotic exploration of the solar system. Remotely operated and semi-autonomous rovers have been deployed on both the Moon and Mars.

#### **4. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

- 4.1 The application of highly-automated technology in manned aviation is already well-established, and yielding significant benefits, particular in terms of safety. Early aircraft operations were highly hazardous and regular incidents resulted in numerous fatalities. Along with improvements to aircraft structures, power systems, aerodynamics and construction techniques, the advent of the modern flight management systems has enabled commercial aviation, in particular, to become safer as a mode of transport than road vehicles.
- 4.2 Compared, with 2014, the global accident rate involving scheduled commercial operations decreased by 7% in 2015, which equates to 3.0 accidents per million departures in 2014 to 2.8 accidents per million departures in 2015<sup>241</sup>. The 474 fatalities in 2015 are a decrease from the 904 fatalities in 2014 – despite the loss of Germanwings and Metrojet, which caused significant loss of life<sup>242</sup>. Over 1.2 million people die each year on the world’s roads, with up to 50 million people incurring non-fatal injuries as a result of road crashes<sup>243</sup>. The number of deaths on the world’s roads

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<sup>240</sup> The International Civil Aviation Organisation (ICAO) defines RPAS as a form of UAS, which is non-autonomous in its capacities, the aircraft being subject to direct pilot control at all stages of a flight, despite operating remotely from the pilot.

<sup>241</sup> [International Civil Aviation Organisation \(2016\) Safety Report. ICAO, Montreal](#)

<sup>242</sup> Ibid.

<sup>243</sup> [World Health Organisation \(2015\) Global Status Report on Road Safety 2015. WHO, Geneva](#)

has plateaued against a 4% increases in global population and 16% increase in motorisation<sup>244</sup>.

- 4.3 Today pilots monitor systems but leave routine flying to the autopilot. Aircraft fitted with precise navigation instruments means that pilots will rely on autopilots to land in poor visibility conditions. The new generation of highly-automated fly-by-wire systems<sup>245</sup> in aircraft can be programmed to carry out precise adjustments to control surfaces automatically, keeping the flight more stable. Equally, engine management systems work in co-ordination with flight management systems to ensure optimum efficiency and economy of operation, thus addressing fuels costs and emission challenges. Also, the development of virtually autonomous Traffic Collision and Avoidance Systems (TCAS) has made a major contribution to safety in what is increasingly busy airspace.
- 4.4 Pilot error is still the most common contributory factor in aviation accidents, although less so in terms of routine flight tasks, despite the high levels of automation involved in aircraft design and operations. Increasing the application of cockpit technology does not work in concept if it is simply designed to replace the human. Operational weaknesses, such as loss of situational awareness, develop if the human does not know what part they play in the overall system. Pilots, as well as the people managing complex automated systems on the ground, need to be trained sufficiently with the skills and competences required to operate today's complex automated aircraft. This can be particularly challenging when determining how much knowledge the flight crew need to have about the complexities and interactions of automated systems on the latest generation of airliners. Although highly reliable, when problems do occur it can be extremely difficult for the flight crew to understand what the aircraft is trying to do and how best to intervene to ensure a safe outcome. It is prohibitively expensive to give all flight crew sufficient training to cope with every possible emergency, particularly given the rarity of such events, and there is significant reliance on the experience of the flight crew and their ability to work effectively as a team. This issue is only exacerbated in autonomous systems where those who may need to respond to and address malfunctions are remote from the system, and probably poorly places to undertake timely diagnosis and recovery action.
- 4.5 The emergence of greater autonomy in UAS has the potential to create opportunities to extend the widespread benefits to public service and commercial operations that are already offered by human operated UAS (or RPAS). Uses include crop monitoring, infrastructure monitoring and maintenance, natural disaster response and police surveillance. In certain commercial operations, such as parcel delivery, automated UAS could have their own segregated airspace with their own Air Traffic Control (ATC) system, with which manned aircraft would have to comply if they wish to enter. Governments, regulators and the industry will need to understand how the automated system and the human will coexist.

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<sup>244</sup> Ibid.

<sup>245</sup> [Airbus.com: Fly-by-wire](http://Airbus.com: Fly-by-wire)

- 4.6 The hazards posed by the use of automated and autonomous UAS are similar to those posed by autonomous cars, but with the significantly greater consequences when something goes wrong. The biggest is collision with people or property, and manned aircraft or other UAS. Regulations are in place<sup>246</sup> to limit the freedom of operators to fly UAS near people and built-up areas, as well as other aircraft. These regulations are currently being reviewed and should change when technology allowing civilian UAS to operate out of sight of the operator is proven to work safely. Highly reliable ‘sense/detect and avoid’ capability must also be proven to avoid conflict with other aircraft and UAS.
- 4.7 Military UAS are still limited to segregated airspace or flight above 60K feet or for a few low level operations under the ‘due regard’ requirement<sup>247</sup>. Currently, military UAS are deconflicted carefully, either flying in empty ranges, conflict zones or under close supervision to operate under or between ATC civil routes.
- 4.8 Another risk is loss of a data link to the controller in highly automated but not completely autonomous UAS. Civil and military UAS are operated remotely and require a reliable data link between the UAS and operator, which, if lost, could result in an accident. Higher levels of automation, whereby a UAS operating beyond-visual-line-of-sight (BVLOS), becoming distressed would be able to land safely according to pre-programmed scenarios or make a decision itself (autonomously) on a safe landing place, are under development and will improve safety levels.
- 4.9 Autonomous technology, deployed in the satellite/space exploration context, is perceived as a benefit for space applications. Greater autonomy allows for greater cost efficiency, improved resilience and higher returns in both commercial operations and scientific missions. The European Space Agency’s (ESA) Huygen’s probe that landed on Saturn’s moon Titan was fully autonomous (the software being supplied by a UK company). Long delays in communication (for example for missions to Mars and other planets) emphasise the need for vehicles to sense, interpret and respond to their environments with minimal human intervention.

**5. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

- 5.1 Further to the Society’s response to Question 4, there is an already high level of automation in the commercial aviation sector. A comprehensive, though not exhaustive list of the main advantages of automation in manned aircraft is set out by the European Aviation Safety Agency (EASA)<sup>248</sup>
- 5.2 The potential impacts of the deployment of automated UAS, and in the future autonomous UAS, can be inferred from the current use of RPAS in a wide range of

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<sup>246</sup> [Civil Aviation Authority Regulations relating to drones and unmanned aircraft](#)

<sup>247</sup> The military do what they can to avoid impacting civil operations, mostly restricted to low altitude operations.

<sup>248</sup> [European Aviation Safety Agency \(2013\) EASA Automation Policy: Bridging Design and Training Principles](#). EASA, Cologne.

areas. These uses are already well documented elsewhere, such as the House of Lords European Union Committee report on Civilian Drones (2015)<sup>249</sup>.

- 5.3 Autonomy is recognised as a major beneficial technology in the space sector, where its use has been actively pursued for many years, with UK companies having a strong heritage.

**6. What is the scale of the market for autonomous vehicles?**

- 6.1 Autonomy in aviation creates economic opportunities for the aerospace sector itself but also supports growth and efficiency of operations in sectors that deploy or will deploy automated aircraft systems. A study by PwC on the commercial application of UAS technology concluded that the “emerging global market for business services using UAS is valued at \$127bn”<sup>250</sup>.
- 6.2 Legacy aviation and aerospace companies are incorporating UAS into their business or seeking to enter the fast-growing market, through developing UAS themselves, acquiring innovative start-ups or by partnering with UAS companies in ways that complement their businesses.

**7. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

- 7.1 More challenging applications, such as pilotless firefighting aircraft and even conventional freighter aircraft, do not appear to be being considered as strongly as they could in part because the regulatory environment does not make this viable. Progress of the European ‘Specific’ category of UAS regulations<sup>251</sup> has the potential to improve this.

**8. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so?**

- 8.1 No specific government funding actions are in place for autonomy in the space context. The European Space Agency (ESA) site at Harwell includes technology for robotic exploration within its remit.

**9. How effective are Innovate UK and the CCAV in this area?**

- 9.1 The Government supports aerospace research through the Aerospace Technology Institute (ATI), a joint Government and industry investment that aims to maintain and increase the UK’s competitiveness in aerospace design and manufacture. Innovate UK is the delivery partner for the ATI research and technology programme.

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<sup>249</sup> [House of Lords European Union Committee \(2015\) 7th Report of Session 2014-15: Civilian Use of Drones in the EU](#). The Stationery Office Limited, London.

<sup>250</sup> [PwC \(2016\) Clarity from above: PwC global report on the commercial applications of drone technology](#). PwC, Poland

<sup>251</sup> [European Aviation Safety Agency: Civil drones \(Unmanned aircraft\)](#)

9.2 Development and demonstration of autonomous aerospace technologies is already one of the new architectures that will benefit from some of the £3.9 billion Government and industry funding for UK aerospace R&T up until 2026<sup>252</sup>.

9.3 No specific government funding actions are in place for autonomy in the space context.

**10. Is the environment for small and medium-sized enterprises (SME) working in this sector sufficiently enabling?**

10.1 UK SMEs are well placed to lead the UAS industry's expansion found the European Commission (EC)<sup>253</sup>. This is a result, in part, because the "most rapid commercial market for growth [in civilian drones] has come from the small RPAS. In the UK, this has mainly involved the sale of services..."<sup>254</sup>.

10.2 The current regulatory framework for UAS inhibits the application of autonomy in UAS because of the requirement for civilian UAS to remain within visual line of sight. As technologies develop and trials are completed into the viability of 'sense/detect and avoid' technology and the use of BVLOS solutions, the regulatory environment and airspace architecture will need to adapt in a risk-based way and incorporate these UAS to maximise the sector's growth and economic potential. This is beginning with the outline of the 'Specific' category of RPAS presented in the recent 'prototype' regulation from EASA.

10.3 After initially backing research into the commercial application of large UAS through the Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTREA)<sup>255</sup> consortium, the UK Government removed its support for larger UAS in favour of small UAS – often side-lined in the past – with pathfinder demonstration projects leading the way in the commercial deployment of civil UAS, albeit with somewhat limited support for indigenous UAS platform development of any size.

10.4 At a Royal Aeronautical Society conference in October 2015, the Government set out its vision for civil use of UAS in the UK, in particular companies being able to operate BVLOS:

*"To create an environment and enabling infrastructure (legal and regulatory framework and policy) in the UK that: drives growth in the private drone sector (users, manufacturers, services); facilitates public sector adoption (increasing efficiency and*

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<sup>252</sup> [Aerospace Technology Institute \(2016\) Technology Strategy and Portfolio Update 2016: Raising Ambition. ATI, Cranfield](#)

<sup>253</sup> [Tensor.co.uk \(2015\) UK SMEs in the Drone Industry Poised for Massive Growth. Tensor, St. Neots.](#)

<sup>254</sup> [House of Lords European Union Committee \(2015\) 7th Report of Session 2014-15: Civilian Use of Drones in the EU. The Stationery Office Limited, London.](#)

<sup>255</sup> [astrea.aero](#)

*capability); and provides reassurance on societal concerns (safety, security, privacy and data protection).<sup>256</sup>*

- 10.5 The Government's plans<sup>257</sup> for publication of 10-year UAS strategy in the summer of 2016 to deal with regulatory issues surrounding the development and more widespread use of UAS, with the objective of becoming a world leader in the sector, seem to have stalled following the outcome of the EU referendum, which is disappointing. The Modern Transport Bill announced in the 2016 Queen's Speech is the ideal opportunity to resolve legislative and regulatory barriers to the growth of the sector.

**11. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

- 11.1 In the provision of air navigation services, automation is already being widely used alongside high levels of automation in the aircraft they are serving. Today the air traffic controller still makes the decision, but is supported by automated information and advice. NATS is already considering "the implications of introducing more automation into air traffic control...for example providing earlier warnings of potential conflicts, reducing the likelihood of human error and enabling controllers to handle aircraft more safely."<sup>258</sup>
- 11.2 Changes to airspace architecture are not completely dependent on the development of greater autonomy in manned and unmanned aviation. The application of automated systems should improve the way airspace is controlled, including handling higher traffic volumes and even a mix of manned and unmanned aircraft systems with a reduction in dependency on the controller. With greater autonomy controllers might change the focus of their jobs and become supervisory, but it is likely for the foreseeable future that human roles will continue.
- 11.3 The introduction of trajectory management for civil aircraft movements, with their precise paths pre-programmed from gate to gate, and all aircraft constantly broadcasting their positions and trajectories to others, and adjusting their flightpaths to take account of potential conflicts, will largely remove any practical difference between manned and unmanned flights and controlled and uncontrolled airspace.
- 11.4 Plans for the integration of automated or autonomous UAS in controlled airspace would require changes to the way airspace is managed rather than controlled. UAS flying in controlled and unsegregated airspace would be controlled in the same ways as a manned aircraft, at least when there is a pilot on the ground with whom controllers can communicate. The changes required in the immediate term will be

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<sup>256</sup> [Robinson, T. \(2015\) Aerospace Insight Blog: RAeS helps set the drone agenda. Royal Aeronautical Society, London.](#)

<sup>257</sup> [Sciencewise Further Government statements on the role of the current drones dialogue in 10-year strategy](#)

<sup>258</sup> [NATS \(2013\) Safety Management and Automation in Air Traffic Control: the future](#)

legislative and regulatory in order to allow UAS to operate in airspace usually reserved for manned commercial aircraft.

- 11.5 Trials have been laying the foundations for the regular sharing of the skies between manned and unmanned aviation. Yet, despite the optimistic forecasts for growth, rethinking legislation and regulation to suit commercial applications of UAS is a challenging task requiring considerations of safety and privacy issues. Countries that are early adopters of UAS in controlled and unsegregated airspace could be well placed to capture the commercial and economic opportunities from this burgeoning sector.
- 11.6 The important role of the space sector in enabling terrestrial autonomy should be noted, as relevant to ground vehicles, aircraft and marine vessels; indeed, autonomy substantially increases the critical dependence of systems on satellite systems, especially navigation. Three space technologies underpin many autonomous vehicle activities:
- Satellite navigation (e.g. Global Positioning Service (GPS); Galileo) for position, velocity and time information;
  - Satellite communications (satcoms) for remote monitoring and control (particularly for vehicles operating in remote areas on land, at sea and in the air), and for data transmission; and
  - Satellite navigation enhancement systems (e.g. European Geostationary Navigation Overlay Service (EGNOS), mounted on satcoms) today offering greater positional information and “Safety of Live Service” for aircraft landing, but potentially applicable to other vehicles.
- 11.7 These technologies play a central and growing role in the operation of (semi-) autonomous systems, including road vehicles and deployment of military systems in-theatre (e.g. surveillance UAS operations in Afghanistan – guided via GPS; linked via satcoms).
- 11.8 UK companies have gained key roles in these technology areas. In satcoms, for example:
- Inmarsat owns and operates the satellites that not only provide reliable communication services to the world’s shipping and air fleets, but also carry in-flight elements of the EGNOS system; and
  - Airbus Defence and Space (D&S) is the prime contractor for many of the world’s communications satellites and operates the Skynet 5 fleet of satellites that provide reliable communications for Britain’s military forces worldwide
- 11.9 In the Galileo satellite navigation programme (Europe’s version of the US GPS system) the UK Government has taken a leading role in defining and managing the security aspects of the programme (including chairing the Galileo Security Accreditation Board) and UK companies lead the development of many of its critical elements of Galileo, for example:

- SSTL built the payloads for all 22 of the operational Galileo satellites and also built the complete first Galileo prototype satellite;
- CGI is providing the security facilities, such as the cryptographic key management facilities, and security services that will ensure Galileo is cyber secure;
- Airbus D&S is leading the development of the control facilities that operate the constellation of satellites.

11.10 In addition, satellite remote sensing provides key inputs to modern mapping systems and weather forecasting (of particular relevance to UAS and marine vessels).

**12. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

12.1 The path that UAS undergo towards being everyday technology is unlikely to be as uniform or predictable as for autonomous cars, given the variety of size and capabilities that different UAS have, and because they operate with less constrained physical infrastructure. The main barrier for UAS to overcome is the lack of certainty in airspace regulations and protocol, and it may be a time-consuming task for countries to establish suitable frameworks for UAS to safely operate. Nevertheless, many countries have expressed commitment to achieving this task, and recent years have seen increasing progress towards the opening up of the skies for commercial UAS, including the UK.

**13. Does the Government have an effective approach on data and cyber security in this sector?**

13.1 As with autonomous cars, there is concern about the vulnerability of UAS to cyber threats. UAS need to be protected from hacking, for example to prohibit non-authorised operators from taking control (pirating), or to prevent theft, particularly of the data being collected by the UAS, which may be personally or commercially sensitive to the operator, or representing a threat to national security when collecting aerial intelligence data. It has already been proven that UAS GPS systems can be hacked<sup>259</sup>. The proliferation of UAS use closer to people or other airspace users will need to be accompanied by the application of high standards of systems resilience, and their proper regulation. Equally, the necessary further increase in Air Traffic Management (ATM) to cope with the complexities of the integration of manned, unmanned and autonomous aircraft systems will have an increasing vulnerability to cyber-attack; indeed, there are already very significant concerns about the vulnerability of ATM systems today.

13.2 Data protection laws in the UK and at the EU level are sufficient to regulate the collection and handling of data collected by UAS. Education on the laws and their application to UAS, with enforcement where necessary, will be required.

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<sup>259</sup> [BBC \(2012\) Researchers use spoofing to 'hack' into a flying drone](#)

**14. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

- 14.1 See the Society's response to Question 11 in relation of further revisions to regulation and legislation.
- 14.2 There is likely to be a large market for UAS insurance products as the UAS sector grows. Coverage would be offered to manufacturers, owners and operators, according to the risk posed by the size, weight and use of the UAS.
- 14.3 While insurance is an important component in the protection of society, it must not replace the importance of education and making owners and operators automated and autonomous vehicles aware of their responsibilities and legal obligations regarding their vehicles and use.

**15. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

- 15.1 In the same way that commercial aviation retains human oversight despite the high levels of automation in the cockpit and on the ground in air traffic control, UAS are likely to remain under the control and oversight, and/or to be programmed by human beings in the near term. This is unlikely to raise any new ethical issues. Concerns about the civil use of UAS mainly relate to potential negative societal impacts, for example noise, privacy and safety.
- 15.2 Currently, human operators of UCAVs are subject to military and international law to ensure that the use of force is justifiable. In this situation, there is nothing unethical about the deployment of automated or semi-autonomous military UAS:

*"The remoteness of the UAV pilot is not inherently different from that of a FJ [fast jet] or attack helicopter pilot or even an army sniper. It does not follow that this remoteness results in an emotional or moral detachment from events...In short, 'drones' are no different from any other type of weapon in legal or moral terms."*<sup>260</sup>

- 15.3 However, a completely autonomous UCAV that makes its own independent target selection and weapon release decisions would represent a significant change in military hardware and require a major reappraisal of the issues of control and responsibility.
- 15.4 In the military context in particular, but with some relevance to the civil environment:

*"There remain...extraordinary challenging engineering and programming tasks in order to design autonomous systems able to operate in complex and messy operational environments. Such [autonomous] systems would have to be able to*

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<sup>260</sup> [Aerospace Magazine \(2013\) The 'drone' debate: The ethics of armed unmanned aircraft.](#) Royal Aeronautical Society, London

*apply the principle of distinction between what is a legitimate military target that can be attacked in accordance with international humanitarian law, and persons who require protection, including civilian, surrendering forces and prisoners of war.”<sup>261</sup>*

- 15.5 Away from the battlefield, and in addition to the UK’s existing Code of Conduct for the Testing of Autonomous Vehicles<sup>262</sup>, a proper set of “ethical” rules must be established and validated for the operation of autonomous vehicles, for example in situations where a vehicle is obliged to judge between its own safety or mission, its pilot, driver or passengers, and people or vehicles in its path.

**16. What does the proposed Modern Transport Bill need to deliver?**

- 16.1 The market in civil UAS is growing rapidly, driven largely by small, cost-effective and versatile systems with a variety of uses. The rate of increase in new market entrants for small systems is a reflection of their accessibility and low costs. The challenge is to further enable this early industrial base to a sustainable future where it could become the first in the world to be fully integrated into the manned aviation sector.
- 16.2 The UK has made substantial progress in this areas thanks in part to the progress so far with its regulatory framework and the pragmatic approach adopted by the UK Civil Aviation Authority (CAA). The Government must use the proposed Modern Transport Bill to set out how regulation can enable widespread public acceptance of UAS operations, how the existing base of small UAS operations can be used to enable a bigger step towards integration into controlled and unsegregated airspace and how it will take early advantage of what is happening in the civil market to accelerate the expansion of the industrial base to deliver the substantial benefits available to society and the economy.

**17. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?**

- 17.1 Autonomy is built upon a wide spectrum of underlying enabling technologies, including satellite systems and high integrity software.
- 17.2 Individuals with relevant science and technology skills continue to be in high demand and can be in short supply at times, which will undermine the development of autonomous solutions if not addressed. This is not only crucial in the design and construction of systems, but also for their maintenance and operation. Design is a particular area of concern given that the safety of autonomous systems will depend very largely on safety of operation being designed in from the start.

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<sup>261</sup> Birmingham Policy Commission (2014) *The Security Impact of Drones: Challenges and Opportunities for the UK*. University of Birmingham, Birmingham.

<sup>262</sup> Department for Transport (2015) *The Pathway to Driverless Cars: A Code of Practice for Testing*. DfT, London

17.3 British companies and universities<sup>263</sup> are at the forefront of these developments and GATEway is one of many projects in the UK in this field. However, as with all STEM subjects, continuous effort must be made to draw the younger generations into these and related fields, in particular electronics, structures, aerodynamics and propulsion.

**18. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

18.1 The industry is leading the way in increasing the levels of autonomy used in the manned aviation sector, albeit with some funding (often EU) for new technologies.

18.2 The Government has made progress in the development of a much-needed Government-wide civil UAS strategy, including commission a series of public dialogues<sup>264</sup> to provide members of the general public with information about UAS, in order to assist with the advancement of the technology and its practical application. Regrettably progress has stalled following the outcome of the EU referendum. Support for automated and autonomous technology development and industrial growth should be a feature of any future Government industrial strategy.

18.3 Upon resumption of this UAS strategy activity, the strategy should support industrial progress to maximise the socio-economic benefits of UAS application, as previously described, as well as providing an early public education programme to minimise the risk of entrenched positions, misunderstandings and over-reaction. However, the Government should not focus on a few narrow commercial applications, particularly those based on imported technology as this will not help the UK industrial base to achieve its growth potential.

18.4 The Government's strategy should recognise the role of space technology in autonomy and must continue to support the UK's leading role in the space sector as a necessary element in delivering autonomy advances. Specifically, space technology:

- Enables autonomous vehicles (cars, UAS, marine vessels);
- Contributes to the research and development of autonomy; and
- Benefits, itself, from autonomy developments in the wider economy

**19. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

19.1 The EU's main role in research, development and innovation is in defining priorities and allocating funding through the research framework programme; indeed, one of

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<sup>263</sup> Including Oxford, Cambridge, Cranfield, Leeds, Warwick and Birmingham.

<sup>264</sup> Hinton, S (2016) [Drones a public dialogue](#). Sciencewise,

the best ways to achieve impact from research activities is to collaborate on projects across international boundaries

- 19.2 The EU's research frameworks have provided an invaluable mechanism for building appropriately-funded EU-wide collaborative partnerships, encouraging projects and consortia from those targeted by national initiative, creating economies of scale and providing useful structures and links to facilitate international collaboration. EU research priorities and investment have been more stable than domestic budgets, which has helped nurture longer-term strategies that are less susceptible to short-term national political cycles.
- 19.3 The benefits of sharing in a large research programmes are considerable. Unless the UK is able to negotiate participation in EU-funded programmes, the UK will lose the multiplier effect. EU funding generates a beneficial effect in civil and general aeronautical research. The UK's recently enhanced Research and Technology (R&T) budget is far short of the EU's shared commitment.
- 19.4 The Government should avoid the creation of a situation where there is a disconnection from research networks and collaborators within the EU. The only way to have productive collaborations is for them to be funded. Collaboration with parties outside the EU is current far more difficult than inside the Union due to the variabilities and often non-aligned nature of funding. Continued collaboration with EU partners outside the Horizon 2020 Framework is unlikely to be acceptable to Member States, and involvement is likely to require freedom of movement of those engaged in the research.
- 19.5 The EU has budgeted approximately €120 billion to support research and innovation projects from 2014 to 2020, of which a proportion was destined for the UK. Between 2007 and 2013, the UK had contributed an estimated €5.4 billion to EU research and development, and had received €8.8 billion in direct funding for research, development and innovation.
- 19.6 Horizon 2020, the biggest EU Research and Innovation programme with nearly €80 billion of funding, including €83 million for robotics and autonomous systems<sup>265</sup>, available over 7 years (2014 to 2020), is aimed at supporting European economic growth and competitiveness through investment in research, removing barriers to innovation, creating a world-class science base and supporting international research collaboration.
- 19.7 Full participation in EU funding programmes would likely require full access to the Single Market and the acceptance of the freedom of movement, unless an alternative relationship can be negotiated.
- 19.8 Several countries outside the EU, including Norway, Turkey and Israel are eligible to participate in all Horizon 2020 projects as Associates, and Switzerland has more limited

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<sup>265</sup> [connect \(2014\) Horizon 2020 delivers an irresistible call to roboticists. Innovate UK.](#)

access to funding for some projects as a partial associate. The UK could pursue this relationship either through an EEA Agreement or under a bilateral arrangement but should expect to contribute financially (as Norway does<sup>266</sup>) and lose some policy-making influence.

19.9 Without specific preventative action, Brexit will lead to the UK's withdrawal from EU funded space programmes relevant to autonomous vehicles including:

- **The space element of Horizon 2020:** The UK will be unable to participate in this EU R&D funding framework;
- **Galileo:** The UK will be unable to participate in the programme itself, will lose access to specific protected features of the Galileo service that are of great interest to the autonomous vehicle community, and will lose knowledge, and influence on, evolutions of the Galileo service. The Ministry of Defence (MoD) decision to use the secure Galileo services announce in the Strategic Defence and Security Review 2015<sup>267</sup> will be compromised. The open navigation service will continue to be available to UK users;
- **Copernicus:** The UK will lose access to much of the Copernicus (surveillance from space) programme, since it is largely EU-funded; and
- **Governmental Satellite Communications (GOVSATCOM):** The UK will lose access to GOVSATCOM, space surveillance and tracking, and other EU-funded space programmes currently being defined.

26 October 2016

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<sup>266</sup> [Norway Mission to the EU: Norway's participation in EU programmes and agencies](#)

<sup>267</sup> [HM Government \(2015\) National Security Strategy and Strategic Defence and Security Review 2015: A Secure and Prosperous United Kingdom. HMG, London, paragraph 4.153.](#)

## **Royal Society for the Prevention of Accidents (RoSPA) – Written evidence (AUV0025)**

- Autonomous vehicle technology is developing rapidly and will profoundly change the way we drive.
- It offers enormous benefits, including significantly reducing road casualties, improving mobility for people unable to drive ‘normal’ cars, and reducing congestion, fuel consumption and emissions.
- However, there are also significant risks, especially during the development and gradual introduction of autonomous vehicles, including failures in the technology, drivers over-relying on the technology or not being able and ready to take over control of the vehicle when required, and data security.
- Estimates suggest driverless cars could be available from the mid-2020s. RoSPA does not believe it will be this soon, but some forms of highly autonomous vehicles may be in use during the 2020s.
- There will be a transitional period of many years during which conventional vehicles, vehicles with Advanced Driver Assistance Systems (ADAS), highly autonomous vehicles and ultimately, fully autonomous vehicles, will be sharing our roads. It will be vital that drivers understand the differences between these vehicles and that those with ADAS and highly autonomous vehicles are designed to help, but not replace, the driver.
- Thorough and ongoing reviews of driving laws and offences will be needed to keep pace with the development of autonomous vehicles.
- Most road traffic laws should continue to apply to highly autonomous vehicles but when fully autonomous vehicles that no longer need a driver to be ready to take control have been introduced, it may be feasible to relax these laws.
- A review of the driver licensing regime for autonomous vehicles will be necessary at some point
- Public education and awareness raising initiatives will be needed to ensure people develop a proper understanding of autonomous vehicles and their performance abilities and limitations.
- Regulations governing vehicle type approval standards and MOTs will need to be updated.
- The Fire and Rescue Service will need regular updates from vehicle manufacturers so they can plan what changes are needed to their equipment and procedures for responding to emergencies.

- Manufacturers will need to meet minimum security standards for data protection and cyber security.
- Victims of a collision with a vehicle that is operating in an autonomous mode should be no worse off in the level of insurance and compensation they receive than if hit by a conventional vehicle.

## **Introduction**

- 1 RoSPA's submission to the House of Lords Select Committee on Science and Technology Inquiry, "Autonomous Vehicles", has been produced following consultation with our National Road Safety Committee. Our submission focuses on the development of autonomous road vehicles.
- 2 Autonomous vehicle technology is developing rapidly and will profoundly change the way we drive. We are changing from vehicles with some autonomous functions (advanced driver assistance such as autonomous emergency braking, lane assist and blind spot monitoring) to ones that are highly, but not completely, autonomous (can operate on the road without a driver, but with normal driving controls and a driver who must remain able and ready to assume control). Ultimately these will change to vehicles that are fully autonomous (they drive themselves with the 'driver' being just another passenger who does not need to be able and ready to assume control).
- 3 It is not yet clear when people will be able to buy and use truly 'driverless' cars, although estimates have suggested it could be any time from the mid-2020s onwards. Virtually all car manufacturers are developing autonomous vehicles of one form or another, and many have estimated when they expect to have fully autonomous cars available, with their dates varying from around 2020 to 2030.
- 4 RoSPA does not believe that fully autonomous vehicles will be in use this early, but some forms of highly autonomous vehicles may be in use on certain types of roads (e.g., motorways) during the 2020s. Vehicles with advanced driver assistance systems are already available, a trend which will increase rapidly over the next few years, as the technology becomes more and more sophisticated.
- 5 There will be a transitional period, probably of many years, during which a mixture of conventional vehicles, vehicles with increasingly sophisticated Advanced Driver Assistance Systems, highly autonomous vehicles and ultimately, fully autonomous vehicles, will be sharing our roads.

## **Benefits of Autonomous Vehicles**

- 6 We are already seeing road safety benefits from driver assistance technology, such as electronic stability control, autonomous braking, lane departure warning systems, etc. RoSPA believes the further development of autonomous technology will offer enormous benefits by:

- Reducing road crashes and casualties significantly by reducing (or even eliminating) human error by drivers that contributes to a significant proportion of road crashes and casualties.
  - Improving mobility for people unable to drive conventional cars, enhancing their mobility, independence and quality of life.
  - Improving the use of road space, and reducing congestion, fuel consumption and emissions
  - Reducing insurance premiums, especially for younger drivers, due to the lower crash risk.
- 7 If autonomous vehicles live up to their promise, the Government should consider providing financial incentives at some point to encourage their take up.

### Risks of Autonomous Vehicles

- 8 However, there are also significant risks, especially during the years of development and gradual introduction, including:
- **Failures in the technology**  
For example, a recent fatal crash in the USA involved a Tesla vehicle with autonomous technology.
  - **Drivers over-relying on the technology**  
Drivers may not pay as much attention to their driving if they believe that the technology will prevent them from crashing no matter what. During this period, it must be clear to drivers that vehicles with Advanced Driver Assist Systems and highly autonomous vehicles are designed to help, but not replace, the driver.
  - **Drivers struggling to remain able and ready to take over control of the vehicle when required**  
With highly autonomous vehicles, a rarely-involved driver will be required to remain alert enough to take control of the vehicle at critical times and probably at short notice. Maintaining full concentration while the vehicle is driving itself for long periods will be very difficult; boredom, inattention and distraction will be difficult to overcome. How quickly will a driver need to react? How will they know when and how they need to take control? Will they understand the warnings given by the vehicle?
  - **Drivers becoming de-skilled during the transition period**  
As drivers become more used to the vehicles driving themselves, they may become less able to take control of the vehicle when it becomes necessary. Young drivers who start their driving career with highly autonomous vehicles may not be able to

accumulate the ability to anticipate situations when they may need to take control, or to drive the vehicle when they have taken control. They may make incorrect decisions or even panic at the moment they need to assume control.

- 9 It will be important to monitor any such problems during the development of autonomous vehicles so those identified can be designed out as soon as possible and other measures, such as modifications to road design, or driver education and training, can be identified. For example, an over-reliance on autonomous technology could increase crash risk. It is important that drivers understand that until fully autonomous vehicles are available, the technology is designed to assist the driver, but not to replace him or her.
- 10 Autonomous vehicles will be reliant on accurate GPS and speed limit data. RoSPA were pleased to hear that the Department for Transport are funding the creation of a detailed digital roadmap by Ordnance Survey.

### **Road Vehicle Regulatory Regime**

- 11 The introduction of autonomous vehicles will obviously require many changes to international, EU and UK laws, regulations and guidance. It is important to consider the implications of the regulatory reform on the use of UK autonomous vehicles overseas, and to liaise with other countries' on their approach to these issues. In due course, UK drivers will presumably wish to take their vehicles when working or holidaying overseas. Co-ordination with the devolved Governments in Scotland, Wales and Northern Ireland will also be crucial.
- 12 RoSPA believes that most existing road traffic laws and rules of the road should continue to apply to highly autonomous vehicles (ones with a driver who must remain able and ready to assume control). For example, the prohibitions on using hand-held mobile phones, drinking and driving should be retained, so that drivers are “able and ready” to assume control of the vehicle if necessary, and so they understand they must do this. There may even be a case for arguing that drivers who are not alert and ready to take control of the vehicle should face stricter penalties to emphasise the importance of the driver remaining alert. It may be feasible to relax these laws when fully autonomous vehicles that no longer need the driver to remain alert and ready to take control, have been introduced.

### **Driver Licensing, Training and Testing**

- 13 As highly and fully autonomous vehicles are developed it will be necessary to decide whether they can be driven on a normal car licence, or whether a new licence category for highly autonomous vehicles will be needed. The driving test is already being adapted to include driving vehicles with new technology through the trial the DVSA is conducting of the use of SatNavs in the test. If it becomes possible for people to take their driving test in a highly-autonomous vehicle, it may be sensible for their licence to be restricted to driving such vehicles (just as someone who passes their test in an automatic car is only licensed to drive an automatic car).

- 14 A lower licence fee for autonomous vehicles might be a useful way of encouraging their adoption. Once fully-autonomous vehicles are in use, a driving licence may not be necessary, but only when the driver is not required to drive the vehicle in any circumstances.
- 15 Therefore, a review of the driver licensing regime will be necessary at some point.
- 16 The Government has been preparing initial changes to the regulatory framework, having:
  - established that autonomous vehicles can be tested on any road in the UK
  - published a Code of Practice to help testers understand how to comply with the law
  - consulted on proposals to change regulations that could prevent the adoption of vehicles with Advanced Driver Assistance Systems and Automated Vehicle Technology as they come to market
  - helping to fund research, development, demonstration, and deployment of this technology.
- 17 Thorough and ongoing reviews of driving laws, offences and civil and criminal sanctions will be needed to keep pace with the development of autonomous vehicles.

### **Public Education**

- 18 Euro NCAP ([www.euroncap.com](http://www.euroncap.com)) conducts independent tests on cars that are more stringent than the legal minimum, so cars given a five star rating by Euro NCAP far exceed the safety requirements set by legislation. It gives higher ratings to cars with active safety systems, such as Autonomous Emergency Braking, Speed Assistance and Lane Support. This encourages manufacturers to incorporate these systems into their vehicles and helps to encourage take-up of these safer vehicles by the public and fleet buyers.
- 19 As vehicles with increasingly sophisticated technology are introduced, public education and awareness raising initiatives will be needed to help drivers understand the distinction between the different levels of autonomous technology. A crucial message is that until truly fully autonomous vehicles are available, the driver must be fully alert and ready to assume control at all times, and is legally responsible for any accidents that occur. Promotion and marketing by vehicle manufacturers and media coverage, also needs to help people develop a proper understanding of autonomous vehicles, their performance abilities and limitations, the importance of not over-relying on the technology.
- 20 For example, it is estimated that trials of HGV Platooning may begin on UK motorways within the next two to four years. Platooning will allow a number of trucks, each equipped to drive as a single body close together at a constant speed, with the lead truck setting the speed and braking of the following trucks. This would reduce fuel consumption, cost and CO<sub>2</sub> emissions, as well as improve the efficiency of traffic flows.

- 21 This technology will allow a much shorter gap between the vehicles in a platoon, because the following vehicles brake simultaneously with the lead vehicle, which reduces their stopping distance by reducing (or even eliminating) the driver's reaction time. Therefore, potentially the two-second rule for safe following distances (Rule 126 of the Highway Code) could be reduced for these vehicles.
- 22 However, it will need to be absolutely clear that this only applies to vehicles with this technology and only when they are operating in a 'platoon'. Great care should be taken to avoid creating a perception that the normal following distances for other vehicles is being changed. People will also need help to understand how they should behave towards platoons, and how they should expect the vehicles in the platoons to behave. Other drivers and motorcyclists will need specific advice on overtaking a platoon of vehicles, along with advice on entering and leaving the motorway if there is platoon of HGVs in lane one.
- 23 The Highway Code will need to be updated to provide information and advice on Advanced Driver Assistance Systems and should explain the purpose of the new technology as it is introduced and how it should be used by the driver and the risks to avoid.
- 24 Ongoing education campaigns will be needed to raise awareness of these vehicles, how they differ and how other road users should behave. This should involve central and local government, manufacturers, police, driver training bodies and road safety organisations.

### **Vehicle Roadworthiness**

- 25 It goes without saying that autonomous vehicles will need to be safe and roadworthy, and subject to maintenance regimes to keep them in good working order, which might involve (for example) compulsory software updates. Regulations governing vehicle type approval, standards and construction will need to be updated, as will regulations governing MOTs. For example, MOTs may need to include a check of whether the latest software updates have been downloaded and installed in the vehicle. Training for those who conducted MOTs will need to be updated in parallel.
- 26 The reliability of these vehicles and their technology will be crucial. If it is much more expensive to repair or replace components, people may be tempted to skimp on maintenance, which could increase the risk of malfunctions.
- 27 The Fire and Rescue Service will need information from the vehicle manufacturers so they can plan what changes are needed to their equipment and procedures for responding to emergencies (e.g., extricating people from vehicles)

### **Cyber Security**

- 28 The regulatory framework also needs to ensure that manufacturers meet minimum security standards to prevent hacking and to ensure their software downloads do not breach data protection laws. Manufacturers will need to ensure that robust cyber security measures are built into their vehicles and technology.
- 29 If there are collisions or other types of loss (such as identity theft), where the vehicle owner has not installed security updates, it may be reasonable for insurers to recover their costs from the vehicle owner. If an autonomous vehicle owner fails to follow all reasonable anti-hacking security measures, such as software updates, other victims should be compensated.
- 30 It should, of course, be a serious criminal offence to hack into an autonomous vehicle, especially where this causes a crash. Where such hacking results in serious or fatal injury, the penalties should be no less stringent than those currently available for causing death or serious injury by dangerous driving. Where the hacker can be traced, the insurer should be allowed to seek to recover the damages from them. They should also be able to recover damages from the vehicle manufacturer if they failed to incorporate sufficient and appropriate anti-hacking security features.
- 31 Any person injured in a collision caused by someone hacking an autonomous vehicle should be covered by insurance in the same way as someone injured in an accident caused by a stolen vehicle.

### **Motor Insurance**

- 32 Motor insurance rules will need to be developed for vehicles that can drive themselves. Under the current system, motorists must hold compulsory third party insurance to compensate victims of any collision, regardless of who is at fault. When victims are injured by uninsured or untraced drivers, the Motor Insurers' Bureau (MIB) steps in as the insurer of last resort. This is designed to ensure that victims of road traffic accidents are compensated fairly and quickly.
- 33 Determining liability where a driver has activated the advanced vehicle technology and disengaged from the driving task could be complex. The fault could rest with the driver (e.g., if they have failed to retake control when the system exceeded its performance limits) or with the manufacturer (e.g., product failure). RoSPA agrees with the approach recommended by the Association of British Insurers to extend compulsory motor insurance to include autonomous vehicles, rather than place product liability on the vehicle manufacturer. Where an autonomous vehicle crashes, this would provide cover for the 'not at fault' driver, passengers and external third parties.
- 34 The Government has consulted on proposals to:
  - Extend compulsory insurance requirements for automated vehicles so the owner must also ensure that there is an insurance policy in place that covers the manufacturer's product liability.

- Require compulsory product liability insurance for automated vehicles to also cover injuries to the ‘not at fault’ automated vehicle driver as well as passengers and third parties.
  - Develop a system to classify an automated vehicle so that manufacturers, insurers and consumers know which vehicles this particular insurance requirement applies to.
  - Extend the MIB’s role and the Uninsured Driver’s Agreement and Untraced Drivers Agreement to cover the new mandatory product liability insurance requirements for autonomous vehicles.
- 35 RoSPA supports these proposed changes. It is important that victims of a collision with a vehicle that is operating in an autonomous mode and in which the driver has (either correctly or mistakenly) disengaged from the driving task, are no worse off in the level of insurance and compensation they receive than they would be if hit by a conventional vehicle.
- 36 Although our response has concentrated on autonomous road vehicles, and road safety, we recognise that autonomous vehicles have potential in many other safety fields, including
- Remote, autonomous monitoring of assists, such as infrastructure checks for wind turbines or dangerous water spaces, such as weirs, or hazardous or polluted spaces.
  - Drones could help in search and rescue by locating victims and deploying rescue equipment before the rescue crew can reach the incident.
- 37 RoSPA thanks the Select Committee for the opportunity to submit evidence.

*25 October 2016*

## The Royal Society – Written evidence (AUV0052)

1. The Royal Society is the UK's national academy of science and the academy of science of the Commonwealth. It is a self-governing Fellowship of many of the world's most distinguished scientists working in academia, charities, industry and public service. The Society draws on the expertise of its Fellows and Foreign Members to provide independent and authoritative advice to UK, European and international decision makers.
2. The timing of this inquiry is welcome. As the government develops an Industrial Strategy that seeks to create an environment where new technologies are invented, developed and produced here in the UK, and has already identified driverless technology as a key area for the UK, with a Modern Transport Bill expected shortly, it is valuable to develop a better understanding of what will be needed to safely exploit autonomous vehicle technology with public confidence. A dialogue between the scientific community, policymakers and the public will be important to shape this.
3. The Society is currently working on two projects that are relevant to the Committee's inquiry into autonomous vehicles: machine learning and data governance. Machine learning technology, which allows machines to learn from data and self-improve, underpins the development of autonomous vehicles. Our Machine Learning project is investigating the potential of machine learning in the next ten years, and barriers to realising that potential. While not focusing specifically on autonomous vehicles, the project will provide insights that are relevant to all applications of machine learning.
4. In the course of our machine learning project we have engaged with experts from a range of areas where this technology may be applied, including autonomous vehicles. For example, we held a public 'ask the experts' event on driverless cars as part of our Summer Science Exhibition<sup>268</sup>. One of the project's industry roundtables also considered barriers to the use of machine learning in the transport sector<sup>269</sup>. If the Committee would like further advice about who to approach in this field for further input, we would be happy to provide this.
5. As part of the project, the Society has conducted public dialogue that has provided insights into public views about autonomous vehicles. These are set out below.
6. Technologically engaged participants could see benefits from increased efficiency on the roads, as a result of driverless cars being programmed in a similar way.
7. Participants who enjoyed driving were usually concerned that introducing driverless vehicles would reduce their freedom to carry out an activity they took pleasure in.

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<sup>268</sup> Royal Society (2016) *The journey to driverless cars* <http://blogs.royalsociety.org/in-verba/2016/07/20/the-journey-to-driverless-cars/>

<sup>269</sup> Royal Society (2016) *Machine learning in smart cities, transport and utilities* <http://blogs.royalsociety.org/in-verba/2016/10/19/machine-learning-in-smart-cities-transport-and-utilities/>

Conversely, if participants were unable to drive, they said that access to a self-driving car could be liberating.

8. Participants in our dialogues were easily able to imagine the impact of inaccuracies in the algorithms used in self-driving cars. They therefore sought assurances on: standards and safety; how this technology would work in the context of existing road infrastructure; and how the benefits of this technology could be secured for social good. Of these, safety was the main concern. Participants supported the idea of driverless vehicles, if they could be shown to be safer than human drivers. Participants also wanted driverless cars to be tested under a range of conditions (such as icy roads, heavy rain, and sudden objects appearing in their path) before being put into common usage. An effective testing ecosystem could help address some of these concerns.
9. Communications activities about automotive vehicles should seek to create a dialogue about the benefits and risks associated with these, providing space to discuss concerns and develop regulatory approaches that everyone can have confidence in. Such a forum will be increasingly important as public awareness about this technology increases, likely to be fuelled by reports of both successful applications and risks. For example the first known fatality in a car on autopilot was reported on 1 July 2016 and gained significant media attention<sup>270</sup>.
10. The Royal Society's machine learning project has sought to engage with the public from an early stage – through public dialogue sessions with Ipsos MORI and our programme of public events – with the intention of integrating the results of this engagement into the project's findings. This project will continue into 2017, making recommendations to manage the risks associated with machine learning and achieve the potential benefits, and creating space for public dialogue about this topic.
11. Access to data underpins machine learning technology, and so the development of applications including autonomous vehicles. The Society is conducting a joint project on Data Governance with the British Academy that examines new uses of data and their implications. The project will review the existing data governance landscape and explore how this may need to move forward. As our public dialogue highlighted, public confidence in regulation and governance will be key to the exploitation of technologies such as autonomous vehicles. As such, the recommendations of this project will be relevant to this inquiry.
12. In November 2015, the Society hosted a high-level conference on the subject of robotics and autonomous systems (RAS), bringing together academics, industry and policymakers. Some of the issues raised may also be relevant to the development of autonomous vehicles. These include the need to develop a skilled workforce to deliver major scientific advances; the need to have clear legal frameworks and regulatory guidelines in place to encourage development, without creating

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<sup>270</sup> <https://www.theguardian.com/technology/2016/jul/01/tesla-driver-killed-autopilot-self-driving-car-harry-potter>

regulatory hurdles that are so high they might stifle innovation and the value of employing smart procurement strategies to address the real needs of each industry sector. A report of the conference is available on our website.<sup>271</sup>

13. As our projects on Machine Learning and Data Governance progress we would be delighted to keep the Committee informed.

*26 October 2016*

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<sup>271</sup> Royal Society (2015) *Robotics and autonomous systems – visions, challenges and actions: Conference report* <https://royalsociety.org/~media/events/2015/11/robotics/Robotics%20conference%20report.pdf?la=en-GB>

## Professor James Scanlan, University of Southampton – Written evidence (AUV0030)

*Submitted by: Professor Jim Scanlan, Director of University Strategic Research Centre in Autonomous Systems, University of Southampton*

1. This submission focusses on unmanned autonomous air vehicles. I have been involved in research in autonomous air vehicles for over 15 years, and lead the University of Southampton's Strategic Research Centre in Autonomous Systems.
2. The potential market for unmanned air vehicles (UAVs) is huge, and the UK is potentially in an excellent position to benefit from this new market. However, there are both technological and regulatory issues to overcome.

### Potential applications

3. The potential applications for autonomous air vehicles are enormous, and cover a large number of sectors and interests. In trying to map out these potential applications and markets, it is helpful to consider three fundamental things which autonomous air vehicles might be able to do:
  - **Observation** – vehicles can be used to carry cameras, sensors and data-collecting devices, both to observe the ground below them and the air around them. Aerial photography is already a growing market, and this will be supplemented by detection using other sensors. Uses could range widely from agriculture to urban planning; mapping changes due to, for example, natural disasters; monitoring coastal erosion; and for leisure uses such as providing TV images of news or sporting events.
  - **Transportation** – vehicles which can be used to transport items. An example launched in Rwanda in October 2016 is Zipline, which is transporting blood products and medical supplies to remote locations which cannot quickly or easily be reached by road. Major companies are also interested in using autonomous air vehicles for more regular parcel delivery in urban areas.
  - **Interaction** – vehicles which can interact with something in the environment, such as tightening a bolt or attaching a label. There are commercial opportunities in construction, and in maintenance of structures.

### Technical challenges

4. Autonomous air vehicles are already in use today. For this market to grow and develop, such vehicles need to become:
  - **more useful** (performing tasks previously impossible or improving performance of existing tasks, such as working in a wider range of conditions);

- **cheaper**, both in terms of the investment needed to deliver a new mission and of the operating cost to perform it, reducing time and personnel required; and
  - **safer**, following routine operating procedures and subject to rigorous evidence-based risk assessments and mitigations.
5. In order to achieve this, there are technical challenges which need to be overcome which researchers at the University of Southampton and elsewhere are tackling. These challenges include:
- greater levels of **autonomy**;
  - higher **agility** and reduced turnaround time from requirement to mission;
  - better **scalability** - the exploitation of increased numbers and operational tempo of aerial robots;
  - more **capability** - vehicles that can do harder tasks in more difficult conditions; and
  - a higher level of **safety**, where more complex operations can be performed without unacceptable risk.
6. These are significant individual challenges but they also interlinked, and increasingly researchers are addressing them in large, interconnected programmes of research.

### **Regulatory issues**

7. Getting the right regulation is critical to develop both the technology itself and the commercial applications of that technology. Regulations which are too permissive could put people and property at risk, but if too restrictive they will suppress innovation and new developments.
8. In the United States, the Federal Aviation Authority is investing heavily in widespread civilian drone trials at a large number of US universities. This will ensure that future US drone legislation will be evidence based and robust.
9. In the UK, the Civil Aviation Authority is responsible for regulating the use of autonomous air vehicles. So far it has been cautious in allowing such vehicles to fly autonomously beyond the “line of sight” of an operator, and with no distinction made between urban, rural and remote regions of the UK. The Zipline technology which is now operational in Rwanda, for example, could not be used in the UK for regulatory reasons, even though it could have real benefits to remote communities in (for example) Scottish islands.
10. In Europe, the European Aviation Safety Agency (EASA) have recently proposed a Prototype European Commission Regulation on Unmanned Aircraft Operations, which is currently out for consultation. We believe that these draft regulations would have the effect of stifling the market for innovation in this area, by placing burdens on modellers and academics (the groups where much of the innovation comes from) which are completely disproportionate to the associated risks. In part that is because

the EASA risk assessment is based only on the severity of possible events but not the likelihood, and without a comparison to the current environment.

11. The UK will have to make regulatory choices over the next few years which will have a significant impact on the development of autonomous air vehicles and the industries which will use them.

*25 October 2016*

## Professor Sarah Sharples and colleagues, University of Nottingham – Written evidence (AUV0049)

*Authors: Professor Sarah Sharples, Professor Terry Moore, Professor Herve Morvan, Dr Gary Burnett, Dr Xiaolin Meng, Dr Michael Galea, and Professor Derek McAuley The University of Nottingham.*

### Impact and benefits

1. ***What are the potential applications for autonomous vehicles?***
2. The term autonomous vehicles could cover a range of instances; truly autonomous, remote operated, or even semi-autonomous. The term ‘Autonomous’ itself suggests no human involvement at all. In some applications, this state will arise eventually but there will be a number of stages, with different levels of autonomy prior to this.
3. Application could be far reaching, and we have outlined possible applications below:
  - **Air:** parcel delivery e.g. Amazon’s UAVs. Airline piloting may also be autonomous in the longer term; this is already to some extent but pilots are highly trained in order to monitor the status of the system so that they can respond to emergency situations.
  - **Maritime:** freight/container ships and shipping, especially in open waters, but more critical in narrow and busy channels such as the English channel. It is likely this application would be seen sooner due to fewer issues than some application areas, such as aviation.
  - **Public roads:** cars and buses, however, as above there will be different levels of autonomy. Truly self-driving cars will not be operational in the near future on public roads due to the challenges in the aspects of technology, policy, behaviour and business models; different levels of autonomy will be required in different settings. This will cover both consumer products such as privately owned vehicles as well as public transport such as buses, taxi’s and freight. Application in freight is where the strongest cost benefit arguments exist such as platooning of trucks.
  - **Space:** this is effectively already happening, for example, space craft that dock with the International Space Station as supply vessels.
  - **Military:** a number of applications are already utilised by the military, such as truck platooning and remotely piloted UAVs. Bomb disposal activities are currently semi-autonomous.
  - **Warehousing:** use of specific tracks for transport of goods around the warehouse.
  - **Metro and rail:** cab driving applications (to some extent again, this is already present with the Docklands Light Railway and the planned refurbishment of the Metro system in Glasgow).
  - **Ambulance services:** truly autonomous vehicles will start to play a role in emergency care; whether by design or not passengers will arrive at A&E unconscious; better that we plan for this.
  - **Precision Agriculture:** this application is already well developed and is set to expand.
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4. Looking at application to privately owned vehicles, truly empty cars with no people, or completely “hands-off”, are unlikely to be seen on public roads for 20-30 years. They will however be seen sooner in constrained environments such as pedestrianised areas or theme parks. In the next few years future application of degrees of autonomy in consumer cars will be present on public roads. ‘Drivers’ will be present but with only occasional involvement required.

**2. *What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?***

5. We envisage the key benefits to be as follows:

- Safety and efficiency or productivity; both economic and environmental – these will be key drivers across all applications. For example, practices such as platooning reduce fuel costs, automated cars are more fuel economic than manual driving. In the future where high levels of autonomy are present, this will replace the need to employ drivers or even it will allow drivers the time to undertake additional tasks. This is the same for application in freight, marine and aircraft.
- Autonomy will also stimulate the economy and therefore indirectly benefit users through the development of new products.
- Benefits may accrue from incentives or subsidies that may be offered to users to encourage uptake of the technologies e.g. subsidies for purchasing autonomous vehicles - this could provide economic benefit.

6. Disadvantages:

- Increase in unemployment as driver roles become replaced by autonomous vehicles.
- Users begin to rely on technology; complacency and over trust begins to develop. For privately owned/consumer products there is a higher potential for over reliance with users assuming 100% reliance which can result in accidents e.g. the recent Tesla incident.
- Pedestrians might also become complacent assuming that autonomous vehicles would avoid them and therefore they cross roads at any point. This raises a number of issues around the behaviour of vulnerable road users on public roads.
- Cyber security threats: the more reliant users are on these systems the more vulnerable they are especially when opening out communication between systems (connected vehicles). For example, car companies are steering away from hosting content on the cloud due to security fears.
- Safety risk to users may arise as a secondary impact due to adaptation of behaviour by others. Research exists that shows other vehicles change their behaviour in response to autonomous vehicles being on the road such as changing to shorter headways making the new norm in the traffic flow different. For example, autonomous vehicles break differently, they are highly conservative and this will unconsciously change the way that manual drivers respond.
- As noted from aircraft incidents, a problem can become a disaster when switching from autopilot to manual driving in emergencies, much more work is needed to understand this.

7. Benefit/disadvantage depending on perspective:

The role of the user will change in autonomous vehicles. They will go from being a controller of the vehicle to a monitor of the status of the vehicle. This will have implications on driver training and may necessitate new types of training.

**3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

8. Very little and the impacts will be highly distributed. For example, fully autonomous vehicles would enable elderly non-drivers to choose to live in rural areas, which could radically change housing and infrastructure demand.

**4. How much is known about public attitudes to autonomous vehicles?**

9. The UAV / Drone Industry is an excellent place to look. There has been a technological and market revolution over the past 10 to 15 years. The public and regulatory debate and response has been intense and is on-going. Research can easily include the growing body of academic work, but there is also real-world material from government regulatory authorities (FAA, CASA, CAA etc), drone industry lobby groups, drone amateur enthusiast lobby groups, Anti-drone lobby groups, legal and insurers etc. Drones are probably the autonomous vehicle system which has had one of the greatest general public space proliferation and penetration of any to emerge in recent times. Highly regulated aerospace automation in human inhabited air vehicles is ongoing, but is also the subject of heated debate within the confines of the industry

10. Outside of drones, very little accurate knowledge on public attitude exists. Lots of surveys have been published about trust and driverless cars but these are not useful for informing acceptance of a future technology. To truly understand attitudes, the public need to experience the vehicles first hand through full scale demonstrators rather than respond on a conceptual basis. Testing facilities and programmes are critical in this. The University of Nottingham has itself undertaken studies on user behaviour when commuting for a week using driverless vehicles. User behaviour changed from day one to day five to show an increase in trust. There is a concern in the academic community that surveys are not accurate and as such should not be used to influence policy or governmental decisions.

**5. What is the scale of the market opportunity for autonomous vehicles? Creating an enabling environment Research and development**

**Creating an enabling environment**

**Research and development**

**6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

11. Simulation facilities are critically important for both research and technology development. They have a very strong role in enabling researchers and companies to understand user behaviour and develop autonomous vehicles that are appropriate for use. In addition, they provide excellent training facilities as we move towards a new way

of driving – much in the same way pilots will use simulators, these will allow us to develop safe driving practices on public roads.

12. Overall, the existing facilities are adequate but there is an opportunity to supplement this through advanced simulation where you can test things that you wouldn't on public roads where it is not safe.
13. There is a concern that some demonstration facilities and initiatives are unconnected. There are a number of test facilities such as MIRA that are available alongside a number of facilities located across different universities and geographies but there is also investigation into the development of a holistic test site that may well duplicate what is already present. Some demonstrator projects exist that need to be joined up to make the most of innovations. In addition, there are rafts of European projects looking to demonstrate autonomous developments. Whilst there is breadth the lack of connectivity makes it difficult to judge the sum of these parts.
14. Again, the drone industry has significant numbers which are easy to find. There is also a good body of research in the field of Personal Air Vehicles (PAV) which will rely on automation to succeed. An excellent case study to highlight the fact that society issues far outweigh technological capability in implementing these systems.

**7. *Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?***

15. Funding for research and development is being provided though, for example, the EPSRC. Indeed, autonomous vehicles directly align to the EPSRC focus on a connected and resilient nation and there is a need for fundamental research funding; continued significant investment into bodies such as EPSRC are essential.
16. Current funding has some effectiveness. It is important however that it continues alongside the important investment in infrastructure in the UK. We note that there has been a recent agreement between the Transport Systems Catapult, the Future Cities Catapult, the Satellite Applications Catapult and the Digital Catapult to collaborate around these issues and we fully support this move.

**8. *How effective are Innovate UK and the CCAV in this area?***

17. One challenge to accessing support from Innovate UK is that there is only really one major car company in the UK that is active in research and they are not a big player when it comes to automated driving. The academic and research community needs methods to collaborate with international car companies and draw down Research and Development funding; a number have manufacturing bases in the UK but no research base.
18. We support there being a number of avenues for funding such as Innovate, CCAV and the Research Councils in order to ensure it is not all through one body such as the automotive Council and allows for inclusivity. The peer review process of IUK and EPSRC is highly valuable.

**9. *Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling? Real world operation***

**Real world problems**

**10. *Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?***

19. Changes to both types of infrastructure can be foreseen. Looking at the digital infrastructure, if autonomous vehicles use GNSS or similar there may be issues of cyber security, jamming, spoofing and issues with signal reception in built up environments. There is currently no positioning system which can provide a backup to GPS or GNSS; and cyber security is a real issue. Both Europe and the US have recently shut down a terrestrial back-up systems to GNSS (known as eLoran), although the US are set to reverse that decision. For companies such as Jaguar Land Rover, autonomous features are based on RADAR, LIDAR and cameras, but this is only a part of the provision – this may cause issues of reliability. Reliability issues come about where systems such as LIDAR and cameras may no longer operate or function as they are not able to recognise road features (e.g. deep snow, or a low sun angle and wet road with can distorts the vision of the road and impact capability). Sensors alone will not have an accurate vision so multiple digital infrastructure is needed. An ideal solution is an integrated system where GNSS is a part of the answer.

20. Changes in physical infrastructure will also be required. If fully autonomous vehicles are used by the public they may need to be running on a separate road, parallel to manual drivers resulting in challenges around the required infrastructure and the costs of this. The UK is much less prepared for this than China for example.

21. When thinking about physical infrastructure changes, different road surfaces may need to be considered due to driving style, different design of vehicles also such as lights/indicators etc and looking at the most appropriate ways of communicating the different functioning of the autonomous vehicles.

22. There are many examples from Aerospace where much of the potential for modern systems is compromised or defeated by legacy. The aviation certification system makes change slow, lead times are usually in excess of technological development cycle times for instance in mobile telephony. However, some constraints such as lack of dependability of GPS leads to more robust systems development such as ‘Sensor Fusion’ and ‘Signals of Opportunity’. In these, any and all available sources of data are used. Example, TV / radio station transmitters, may be used for position fixing when combined with accurate data base of source location and characteristic. Lidar or radar sensors can locate position of electrical power distribution networks (power lines) or roads, again referencing data base knowledge of geometry etc.

**11. *How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?***

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

23. Costs and subsidies (financial or compliance/legislative) could be a big motivator for people to have an autonomous vehicle. If, for example costs are too high for a manual car and this enabling environment may arise naturally through cost incentive e.g. due to the driving style, autonomous cars have lower emissions and stay within a safety threshold therefore lowering the insurance and tax costs.

24. Whilst not necessarily ‘enabling’ revisions to insurance will need to occur in order to take account of the following:

- a ‘danger’ algorithm.
- Liability regime that is different to manual driving.
- Premium models (if the cars no longer crash where do insurance companies make their money).

25. Legislative considerations will also need to be made, specifically with reference to understanding the status of the driver in any given state or situation. With highly automated driving there will be problems if the car doesn’t understand that status of the driver and adjust manual intervention times accordingly e.g. if the driver is sleeping it may take longer to intervene or they may have no capability to respond and take a decision/control.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence? Wider governance**

26. A number of ethical issues arise here that will influence acceptance of autonomous vehicles. For example, if a car kills one person and not another there will be considerations of how to make decisions that favour one person over another.

27. As discussed previously, in aiming to understand issues of “human judgement”, it is necessary to measure and study humans, not ask them what they would do by survey – the latter is a philosophical thought experiment, which does not provide insight into human judgement in time critical situations. So before deciding on such a philosophical definition of human judgement, we need research into what human drivers actually do in an emergency before judging algorithms.

#### **Wider governance**

**15. What does the proposed Modern Transport Bill need to deliver?**

**16. How effective is the UK’s education system in delivering people with the right skills to support the autonomous vehicles sector?**

28. Skills that we believe are needed:

- Computing
- Institute of civil engineering (infrastructure)
- HFRG ergonomics
- Engineering in general (electrical, mechanical – all fundamental technologies)
- Autonomous vehicles are alongside electrical

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

29. We will wish to maintain the EU as a major export market and so we should ensure work focusses on common standards, indeed such standards should best if internationally agreed.

30. In common with all existing EU R&D collaborative programmes under Horizon 2020, if the UK government wishes to maintain its standing internationally, replacement funding sources will be required. However, while maintaining some R&D links with the EU will be important, replacement funding should encourage more widespread collaborations. Such mechanisms are coming into place with the Global Challenges Research Fund for OECD developing nations, but mechanisms for collaboration with, for example, non-EU G20 countries.

***Other comments:***

- Change acceptance will be more challenging for older more experienced drivers. If there is an insurance break for younger drivers, they will be more accepting and engage.
- We may see a move away from cars as a product I buy to a service. Especially if the pricing system works; fewer young people are buying cars and have drivers licenses. Extension of the Boris bike model.

*25 October 2016*

**Professor Sarah Sharples, University of Nottingham, Professor Natasha Merat, University of Leeds and Andy Graham, White Willow Consulting – Oral evidence (QQ 55-62)**

Tuesday 22 November 2016

[Watch the meeting](#)

Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Neville-Jones; Lord Oxburgh; and Baroness Young of Old Scone.

Evidence Session No. 7

Heard in Public

Questions 55 - 62

**Examination of witnesses**

Professor Sarah Sharples, Associate Faculty Pro-Vice-Chancellor for Research & Knowledge Exchange, Professor of Human Factors, Faculty of Engineering, University of Nottingham; Professor Natasha Merat, Professor in Human Factors of Transport Systems, Institute for Transport Studies, University of Leeds; and Andy Graham, Director of White Willow Consulting and Founding Chair of ITS (UK) Connected Vehicles Interest Group.

**Q55 The Chairman:** On behalf of the Committee, could I welcome our three witnesses to this, the penultimate session of oral evidence on this inquiry? We are being broadcast, so I am going to ask you first if you would like to introduce yourselves for the record. If you would like to make an opening statement, please feel free to do so. Could we start with Professor Sharples?

**Professor Sarah Sharples:** Thank you. I am Professor Sarah Sharples. I am a professor of human factors at the University of Nottingham where I am also the associate pro-vice-chancellor for research and knowledge exchange in the Faculty of Engineering. I am also the immediate past president of the Chartered Institute of Ergonomics and Human Factors and a non-executive director of the Transport Systems Catapult. As an opening statement I would like to comment on the contribution I can give today. My expertise looks at the impact of automation on human performance in a range of contexts, particularly in transport. From a human factor specialism point of view we know that people respond to automation technologies in different ways and that it changes the way they behave. We need to take their cognitive capabilities into account when we design these automation technologies.

Within the role I have within the Faculty of Engineering I also oversee other groups, particularly a group led by my colleague Dr Gary Burnett, which looks at human-machine interfaces for autonomous vehicles and future vehicles generally, and

[colleagues in the faculty] work on other relevant areas, including electric power systems and positioning technologies.

**The Chairman:** Thank you very much. Professor Merat?

**Professor Natasha Merat:** Good morning. Thank you very much, first of all, for the invitation. My name is Natasha Merat, and I am a professor of human factors of transport systems at the University of Leeds Institute for Transport Studies. The institute is the biggest place for academic training and research in transport, and my work involves looking at human interaction with technology, particularly drivers in the car and pedestrians outside the car. I will say a little about what I do more specifically in answer to the next question.

**Andy Graham:** Good morning. My name is Andy Graham. I am director of a company called White Willow, but I am also the previous chair of the ITS (UK) group on connected vehicles. ITS (UK) is a group of about 150 organisations, and we are focusing on the outcomes and solutions from linking automated vehicles, roads, data and drivers together. Although we look at the technology, we are really interested in the problem we are trying to solve rather than necessarily the bits and bytes.

Wearing various other hats, I also work with the Transport Technology Forum, and I have been doing work with one of your other witnesses from the City of York Council on how we can make signals work better with data from vehicles. We note that your inquiry is into autonomous vehicles, but we believe that a lot could be done with the data from vehicles as they stand, particularly on the capacity and safety of current road networks.

- Q56** **The Chairman:** That reminds me to note that our inquiry is not just about autonomous vehicles but very much about connected vehicles, and we recognise that the government strategy is to follow two not necessarily compatible strands of development: one a leapfrog perhaps towards autonomous vehicles, but one that certainly has more credibility at the moment of connected vehicles and incremental improvements to existing technologies. In light of that, I wonder if you could each, as Professor Merat anticipated, tell us how your work relates to these activities and these policies. Perhaps Professor Merat would like to start.

**Professor Natasha Merat:** Thank you very much. My work looks at the interaction of people with automated vehicles. My background is in psychology, so a lot of my work is understanding the behaviour of people. We have used the University of Leeds driving simulator for the last 10 years or so looking at what people do in the vehicle when it is highly automated: where they look, what kind of activities they might engage in when the vehicle is effectively driving itself, how quickly they resume control of the vehicle if there is an imminent crash/potential conflict, and so on.

In the last few years I have also been looking at the interaction of pedestrians and cyclists outside such automated vehicles. The work I do is funded mostly by the European Commission and the UK Government. We have two particular projects at the moment looking at the driver inside and the pedestrians outside. We have European-funded projects where highly-automated level 4 vehicles are running

around in cities in Europe—as we have coming up in the next few months in the UK. We are asking pedestrians and cyclists what they think about these vehicles and what kind of information they want, and so on.

As part of doing more and more work in this area, I also have been involved in workshops and advisory groups for the UK, the European Commission and the US Department of Transportation. I chair a committee in Japan, the US and Europe on the potential implications of these vehicles on society and what it means for informing the driver and the public. The biggest matter for me is managing expectations. The words “driverless” and “autonomous” are very confusing and give the wrong impression to people. You might notice as I am talking that I use the word “automated” rather than “autonomous”. I looked “autonomous” up in the *Oxford Dictionary* recently and it refers to vehicles, but generally speaking it means that the system itself has control and power. We are not in that situation at the moment. I work a lot with the car manufacturers and we are talking about where we are at, where we are going and the user’s understanding of these systems. Considering that on a daily basis is a real challenge. The media et cetera talk about these systems but it is a bit of hype, to be honest.

**The Chairman:** At which level do you think these issues kick in?

**Professor Natasha Merat:** At the moment, level 2 is in some vehicles. We still have to monitor the system. The autopilot is mentioned in some vehicles, but we are still in control. There is a desire to come to level 3, but some manufacturers want to skip that and go straight to level 4, where they are then responsible. I must stress that it is very much about prototypes at the moment; it is very much about testing and deployment on a small scale rather than us, at least on the private side, being able in five years’ time to get into these vehicles and they drive us from A to B.

On the more public vehicle side, the sorts of things going on in Milton Keynes et cetera are level 4, at very low speed because you are interacting with pedestrians and cyclists in a shared space, and very much under control. There is still an operator in there. It depends who you speak to. Some of my human-factor colleagues are talking about 2075 for level 5, so I am certainly not going to be around. It very much depends on public acceptance of how these will work in our cities. That still has to be decided.

**Professor Sarah Sharples:** My perspective is slightly different in that I am interested in the fundamental concepts of human behaviour and the human factors knowledge we already have which is of specific relevance to autonomous vehicles, as well as some work that my colleagues have done particularly on autonomous vehicles, which I will explain a little.

There are a couple of notions that it is important to be aware of. The first is workload. We know that humans perform best when there is an optimal level of workload, but identifying that optimal level of workload is quite difficult. We know that human performance can suffer when we are underloaded and overloaded. One of the things that is incredibly important with autonomous vehicles is understanding the implications of the introduction of increased autonomy into the driving task, which is quite a demanding task in its current form, on the capability of humans

managing an appropriate level of workload by being able to respond to an emergency situation and to maintain vigilance and attention to the driving task.

Another concept we use in human factors and have a lot of knowledge about from other contexts—I know that in previous discussions you have looked at examples from the aviation industry—is situation awareness. Situation awareness refers to: perception—to what we can physically see or interpret from the situation; comprehension, the understanding, of the situation; and the prediction of the future state of a situation. It is used very commonly in air traffic control, for example, to predict the future position of an aircraft and to help manage aircraft. In autonomous vehicles, understanding how the introduction of these new systems will impact on driver situation awareness is incredibly important. There is work going on on how we design displays or interaction to both maintain situation awareness while a driver is driving and to enable a driver to regain situation awareness very quickly once they move from the autonomous mode to a manual mode. We know that that handover point is important.

The final thing I would note in this context is there is a lot of knowledge out there. An excellent paper was written in the 1980s on the unintended consequences of introducing automation, called *Ironies of Automation*. In this context it was work in the process control industry. Some of the notions introduced are relevant here. For example, there was interest in deskilling. If we introduce automation, do we lose the capability to maintain skills? On some of the questions that will come up later, this has relevance to the driving test and how we manage that. There are many other relevant concepts. For example, we are asking a human to monitor technology. But the technology is performing with a capability that is of a higher resolution and speed than the human's perceptual system. That is an irony, because we are asking a human to monitor something that is doing a job, theoretically, better than a human is capable of doing it.

**The Chairman:** Perhaps you could send us the reference to that paper.

**Professor Sarah Sharples:** Absolutely, yes. It is an excellent paper.

**Andy Graham:** ITS (UK) has focused on “Where do we get off the ground?” I am glad you mentioned aviation, because in some cases we are trying to build the airliner that flies the Atlantic before we have got one off the ground. We are looking at those kinds of early steps, in particular what the changes to the safety and accident rates would be from the developments in technology for human driven cars that are coming in. That could change the pattern of accidents. We cannot save accidents with highly automated vehicles if they have already been saved along the way.

We are also interested in the impacts on capacity and how we could make traffic signals better with a mix of vehicles. I think it is fairly clear from all your witnesses so far that we will not be able to stop the world. Many of the benefit calculations that we see, the headlines, assume that we can move directly to fully automated vehicles and not have cyclists or pedestrians, everything works and it never rains. When you start diving into the detail there are some quite interesting questions about the evolution and the mix of vehicles, particularly early days.

We are also interested in the way we can use data from vehicles at the moment to improve, for example, emissions. Some good work has been done on reducing the timing problems at traffic signals. You might say that reduces the emissions out of the tailpipe, but it also reduces the amount of tarmac wear. Tarmac is one of the contributors to particulates are the emissions we worry about in cities. There is a double benefit in that in taking data we may be able to make things better and improve road networks without the need for so much automation.

I have mentioned the work that we are doing to look at how we could use data within junctions in the UK without having to change much of the existing infrastructure. The ITS (UK) people I am working with are focusing on where we start from now to get to this “flying the Atlantic” target. I am very much aware of the work done on human factors, and that people are probably the biggest barrier to driverless cars that we see.

**The Chairman:** Thank you very much. We must move on.

- Q57** **Lord Mair:** My question is for Professor Sharples. You have already referred to emergency situations. I want to know a bit more about what is known about this difficult situation of handing back control from an autonomous vehicle to a human. You said in your written evidence that much more work is needed on that. Can you elaborate?

**Professor Sarah Sharples:** My colleague Dr Gary Burnett led a very small-scale study in the summer that identified some of these issues that are starting to emerge. He has worked in a driving simulator. He asked people to come into the driving simulator every day for five days and behave as if they were on their normal commute to work, which he built up as a 30-minute commute on a motorway. He told the participants that they were in a fully autonomous mode while they were driving—they engaged the fully autonomous mode after about two to three minutes—and he observed the behaviours people started to demonstrate through this time.

This very early stage small-scale study, which was done with internal funding rather than external funding, demonstrated a few things. It demonstrated, first, that people very quickly became accustomed to and began to trust the autonomous technology and started to change their behaviour. This was a slightly artificial situation. It was perhaps exaggerating; we were asking people to imagine that it was okay and acceptable for example to read your emails while driving along, and, sure enough, that is what people did. They adjusted their chairs to watch films. Very interestingly, they put their reading glasses on because they were attending to information inside the vehicle rather than outside the vehicle.

On day four, this work introduced an emergency handover request. The drivers were given a small number of seconds to take over manual control from the vehicle. The research team identified a couple of things: first, that drivers did not seem to be continually monitoring the display on the vehicle to alert them of this possibility; secondly, they panicked a bit when they found they had to take manual control and immediately focused on the control element of the driving, taking hold of the steering wheel and the accelerator, and they did not have time to take their reading

glasses off. It is a small but very relevant example of the need for a deeper understanding of the different scenarios, how long a realistic time for that handover request should be and what type of information needs to be given to people in the build-up. I know from the written evidence that there is some work at Southampton that talks about a “chatty” display. We could look at the way we design the technologies to maintain the driver’s situation awareness even while the car is an autonomous vehicle, for example.

**Lord Mair:** Can I follow that up? What you have described is very interesting, and it is essentially in a simulator.

**Professor Sarah Sharples:** Yes.

**Lord Mair:** What is your view on full-scale trials and investigating that same behaviour but in the real thing, where a vehicle is moving and again there is this hand back of control?

**Professor Sarah Sharples:** My recommendation would be that we look for a mixed-methods approach. Simulators are incredibly useful for looking at safety critical scenarios; Natasha has more expertise on this, so I will let her add to this later. They are also very good for what we call “relative validity”. If you are comparing two different set-ups and two different scenarios, a simulator is very good at distinguishing between the effects of those different scenarios on behaviour, but full-scale trials are the only way we can get that systems and situated understanding of the implementation of new technologies. As I said, I am associated with the Transport Systems Catapult, and some of the early data from the demonstration they ran a few weeks ago was very positive, for example the public attitude towards those vehicles. It is only when the public see those vehicles deployed in a real situation that we can start to understand what people might think when they see these new technologies implemented in the context they are so familiar with.

**Lord Hennessy of Nympsfield:** I am very interested in those early results, but can I come back to something Andy said? He thinks that people will be the biggest barrier to all this. You know about people’s psychology and I do not, but it seems to me that since the chariot some people have seen wheels as an extension of their personality. I would imagine that the people you used in these early trials are nice, herbivorous types; they are not boy racers. We are going to have to change human nature for this to work, are we not, on quite a grand scale?

**Lord Maxton:** We already have. My grandfather never saw a motor car.

**Professor Sarah Sharples:** Let us think about how quickly we become accustomed to technology. First, I agree with you. From past work I did as part of a digital economy funded project with the Horizon Digital Economy Research Institute, where we looked at car sharing, we found that some people were willing to engage in car sharing and others wanted their own cars. Some people love their cars; we know that. We also know that people will change their behaviour. Think about how accustomed we have become to satellite navigation devices, for example. Think about the fact that we are all so accustomed to using our tablet computers, but the iPad was only in the shops in 2010. That is a really short time ago, yet we have changed the way we work so quickly in response to these deployed technologies.

If you will forgive me, I will give another example from another context. I do not know how many of you have played Pokémon Go, but it is a game that was launched in the last few months and has absolutely changed the way humans behave in that particular environment and context. Some very nice research by some of my colleagues at Nottingham 10 years before looked at those sorts of games in a deployed context in which they put people in towns using technologies. That sort of simulated but full-scale trial identified a number of the issues that were evident when Pokémon Go as a game was deployed in real life. These full-scale trials can be very powerful at predicting how people will adapt.

One of the things that I say to my students is that humans are fallible but humans are brilliant. We know that humans are great at adapting to new situations and changing the way they work with new technologies, but we need to be aware of their capabilities and limitations when we design those technologies.

**Baroness Young of Old Scone:** Can I ask about one other issue and see whether there is any research evidence on it? There has been quite a lot of talk about the fact that we will all move quite rapidly to buying mobility services rather than owning vehicles. Your car-sharing research might cast some light on this. In some respects, for many people cars are a very convenient way of moving their life around with them.

**Professor Sarah Sharples:** Absolutely.

**Baroness Young of Old Scone:** Is there any evidence that that will be a resistance factor if we are no longer vehicle owners?

**Baroness Neville-Jones:** You mean the junk they keep in it?

**Baroness Young of Old Scone:** Yes. My horse gear never moves from the car.

**Professor Sarah Sharples:** Yes, but, again, I would use an example. Uber has absolutely transformed the taxi as a service context in the last two years. Uber is not a transport company; it is a technology company. Uber's key success is that it has thought about the human requirements: the requirement for safety—for assurance about the driver; the requirement for ease of payment and the business model, and ease of access. Human behaviour is driven by a multitude of things. One of those is convenience, some of them are safety and some of them are business models. Thinking about all those different aspects together is one of the important things. Autonomous vehicles will succeed when there is an appropriate business model and appropriate safety model and it fits our societal and behavioural needs.

**Professor Natasha Merat:** As for us liking driving, absolutely, but, as I have already mentioned, we do change our behaviour. In our research we found that it is very attractive to older people who were thinking that they might not be able to drive for much longer, and to younger people; there is real evidence now that young people do not want to spend money on a new car; they would much rather spend money on an iPad or an iPhone. They do not see the value. It is expensive, the insurance is high and you cannot park it, et cetera, et cetera. Society is already changing, hence the attraction, I guess, on the part of the manufacturers, for bringing what people will likely want in 10, 15 years' time—to sit in their vehicles and watch a video, as you say.

I love the quote from a French guy who held a TEDx event at the University of Leeds that cars will be like horses in the future; we will have these things that we will take to a place and ride around, or we might take them to the country roads and enjoy them. But for getting from A to B and it being practical mobility perhaps in 2050, we will see.

**Lord Oxburgh:** In considering the interaction between the vehicles you are describing and their surroundings—pedestrians, cyclists and other motorists—do you anticipate that they will be distinguished in some way; that there will be clear, visual signals to those outside that this has some level of autonomy or automation? Has much thought be given to this? It will influence a lot of things in vehicle design, I guess.

**Professor Natasha Merat:** Yes, they are definitely recognised as obstacles and the vehicle sensors stop before they hit them, so that is quite nice. But we are really not there yet in interaction and communication. There are some fantastic examples. Google had one, obviously, which made the news. Our CityMobil2 European project put the vehicle in a very mixed environment along the beach in Sardinia, and it cannot be busier than that. A couple of guys are chatting in the pedestrianised area, the vehicle comes along and stops because these guys are in its way, they look over and carry on chatting because in a normal situation the vehicle would be able to go past the pedestrians. It does not. Nor does it say anything. Unless there is an operator on board who can manually take the vehicle out of the way or say, “Get out of the way”, or whatever, that is where we are at the moment.

I do not know whether they were thinking about it beforehand, but in the last couple of years the manufacturers have definitely been saying, “Okay, we are in a very, very complicated situation where we will have to understand all the gestures and behaviours that pedestrians have, and there will be no car driver, so how do we now interact so that we can all work together in a mixed environment?”

**Lord Oxburgh:** My question is slightly different. How did the pedestrians know that it was safe to stand there and continue chatting?

**Professor Natasha Merat:** A good point. I do not know.

**Professor Sarah Sharples:** This issue is being looked into quite actively at the moment, because it has been raised. The first thing to note is that as pedestrians we already judge the behaviour of a vehicle before deciding to cross the road. Interestingly Volvo, I believe, has declared that it will make its more automated vehicles look the same as conventional vehicles, because it is worried that people might behave irresponsibly. I was surprised, because my instinct is that we need to give pedestrians a little more credit and allow them to make an informed judgment about the vehicle approaching.

The sort of thing that we can think about is the lighting display on the front of the vehicle. We have to remember that it is probable that an autonomous vehicle would brake more gracefully than a conventionally driven vehicle, so it might be slightly harder to detect that braking. Of course, with autonomy comes the increased use of electric vehicles, which are quieter, so we do not necessarily have the same auditory

cues to the movement either. I agree that it is an essential area where we need more research and understanding.

**Professor Natasha Merat:** May I add a couple of points?

**The Chairman:** We have a lot to get through, so I will try to press on. I am sorry.

- Q58 Baroness Neville-Jones:** My question is also about human behaviour and human reactions. A driver knows, even if they are not very good at it, that at some point they will get control handed back. I want to ask you about situations that are unanticipated and unwelcome, such as an accident. One bit of evidence we have heard is that in this world of autonomous vehicles—and I would be interested to have your comments on the other aspect of the highly automated vehicle—this will help to reduce accidents. Do you reckon that we know enough about human behaviour to make that kind of assertion with confidence? What are the considerations that lead to a conclusion of that kind, and do you agree with it?

**Andy Graham:** The accident statistics for the UK fall into two very broad groups. One is “did not look properly” in an urban area. You can see that a higher level of automation might help that. Increased sensors in human-driven vehicles that identify something you have missed might also help that. The other one, on rural roads, is loss of control: you were going too fast, you went round the bend too fast, and hit something. Again, vehicle sensors at the moment could contribute to that, and connected vehicles could tell you that round the corner there is a tractor going quite slowly. There is a lot of news at the moment about human behaviour in relation to things that already happen, such as mobile phones in cars. There have been 22 deaths associated with mobile phone use over the last few years. There are also ludicrous things such as running out of fuel and not having enough air in your tyres. More people may have been killed by having underinflated tyres than through mobile phones. There is a whole load of accidents that we will not necessarily deal with: a drunk pedestrian walking in front of a vehicle may still be hit because the automated vehicle still cannot stop quickly enough.

There are a lot of behavioural things, particularly if you look at the way the accident risk changes: it is highest when you are young and when you are old. Middle-aged people like me have had some experience of driving but we are not yet at the stage where we are a very large risk. It is in connection with young drivers and elderly drivers where perhaps the biggest benefits could come, subject to all the problems that if you do not have a driving licence and the vehicle hands back to you, what do you do? I would argue that the business case for a very high level of automation relies on not having to hand back, otherwise anyone under 17 will not be able to use this. There are lots of indications of elderly people finding this quite an attractive proposition, but if it suddenly hands back to them it might not be.

Similarly, you see lots of pictures where people are sitting enjoying a drink in these pods. What if it hands back to you? The hand back is not just about control but is a responsibility and legal area, and there is a lot of work, which I am sure you are exploring, on where accident problems might become worse with it, and equally on the sort of people we might get large benefits with. On the control side, we do not have a measure of how often it hands back. In aviation, pilots get handed back from

autopilot reasonably regularly, but those are very, very complicated systems. My car does not hand back control of the engine management system to me; it degrades automatically. We do not have a feel for whether this will be a regular event, a once in 10 years event or a once in 100 years event. That would be worth exploring, because we all see that it could be a problem but we do not know how often it will occur.

**Baroness Neville-Jones:** It sounds as though there are still a lot of unknowns.

**Andy Graham:** Absolutely. We will explore all this stuff: real people in simulation, real people in on-road trials and real people with vehicles on tracks where, if they do go wrong, the safety driver can take over. But we do not know the answers at the moment.

**Lord Hunt of Chesterton:** Andy Graham, most previous witnesses to this Committee seem to have assumed that they will drive along with plenty of space between the vehicles. A friend of mine was in Tehran and took three hours to go about two or three miles. One of the biggest practical questions is how elements of automation will lead to people behaving. We know from a mathematical point of view that waves travel along, but if you have much better connections between the cars you could reduce that. I wondered whether the primary benefits will be the movement of cars and people's behaviour in highly dense situations, which is not how most of the discussions we have been hearing about have gone.

**Andy Graham:** Indeed. To get a benefit of capacity, say for the M25, you would need to have vehicles driving closer together than they already do on the M25, which in the fast lane is already quite uncomfortable. Quite a lot of work has been done at junctions. John Polak at Imperial has shown that to get vehicles to move through junctions you may get them to perform an acceleration that might feel very uncomfortable, and human-factors people have done a lot of work looking at people being car sick. There is a big question mark here in that, in order to get this high-capacity you might be very, very close to the vehicle in front and you might feel uncomfortable accelerating and decelerating, which in a way undermines the business case, because you have your laptop out and your cappuccino but you feel uncomfortable. We do not know. There is some evidence from other areas.

On the capacity side, there is also a problem with traffic signals in urban areas. We think there is some evidence that data from vehicles could be used to set signals better. You see all these examples of vehicles firing themselves through junctions without signals, but that assumes that there are no pedestrians or cyclists. Our gains in the short term would be marginal, but once we get to a higher level of penetration there will be higher capacity. There are also benefits in that we may have fewer accidents that cause delays, and if we can get four or five people into one of these mobility pods, that is four vehicles fewer on the road.

There is another point in that a mobility pod might drive a much further distance than it did previously, because "I can now work very comfortably, so I do more vehicle miles". Again, we do not know, which is why practical real-world tests in Britain are so important.

**Lord Maxton:** To be honest, taking Lord Hennessy's question and reversing it in a sense, motor cars have only been around for a very, very, short time in human history, yet we have adapted to the regular changes. The first motor cars had to have a man walking in front of them, if I remember rightly—from my history, by the way. My grandfather never saw a motor car, my father never had to pass a driving test, and so on. To what extent is the ability of the human race to adapt very quickly to change part of the research you are doing?

**Professor Sarah Sharples:** The Transport Systems Catapult did a study that I think is of relevance here, the *Traveller Needs* study, which identified different groups of people and their different attitudes. I forget the exact phrase, but I think it was “progressive metropolites”—the people they identified who lived in urban environments, such as London, who were regular users of public transport, very much engaged with smart phones and very willing to change and respond to disruptive technologies. We talk about disruptive technologies in a positive way from a research point of view. We know that those types of people and populations are very quick to adapt to change and are driven by business models, social needs and behavioural capabilities. I would agree with you that we need to acknowledge that human behaviour will adapt quite quickly.

We need to consider whether we are therefore going to end up excluding parts of the population. It is worth remembering that not all the population has a smart phone. I come from Nottingham, which has areas of significant deprivation and significant poverty, so accessing wi-fi is still a challenge for many people who live in many parts of our urban and rural environments in the UK. Making sure that we accommodate all in the developments we are investing in is very important.

We also need to think about whether we need to make sure that currently held skills are retained. We may need to do that almost artificially. Again, thinking about the capabilities for driving—I know there is a question about the driving test, which I must not pre-empt—we need to think about how to adopt changing behaviours and how to maintain the behaviours and skills that we currently have.

- Q59** **Lord Cameron of Dillington:** First, picking up on Lord Hunt's point about traffic, in a rural market town you can always tell the people who have driven in the city, because when they come to a junction they push out into the moving traffic. Sometimes the country folk just sit there. In your automatic cars, will you have a knob that you turn up to make you slightly more aggressive or not? That is an aside.

My real question is that we are told that automated vehicles cut accident rates, as Baroness Neville-Jones has already said. We already have quite a low accident rate in the UK. I wonder whether automated vehicles are the best way of continuing our downward spiral of accidents or whether there are other methods of doing this, and whether there is anything in the psychology that you academics can work out, outside the whole automated vehicle sector, to reduce our accidents.

**Professor Natasha Merat:** They are coming, whether we like it or not. We cannot stop them now, in a way.

**The Chairman:** When you say “they are coming”, what do you mean?

**Professor Natasha Merat:** They are being developed everywhere by all manufacturers, and others as we see, so there is a desire to have these vehicles. Our responsibility is making sure that they are used appropriately. Sarah has already alluded to the fact that drivers text and do things they are not supposed to do when they are in charge of the vehicle. They sit in a traffic jam—this is anecdotal evidence; nothing has looked at that recently—they look down and look up again. Those sorts of things are dangerous and we want to avoid those. Driver distraction has been a real challenge for the last 10 years or so. There have been many ways of trying to reduce them—fines have been increasing, et cetera—but people still do that. However, it is important to make sure that these vehicles are used and deployed correctly and that we do not have unintended consequences from the vehicles and they are not used properly. You mention throughput, and we want to reduce emissions. Does that mean we are going to have more of these cars on the road, because they drive closer to each other?

On the safety side, if the systems are designed as we know how to use them, and we use them appropriately, they can be a good thing; they should be a good thing. They can do things that we cannot do: a blind spot warning, for example, or driving at night. I am starting to have that problem with glare, et cetera, and if the vehicle can identify things that I cannot with my naked eye, that is a good thing. But we have to make sure they are used properly.

**Lord Cameron of Dillington:** From what you say, it sounds as though we will have to move straight to level 5, because driver distraction is the biggest danger.

**Professor Natasha Merat:** I am sorry, but we cannot for a long time. We are not capable of doing that. The technology is not there. The sensors and cameras, et cetera, are still developing. If there is a bit of rain and the sensors get wet then they will not work. Level 5 is a long, long way away. In the meantime, we have to manage expectations and allow the driver to understand what this vehicle can and cannot do. Resumption of control is a very big question. All manufacturers want to know how long it will take for the driver to take back control. It depends very much on the situation and on the speed of the vehicle, et cetera. In the meantime, it is very important for the driver to understand when they should and should not use these systems, and when they should and should not intervene with a perfectly working system. It is a massive challenge that we are looking at very basically in driving simulators, and we are hoping to go on to the real road to look at them.

**Andy Graham:** We should not see connected and autonomous vehicles as the only solution. There is a great big toolkit of things you could do. We have young driver telematics; the sorts of cars that young drivers are getting now are far safer than the sort of cars I had when I was younger, so the trend is going down. The sorts of technologies you talk about, such as the blind spot and so on, are in human-driven cars. Lots of stuff can be done; more engineering can be done, more enforcement and more education. The key point—I have worked this out—is that you have to drive 600 million miles on a UK motorway per fatality. All of us who work in this autonomous vehicle industry have to reach that level of reliability before we make an improvement. We ought to strive to keep improving that with some of the tools we have in the knowledge that eventually another tool will come along. At the

moment, I see everyone focusing on this as a way of reducing accidents when there are many that are all small pots and we keep eating away at them one level at a time.

- Q60** **Lord Oxburgh:** The question I was going to raise follows on naturally from the discussions we have been having and that to some extent have been covered. It is the question of driving tests and what qualification one is going to look for. When I was living in the US, some states, if I remember rightly, had different driving tests for people with automatic transmission, for example, and if you only had an automatic transmission licence you were not licensed to drive a conventional vehicle with a gear change. How is this going to come into these partially automated vehicles that we are talking about? One notices among the young—I find it slightly surprising—much less interest in getting a driving licence. These are the people who perhaps want this mobility and would not be able to take back control, as we have been discussing at the moment. How do you see this going?

**Professor Natasha Merat:** One of the things we are pushing for very much is some standards with respect to the systems coming into vehicles. Each manufacturer has its own version of how these things work, how you turn it on, how you turn it off, where it will work, et cetera, and they have also accorded different things. That provides big confusion for the user. Never mind automation, if we get a relatively simple car with hardly any automation—some handbrakes are a button and some you pull up—one of the biggest challenges is the user's understanding of how these things work. For that, the car manufacturers need to work together, I think, to look at what is the best thing.

Sarah has already mentioned a loss of skills, and we have to think about the responsibility of drivers. Aviation has very, very skilled pilots who are tested regularly and have a big space, but let us bring that down to what we have as car drivers. Licensing is very simple for 14 year-olds in the US to manage to drive, and they have bigger roads, but bring that into Paris or somewhere similar and we have a big challenge. Yes, it is really important to think about how we are going to do this and whether we need training for drivers. Making it as simple as possible, I think, is the best thing, but it is a challenge.

**Professor Sarah Sharples:** There are two things that we need to think about here. There is the control task of the vehicle, and for the control task of the vehicle we need to maintain those skills and maintain the understanding that people have an appropriate level of competence through a driving test. Even with fully automated vehicles we need to build in for the contingency that the driver will need to take control.

Natasha mentioned the aviation context. Of course, pilots learn to control an aircraft, but they also have familiarisation with each model of aircraft they use. I am not suggesting that every time you buy a new car you need to have a familiarisation test, but within this conventional driving test we could consider introducing an understanding of the capabilities of those different types of vehicles. I hesitate to say this, as someone who has not done a driving test for a long time, but there is perhaps an argument that we should also be considering for people like me who

have a long time until—I think it is 70—the renewal of the driving test. It is a long time since I did my driving test, so a refresher might be useful.

**Lord Maxton:** It is 70, but you do not have to pass a driving test unless you have an accident.

**Professor Sarah Sharples:** I will make sure that I do not have an accident. Cars will change an awful lot in that period of time. We need to consider that.

Finally, we need to remember the responsibility for the interface in communicating how technology works. My first car had a choke. When you have a choke, that tells you something about how a vehicle works and how the fuel is injected into the vehicle. We are becoming more and more removed from an understanding of how the vehicle works. That affects how we interact with that vehicle. Our mental model of how the vehicle works affects our behaviour. We need to consider that a driving test would not test just control but an understanding of how a vehicle will behave.

**Baroness Neville-Jones:** You were focusing in your answer on the control of the vehicle and how it works. The other part of a driving test is understanding road conditions and, indeed, the rules that govern driving. Do you see a difficulty over maintaining that level of skill as we move into a more highly automated or autonomous world? People will not exercise those skills as often and only essentially on a periodic basis. You learn these things, but then you experience them, practise them, and so get better.

**Professor Sarah Sharples:** Yes, absolutely.

**Baroness Neville-Jones:** Is there a potential hazard there or not, in your view?

**Professor Natasha Merat:** You may already have a parking aid, for example, in your car. I listen to my parking aid and use it, but if I get into my mum's car and she does not have one I must remember to look. Even with something as simple as that, absolutely. Again, the challenge is that you do not necessarily come across critical situations that often. We are looking at remembering how to come back into the driving task, to know where to look and how to resume control before you crash, and how long it takes in different situations—definitely.

**Baroness Young of Old Scone:** You have quite rightly been sceptical about the rate at which full automation will take place. What do you think the human factors are about a mixed economy when we have some people in automated cars and others who are not?

**Professor Natasha Merat:** At the moment we can say that, on the level 2 side, there are vehicles out there that can do some of the level 2, ACC or lane-keeping or something like that, but we do not have a knowledge because we have not really done any studies out there. The European Commission is hopefully intending a large trial of level 2/level 3 cars, including in the UK, in the next year or so, and I know that the UK itself is looking at trials. We need that kind of information. There are microsimulations of what would happen with network and with different levels of automation, but we do not know enough about the human side of it and whether these systems will be used by the human. One of the things is that ACC, for example, is in the vehicle but is not necessarily picked up by drivers—they do not like it if it

beeps, or whatever. That is one of the places where we need to understand where there is a mixture of these vehicles what happens to the network and so on.

- Q61** **Lord Borwick:** You and other witnesses have said that we should have much more research into this subject. How are we going to get this research done? Who is going to pay for it and how long is it going to take? Do you think it will ever come from any of the private companies or does it have to be government sponsoring of research?

**Professor Natasha Merat:** Who is going to pay for it?

**Professor Sarah Sharples:** I do not mind answering that. In one of my other roles I sit on the EPSRC—the Engineering and Physical Sciences Research Council—strategic advisory network. This is one of the research councils that looks at the fundamental research. It is important that the research councils have sufficient funds to look at these fundamental questions. The fundamental questions are where we look at the advancing of the sensor technologies and the things covered under the digital economy programme in that research council at the moment—the interaction between what happens when we deploy these novel technologies in situations from a multidisciplinary point of view.

Innovate UK is an incredibly important actor in this context because of its role in bringing together industry, organisations such as the catapults and academia. Innovate UK has already been one of the major funders, as has EPSRC in conjunction with industry in funding research into this. Innovate UK research, both through the catapult and through fundamental research programmes, is important.

**Lord Hunt of Chesterton:** If I can follow that up, we have Innovate UK and it does the research, but perhaps 80% of cars in Britain are made in Germany. How will that work out? Will Innovate UK do all this development and Germany make even better cars? The questions of ownership and the economics of this are just as important as doing the research.

**Professor Sarah Sharples:** There is a difference between the research that is directly informing the design of vehicles and vehicle technologies—and of course when that becomes a commercial competitive advantage we should look to the car companies themselves to support that activity—and then the impact of these vehicles as part of a mixed modality transport system on UK plc. Whenever we do research for research councils, whether it is EPSRC or Innovate UK, we know that our job is to look at the appropriate outcome, from the UK perspective, of a productive, resilient, connected and healthy nation. There is a need to think about that impact on the UK as a whole, the productivity of the UK as a whole, the safety of individuals within the UK and healthiness.

- Q62** **Lord Hunt of Chesterton:** One of the ways in which we will commercialise this is through the data that comes out of this work. How do you expect that to happen?

**Andy Graham:** There are a number of companies in the UK that lead the world in using data from vehicles, and have done so for many years, so that we do not have to install sensors at the side of the road. There is a whole way of seeing that you could manage traffic much better in the future by knowing much more about where the vehicles are. There is also the point that if we are funding these projects—the

phrase “the rubber hits the road, the tyres hit the tarmac” has been used—we need to test how they work in cities, and it is very difficult for local authorities sometimes to see how to do that. Monetising all this is a big question, and the industry in the UK does not necessarily make vehicles but we make a lot of the elements inside them. A lot of the computer software, gearboxes and equipment are built by someone and branded by somebody else. If you start exploding vehicles you see—

**Lord Hunt of Chesterton:** That requires a good exchange after Brexit, does it not?

**Andy Graham:** Indeed. There is a large amount of evidence that we could make a lot of things cheaper. For example, we are building roads but we could make them better and cheaper if we knew more about who to build them for and allowed for the building in of data now. What tends to happen is we plug it in later on once it has been built. There is the opportunity to make savings for GB plc on things such as emissions and so on, and there is also the opportunity to make GDP grow.

**Professor Natasha Merat:** I have a couple of extra points to make. One is that it would be lovely if we could make the most of this. Every car company and a few countries are saying, “We are doing it first. Come and test it here”, “We are ahead of it”, et cetera. Sarah has mentioned that we want to be safe, et cetera, but we want to be happy and able to move around in our cities. These vehicles can help with that. One way is to let us have everyone come and test it and perhaps cause a lot of congestion. Instead we can think about what these vehicles can do for us as citizens. If we are happy citizens, that will be a good thing for UK plc.

On the other hand, this is the Science and Technology Committee and we are academics. We are very good in the UK at our training and in academia. The rest of the world looks at us, and we are training these people who are then creating the things in vehicles. When it comes to UK plc that is definitely one area where we could invest. It is all about computers now, and car manufacturers are not computer scientists, necessarily. There are skills being developed by our academics in Oxford, et cetera, that people are dying to get and need access to. That is really where we could benefit, I think.

**Lord Maxton:** Are other countries in front of us?

**The Chairman:** I am going to bring this session to a close because we have two Ministers waiting outside. We have had the allotted time, we have covered a lot of ground and, as I feared, we could have gone on a lot longer—you had much to tell us. If you feel there are matters you have not been able to articulate fully, please follow it up with evidence. I think you have agreed to give us a reference, Professor Sharples.

**Professor Sarah Sharples:** Yes.

**The Chairman:** We are most grateful to Professor Sharples, Professor Merat and Mr Graham for the evidence today. Thank you very much for helping us.

**Professor Sarah Sharples, University of Nottingham – Supplementary written evidence (AUV0091)**

During the oral evidence session with the Committee, I mentioned the paper, – 'Ironies of Automation'. My point here is that, whilst this was a paper that was written in the 1980s, many of the points made within it are still relevant today – particularly where we are asking people to monitor technology that is in fact capable of doing a task more quickly, or at a higher resolution than human perception, or where we are expecting people to maintain skills that they are no longer practising.

I did have two further small points that I would be grateful if you could pass onto the committee:

1. In relation to the question regarding other alternative routes to reducing the accident rate, I would note that we did not discuss the need to remember that autonomous vehicles are only one part of a multimodal transport system. If we are to look at alternative ways to reduce accidents, I would suggest that we should consider how to encourage people to take fewer journeys by car, and either use alternative transport modes, which have lower accident rates (such as rail), or reduce the number of journeys taken.
2. In relation to the question regarding data, I would note that the Horizon Digital Economy Research institute, led by the University of Nottingham ([www.horizon.ac.uk](http://www.horizon.ac.uk)) has an extensive research programme and doctoral training centre which considers issues associated with personal data in a range of contexts. A key question of relevance to data in the context of autonomous vehicles is whether the data needs to be personally identifiable at all for it to be of value to car companies or transport providers (including infrastructure managers). Many uses of relevant to HAVs, such as planning or congestion management, only need aggregated data, which will need to be suitably anonymised. If such situations are identified then the sharing of personal data may be more acceptable to users/drivers than perhaps it might be in other contexts, such as personal insurance premiums being determined on the basis of driving performance for example.

24 November 2016

## SmarterUK – Written evidence (AUV0089)

### About SmarterUK

SmarterUK is the national champion for smart infrastructure development. We bring together companies from across the smart infrastructure value chain. Our vision is to connect parts of the UK economy on the cusp of the 'smart' revolution. In doing so, we hope to drive the uptake of solutions that will deliver a sustainable, low carbon transition that provides value to UK Plc and its citizens.

SmarterUK is a techUK initiative. techUK is the UK's leading technology trade association, representing more than 900 companies which collectively employ approximately 800,000 people, about half of all tech sector jobs in the UK. These companies range from leading FTSE 100 companies to new innovative start-ups. The majority of our members are small and medium-sized businesses.

### Executive Summary

SmarterUK welcomes the opportunity to respond to the House of Lords Science and Technology Committee inquiry into Autonomous Vehicles.

It is correct to identify the difference between Connected Vehicles and Autonomous Vehicles (CAVs). The two are not necessarily the same, nor even reliant on each other. However, it is the combination of the two technologies that are likely to unlock the full potential of both. This response will generally therefore refer to Connected and Autonomous Vehicles. We will be explicit where we will deal with either technology in isolation.

The UK has the potential to become a world leader in developing, producing and deploying CAVs. Major economic benefits come with higher levels of connectivity and autonomy. With almost 90% of new car sales expected to be connected by 2020, the SMMT estimate that CAVs will deliver a £51 billion<sup>272</sup> boost to the economy, creating 320,000 additional jobs, and reducing serious road traffic accidents by more than 25,000 a year by 2030.<sup>273</sup> The increased safety that will be a key feature of CAVs will also have a positive economic impact. Globally, the economic cost of crashes is estimated to range from 1% of GNP (low income countries) to 2% of GNP (high income countries).<sup>274</sup>

The deployment of autonomous vehicles will also lead to shift in how we view public and private transport. Not only will it enable greater mobility for those groups within society who currently have limited options; such as children, the elderly, and the disabled, increasing the welfare of these demographics; but it will also lead to a shift in business and delivery models, with citizens, particularly in urban areas, moving towards ownership models driven by the sharing economy (i.e Mobility-As-A-Service).

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<sup>272</sup> KPMG 2015

<sup>273</sup> <http://www.smmt.co.uk/2015/03/connected-and-autonomous-vehicles-the-uk-economic-opportunity>

<sup>274</sup> [World Report on Road Traffic Injury Prevention](#), WHO Report (2004)

These new business models offer opportunities for more intelligent, reactive transport, supporting better transport planning within cities, reducing congestion and subsequently improving air quality. They also offer the opportunity for increased deployment of electric vehicles with individual costs reduced through shared access ownership models. The increased deployment of electric vehicles also opens up new models of energy supply/demand with vehicles offering power storage capacity.

These opportunities will however bring with them known and emerging new challenges that can only be mediated and shaped with Government, wider society and industry working together to address them.

A comprehensive and stringent testing environment is of critical importance. It will serve to ensure both that CAVs are as safe as possible, including from cyber-attack where an end-to-end systems approach needs to be taken to minimise and protect attack vectors to critical systems, and to build the public's trust in them, without which the UK market will stall.

Surveys on public attitudes to autonomous vehicles are generally positive, with 71.8% believing that they would have a positive impact on everyday commuting, and a quarter believing that the biggest advantage will be fewer accidents<sup>275</sup>. However there are a number of deep-seated reservations related to unwillingness to give up control, and the ability of autonomous vehicles to integrate into the 'social space' that is the road.

The UK road network also has deficiencies in the connectivity and general infrastructure required to support both autonomous vehicles and driving. Significant differences between rural and urban areas, including the availability of data, will impact the availability of services and potentially limit the effectiveness of vehicles. More needs to be done to understand the impact of these differences and appropriate action must be taken early to address challenges.

Government will need to address these issues alongside promoting policy and regulatory regimes that keep pace with technological development. It is important however that at this time the UK does not move too quickly to introduce legal or legislative requirements on an industry and sector that is very nascent and developing.

## **SmarterUK's Response to the Committee's Areas of Interest**

### **Impacts and benefits**

#### **1. What are the potential applications for autonomous vehicles?**

1.1 There are a variety of applications for autonomous vehicles. Sectors which stand to benefit considerably from deployment are

- public transport,
- private motoring and mobility
- logistics,

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<sup>275</sup> Imperial College, [Fewer road accidents biggest benefit of driverless cars](#), June 2016

- agriculture,
- and in manufacturing.

These benefits also apply equally to connected vehicles.

## **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

### *Advantages*

2.1 The deployment of autonomous vehicles will lead to shift in how we view public and private transport. Not only will it enable greater mobility for those groups within society who currently have limited options; such as children, the elderly, and the disabled, increasing the welfare of these demographics; but it will also lead to a shift in business and delivery models, with citizens, particularly in urban areas, moving towards ownership models driven by the sharing economy (i.e Mobility-As-A-Service).

2.2 These new business models offer opportunities for more intelligent, reactive transport, supporting better transport planning within cities, reducing congestion and subsequently improving air quality. They also offer the opportunity for increased deployment of electric vehicles with individual costs reduced through shared access ownership models. The increased deployment of electric vehicles also opens up new models of energy supply/demand with vehicles offering power storage capacity.

2.3 It is expected that autonomous vehicles will contribute to enhanced productivity. This includes industrial productivity through enhanced energy efficiency and just in time delivery through to professional productivity with people freed from having to control the vehicle using time in transit for other tasks. It was estimated that in 2015 £4.5 billion was lost in lost working hours due to congestion.<sup>276</sup>

2.4 Autonomous vehicles will also offer enhanced safety for road users, minimising the instance of car accidents resulting from human error. Driver error is believed to be the main reason behind over 90% of all crashes.<sup>277</sup> In 2014 44% of road accidents in the UK were caused by a failure to look properly.<sup>278</sup> Government backed policies such as Sweden's [Vision Zero](#),<sup>279</sup> and the introduction of increasing automation through Advanced Driver Assistance Systems (ADAS) have already gone some way in minimising road traffic accidents, and it is anticipated that as we move towards full deployment and level 4 and 5 automation<sup>280</sup> there will be further decreases. The SMMT estimate that CAV's will reduce serious road traffic accidents by more than 25,000 a year by 2030.<sup>281</sup> Increased safety will also have a positive

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[https://www.lexautolease.co.uk/assets/Lex%20Autolease%20Report%20on%20Motoring%202015\\_Interactive.pdf](https://www.lexautolease.co.uk/assets/Lex%20Autolease%20Report%20on%20Motoring%202015_Interactive.pdf)

<sup>277</sup> <http://deepblue.lib.umich.edu/handle/2027.42/64993>

<sup>278</sup> [https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/463043/rrcgb2014-02.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/463043/rrcgb2014-02.pdf)

<sup>279</sup> <http://www.visionzeroinitiative.com/>

<sup>280</sup> [http://www.sae.org/misc/pdfs/automated\\_driving.pdf](http://www.sae.org/misc/pdfs/automated_driving.pdf)

<sup>281</sup> <http://www.smmt.co.uk/2015/03/connected-and-autonomous-vehicles-the-uk-economic-opportunity>

economic impact. Globally, the economic cost of crashes is estimated to range from 1% of GNP (low income countries) to 2% of GNP (high income countries).<sup>282</sup>

2.5 This increased safety, added to increased intelligence CAV's will provide will impact the insurance industry. Allowing for better assessment of risk and as such leading to real-time insurance, which can lead to overall lower premiums for customers.

#### *Disadvantages*

2.6 A possible disadvantage of autonomous vehicles, particularly during initial rollout, will be related to skills. Current licence conditions will need to be adjusted to account for different levels of driving ability, similar to current procedures for manual and automatic vehicles. Until we reach level 5 autonomy, drivers will still need to be able to take control of the vehicle in certain situations. This will require drivers to have both traditional skills, in addition to the new skills needed to drive in an autonomous world.

2.7 Currently CAV technology is a luxury and with 15-year churn rates there is a risk that some people will be left out until new models of ownership fully take hold and/or mechanisms are put in place to support those who cannot afford to upgrade to newer, smarter vehicles. To achieve this, there will also need to be consistency amongst manufacturers, ensuring that a minimum level of automation is available to all.

2.8 During initial rollout there is a risk of adding a layer of complexity that doesn't currently exist. By integrating autonomous vehicles into the 'social space' of the road, road users will need to navigate different types of vehicles, which may react differently. From a risk perspective a long term car mix of semi-autonomous, fully autonomous and legacy 'dumb' vehicles will lead to new types of danger. Non-autonomous vehicles with their human intuitive element will remain unpredictable compared to autonomous vehicles.

2.9 A further disadvantage of CAVs relates to increased cyber security vulnerabilities. However by addressing these security risks during initial development and ensuring due-diligence during system integration and upgrades these vulnerabilities can be minimised. An opportunity now exists for future technology installations to learn from prior mistakes, such as those experienced with blue tooth infotainment systems, as well as take advantage of new solutions such as satellite communications, which can play an important role in the connectivity and autonomy of intelligent cars with software updates and machine-to-machine (M2M) communications.

2.10 Finally it must be acknowledged that the deployment of autonomous vehicles will result in job losses for those who are currently engaged in roles that are linked to vehicle ownership and use. This will arise not only from changes in how vehicles are operated but also from a potentially reduced number of vehicles on the road. This will include those employed in logistics, public transport, manufacturing and related services such as MOT servicing.

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<sup>282</sup> World Report on Road Traffic Injury Prevention, World Health Organisation at 2 (2004), <http://apps.who.int/iris/bitstream/10665/42925/1/9241591315.pdf>, WHO Report.

2.11 The challenge in any area that is disrupted by technology is how to mitigate the impact of job losses. This needs to be focused on retraining and where appropriate up-skilling. But just as the past 150 years have seen incredible leaps in technology and disruption the overwhelming evidence points to innovation creating far more jobs than they destroy<sup>283</sup>.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

3.1 The impact of Connected and Autonomous Vehicles (CAVs) is hard to fully understand. They are likely to revolutionise our concept of mobility. Its impact on the automotive industry, in particular, will be significant. Jobs and growth will abound. With almost 90% of new cars expected to be connected by 2020, the SMMT estimate that CAVs will deliver a £51 billion boost to the economy, creating 320,000 additional jobs, and reducing serious road traffic accidents by more than 25,000 a year by 2030<sup>284</sup>. Most of these benefits accrue from the increases to productivity accrued by users who experience a step-change in the ease at which they can travel.

3.2 However, they will also have a disruptive impact across a range of sectors as diverse as agriculture, enterprise, social care, insurance, public transport, and the structure of cities, if consumer adoption of Mobility-As-A-Service results in greater utilisation of vehicles and a reduced need for parking outside offices or shopping and entertainment facilities. More needs to be done to understand the negative impact autonomous vehicles and accompany service models will have on those whose employment is linked to current forms of vehicle ownership and use.

3.3 To look at agriculture, connected tractors – linked to the cloud-enabled data analytics and GPS controlled – could be a significant stepping stone to a smart agriculture revolution. Even on their own they can help reduce fuel costs and soil erosion and increase yields, leading to over £1500 annual savings for the average UK farm<sup>285</sup>. In the longer term automation may lead to changes in the efficiency and operating models of other industries – for instance automated freight could change the delivery methods and systems of retailing. In a city such as London scheduled deliveries may be shifted to night-time as a means of reducing congestion and fuel costs, which would have a knock on impact for a 24-hour service economy. Autonomous vehicles also offer an opportunity for high-risk industries such as mining where companies, who in the face of falling commodity prices, are looking for ways to dramatically reduce overheads costs whilst still maintaining site safety and integrity.

### **4. How much is known about public attitudes to autonomous vehicles?**

4.1 Surveys on the public's attitudes to autonomous vehicles are generally positive, with 71.8% believing that they would have a positive impact on everyday commuting, and a quarter believing that the biggest advantage will be fewer accidents.<sup>286</sup>

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<sup>283</sup> <https://www2.deloitte.com/uk/en/pages/finance/articles/technology-and-people.html>

<sup>284</sup> KPMG, [Connected and Autonomous Vehicles – The UK Economic Opportunity](#), March 2015

<sup>285</sup> Nesta, [Precision Agriculture](#), October 2015

<sup>286</sup> Imperial College, [Fewer road accidents biggest benefit of driverless cars](#), June 2016

4.2 Research has however identified a number of deep-seated reservations related to unwillingness to give up control, and the ability of autonomous vehicles to integrate into the ‘social space’ that is the road. 34% of road users agreed that they did not like the idea of mixing human drivers and autonomous vehicles.

4.3 Research has also shown a correlation between ‘driving sociability’ and ‘openness to autonomous vehicles’. Those road users who were more cooperative were less open to autonomous vehicles, whilst 64% of combative road users were more comfortable with the technology.<sup>287</sup>

4.4 As with any technology development it is critically important to build and retain public trust in it in order to drive widespread adoption. Focusing simply on the benefits of increased safety, lifestyle enhancements or economic efficiencies will not give autonomous vehicles the required traction unless they fit within the public’s idea of what they should be like to drive on. That is why we support the inclusion of work around public attitude into UK pilots in London, Coventry, Greenwich and Milton Keynes.

## **5. What is the scale of the market opportunity for autonomous vehicles?**

5.1 The market opportunity for autonomous vehicles in the UK is significant, with a variety of applications providing benefit across the economy. It is likely that the market for autonomous vehicles will develop in two phases with enterprise applications being realised ahead of consumer. In addition there will be levels of scale within each market. Deployment will be driven by a variety of needs such as efficiency, cost savings, and enhanced service delivery. In addition the environment in which the vehicles are deployed will have an impact on timing. There is added complexity to deployment on public highways meaning applications where vehicles are using private roads within confined tracks/purposes such as within factory grounds are already in use.

5.2 There remains however a need to invest in infrastructure and the additional services, which will provide the future of driving tomorrow – both in a consumer and commercial sense. The insurance and legal industries will also need to have time to respond, adjusting, for example, approaches to liability to fit new classifications of driver or product liability. Given the additional role of software in this ecosystem clarity is needed for all parties on who is liable for what, and when. Including when, if at all, third party actions void liabilities.

5.3 Further an overhaul of how OEMs, suppliers, and technology companies operate, separately and together, within the emerging business ecosystem will be key. Companies will need to reassess the strategies they use to create value, the capabilities needed to carry out those strategies, and even the corporate cultures that underpinned their traditional, pre-digital ways of doing business. Without this we will not have the pioneers to drive the sector forward.

5.4 There is a need for OEMs and industry, particularly insurers, to come together under common standards for data access, usage and security.

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<sup>287</sup> London School of Economics and Goodyear, [Think Good Mobility Survey](#), 2016

## Creating an enabling environment

### *Research and development*

#### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

6.1 The UK has a good market for the testing of CAV systems with projects looking at connectivity, automated performance, interoperability<sup>288</sup> and real world testing.<sup>289</sup> In addition facilities such as those at Warwick enable the testing of real-world robustness and usability of any vehicle or prototype.

6.2 Technology neutrality is important in ensuring innovation so it is imperative that a variety of different connectivity solutions are tested. Currently the European Commission strongly promotes a hybrid connectivity model (cellular + [ITS-G5](#)) which industry are looking at especially for safety related use cases. Ideally it would be very beneficial for industry if the facilities allowed testing of the ITS service(s) with different radio access technologies running in parallel. This approach would allow industry to compare their performance, validating theoretical simulation results. It could also allow the testing of novel services which will require a hybrid based approach in the future.

6.3 It is also important that the facilities enable the testing of additional connectivity options such as satellite-based networks. Satellite-based communications can help reduce the attack surface, minimising the number of 'entry points' and 'exit points' and enhancing system integrity. When these systems are attacked they also offer a global and unified response which can be seen as attractive to automotive companies. Further benefits of satellite communications include global coverage, which is fundamental to achieve truly pan-European services. Immediate full coverage, which combined with a complementary ground network ensures vehicles are connected everywhere. Additionally, it means that a larger users' base can immediately access the service, ensuring a better market penetration.

6.4 To build consumer trust it is important that vehicle systems are robust and vulnerabilities to cyber-attack or system failures are limited. In addition to testing which looks at the use of vehicles on roads sufficient focus must also be placed on testing security and developing minimum standards.

6.5 A further consideration for Government when planning future demonstrations should be an understanding of how vehicles are driven within the UK. This includes an assessment of the impact vehicles will have on mobility in rural areas. Currently testing is focused on urban centres, despite a significant proportion of miles being driven outside of these areas.<sup>290</sup> To fully realise Government's ambition significant investment in rural infrastructure will be key. More needs to be done to fully understand the requirements and business models however.

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<sup>288</sup> Facilities such as those operated by Millbrook and Hiroba Mira

<sup>289</sup> [LUTZ Pathfinder](#), [Volvo's Drive Me London](#)

<sup>290</sup> Road Traffic Estimate: Great Britain 2015

[https://www.gov.uk/Government/uploads/system/uploads/attachment\\_data/file/524261/annual-road-traffic-estimates-2015.pdf](https://www.gov.uk/Government/uploads/system/uploads/attachment_data/file/524261/annual-road-traffic-estimates-2015.pdf)

As stated in the Exec summary, the connected and autonomous aspects of vehicles are not necessarily dependant on each other but without the connected element an autonomous vehicle in an area of poor coverage would presumably have restricted services. Current testing does not sufficiently analyse how infrastructure should be built and who pays the bill.

6.6 Finally testing needs to keep pace with technology development, in particularly AI and related ethics development work. These will be fundamental to ensuring we can actually deliver and deploy autonomous vehicles.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

7.1 No answer.

**8. How effective are Innovate UK and the CCAV in this area?**

8.1 InnovateUK and CCAV have been an important contributor to the success of the UK so far in developing a market for CAV technologies. CCAV have been fundamental to shaping the environment within which we view autonomous vehicles, publishing a number of documents that have moulded the regulatory and market discussion. InnovateUK and related catapults have played an important role in building R&D capacity, supporting innovation not just in technology but also in standards.<sup>291</sup>

8.2 However there is a risk that pilots and projects currently underway in the UK may not join up. InnovateUK will need to understand how projects like those in Milton Keynes and Greenwich link up, not just together, but also with those undertaken by private consortiums to ensure that what is being demonstrated can actually be scaled up. As projects are still in their early days this is hard to capture however it will be fundamental to ensuring long-term success and growth.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

9.1 More could be done to support start-ups and SME's within the market. The creation of accelerators targeting specific sectors, similar to Cylon, could help grow and develop the CAV ecosystem. Creating an effective market of companies with sufficient expertise to drive the agenda forward.

***Real world operation***

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

10.1 It is expected that autonomous vehicles won't need to be connected all of the time in order to operate safely, but they will still have connectivity requirements which will challenge the current coverage on UK roads where, even major roads maintained by Highways England.

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<sup>291</sup> BSI CAV Standards Scoping Project

10.2 Government and industry must work together to utilise existing assets to increase this coverage to ensure that connected and autonomous vehicles deliver their full benefits to users. This is a complicated area but will likely require a mix of technologies.

10.3 See also answer to question 3.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

11.1 To support a move from current levels of autonomy to extensive deployment, Government needs to undertake continuous review of the regulatory framework, ensuring change keeps pace with the technology, as well as enabling and accelerating underlying support infrastructure such as Smart Highways and Smart cities.

11.2 A UK Standards body should govern a rolling programme reviewing standards and regulation in line with international developments. This should feed into updates of the Modern Transport Bill

11.3 Universally agreed minimum and maximum technical requirements for different levels of advanced driver assistance systems and automated driving systems. Alongside universally agreed and easily understood consumer-friendly definitions will encourage a smoother transition to extensive deployment.

11.4 As mentioned elsewhere in this submission there is a need to update driving test protocols to reflect the different skills required for different level of automation. Managing this at an early stage will be important in ensuring vehicles can actually be used by the general public.

11.5 Geo-fencing deployment of autonomous vehicles with controlled “meshing” with less technological advanced vehicles over defined timelines, alongside future restrictions of certain roadways to fully autonomous vehicles only, will support a rollout which manages the complex interaction of ‘dumb’ and ‘smart’ vehicles in the same space.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

12.1 There is more that the Government could do to enhance the automotive sectors approach to data and cyber security. Given the number of companies involved in the supply chain, some of which have no current engagement with data and security, a coordinated approach that takes account of minimum standards is important.

12.2 Government will also need to support the supply chain in understanding the implications of CAV technology for data protection, clearly addressing complex questions around what is classed as personal data and where liability sits. Current regimes are not mature enough to deal with the increasing intelligence of vehicles nor can they handle the new ownership models that are expected to grow. CCAV should focus significant attention to dealing with these issues now; ensuring regimes keep pace with technology development.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

13.1 The EU has issued the Intelligent Transport System (ITS) Action Plan and an ITS Directive. These documents call for European-wide deployment before 2017, and national implementation preparations have already started. In enabling the environment for autonomous vehicles significant work will need to be undertaken to modernise supporting frameworks, policy and regulations.

13.2 Government should continue its full review of all regulation and legislation in relation to all vehicles, including commercial, consumer, private and public use.

13.3 See also answer to question 15.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

14.1 One element of autonomous vehicles worth further research is the public expectations of the ethics of the Artificial Intelligence software in charge of the vehicles. Particularly in relation to how autonomous vehicles interact with other road users and pedestrians, including accident avoidance strategies. There is a need for universal standardisation in dealing with these complex questions and concerns, allowing industry and stakeholder to grapple with aim towards a solution.

14.2 techUK's Big Data, Cloud and Mobile programme is currently looking into the subject of AI and ethics.

***Wider governance***

**15. What does the proposed Modern Transport Bill need to deliver?**

15.1 It will be important for the Modern Transport Bill to deliver appropriate legislation to support not just the testing of CAVs but to deliver deployment. This includes a full overhaul of related policy and regulation including a review of insurance protocols, clarification of civil and criminal liabilities, revisions to the Highway Code and a review of how the existing regulatory framework may be developed to ensure automated vehicle technologies are protected from possible cyber threats.

15.2 New rules related to how software is maintained and repaired are also needed. Malfunctions which arise due to outdated software cause significant risk and can affect questions of liability. There is a need for the Bill to address this question determining who bears ultimate responsibility for upgrades and within which parameters. It is unrealistic to expect consumers to bear full responsibility.

15.3 Further adjustments to DVLA protocols related to licensing will also be needed. This will be important as we move toward level 4 and 5 automation, providing clarity people's rights to drive different types of vehicle.

15.4 The Bill should look to support wider Government actions around machine learning and data ethics. This is in regard to both situations where AI will need to make a proactive decision during an emergency situation (ie a trolley scenario) and in the more general sense of what data can and cannot be used for. At this time the UK must be careful not to move too quickly to introduce legal or legislative requirements on an industry and sector that is very nascent and developing.

15.5 Clarity around data and data ownership will be fundamental. Not only is this important for the market to understand new liabilities but it will be central to the offering of new services within insurance (data stored in apps can be used in the event of an accident) and infrastructure (real time city, environment and transport data can be shared to improve journey decision making). Data underpins the whole concept of autonomous vehicles and the goal for policy-makers and industry alike must be for a secure, widely-accepted and trusted legal framework for data privacy that allows for business innovation in these emerging fields while ensuring a culture of data confidence.

15.6 Any new legislation proposed in the Bill must work to drive forward economic and social opportunities, whilst ensuring that we don't cocoon ourselves from wider European and global markets. The nature of the automotive industry and vehicle use means any and all advancements will need to account for cross-border implications.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

16.1 As we move towards an increasingly digital economy it will be important that the digital skills gap is addressed. This includes addressing not just basic education within schools, but also across workplaces and into advanced technical roles with high digital intensity.

16.2 In July 2015, techUK published a paper *We're Just Not Doing Enough – Working Together to meet the Digital Skills Challenge*<sup>292</sup> which focused on what needs to be done to deliver the digital skills children and young people need in a digital world.

16.3 In October 2016, techUK published a paper *The UK's Big Data Future: Mind the Gap*<sup>293</sup> which focused on how to combat the current lack of big data and data analytics skills.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

17.1 There is potential for government to look further at how improved safety and convenience applications extend beyond driver and passenger to vulnerable road users such as pedestrians cyclists and motorcyclists. More can also be done to understand how personal connected devices can be leveraged to provide additional benefits in the broader CAV ecosystem.

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<sup>292</sup> *We're Just Not Doing Enough: Working together to meet the digital skills challenge*, techUK (2015) <http://www.techuk.org/insights/news/item/5088-techuk-calls-for-national-digital-skills-map-to-stop-the-uk-falling-behind>

<sup>293</sup> The UK's Big Data Future: Mind the Gap, techUK (2016) <http://www.techuk.org/insights/reports/item/9469-the-uk-s-big-data-future-mind-the-gap>

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

18.1 The UK Government needs to continue to manage expectations and reassure European partners that the UK is still open for business and will continue to engage collaboratively to deliver solutions which will engage cross-border. By signifying a commitment to innovation through legislation and funding as well as taking the lead on standards work the UK can address negative perceptions and protect the sector going forward.

*4 November 2016*

## **Mr James Sneath– Written evidence (AUV0005)**

### **1. What are the potential applications for autonomous vehicles?**

Many people have sight disabilities, physical disabilities, mental disabilities or other health problems which makes it unsafe for them to drive. A self driving autonomous vehicle would give them the same mobility freedoms enjoyed by drivers without these disabilities.

Modern cars are becoming lighter and less suitable for towing larger and heavier caravans which many caravan users want. A self driving autonomous motorised caravan that follows a “tow vehicle” using a guide bar would have the following advantages:

- a. A self driving autonomous motorised caravan could have a normal van size wheelbase. This would eliminate stability problems and reversing problems of single axel caravans, conventional twin axle caravans and fifth wheel caravans.
- b. Any size of car could safely tow any size of self driving autonomous motorised caravan.
- c. A self driving autonomous motorised caravan would be much cheaper to buy and run than a conventional motorhome offering similar interior space.
- d. A self driving autonomous motorised caravan is a relatively simple application of autonomous vehicle technology. A conventional car driven before it would add to the public perception of safety. These two factors make the self driving autonomous motorised caravan an ideal candidate for a pilot study or introductory launch of autonomous vehicles on UK public roads.

### **13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

The caravan body length limit for standard touring caravan is 7 metres. This limit results in limited kitchen space, short bed lengths, beds with corners cut off and poor night-time toilet access. An increase in caravan body length limit for self driving autonomous motorised caravans to 8 or 9 metres can solve these space problems.

*19 September 2016*

## **Society of Motor Manufacturers & Traders (SMMT) – Written evidence (AUV0058)**

### **INTRODUCTION**

1. The automotive sector is quickly changing. The innovative use of new technologies is revolutionising vehicle design and manufacture, and fundamentally changing the driving experience. At the heart of this change is the use of digital technologies to create vehicles that are more connected, via the internet, and increasingly autonomous.
2. The development of Connected and Autonomous Vehicles (CAVs) could have a significant and positive impact, not only on the automotive sector but on society as a whole. Unlocking this potential requires government, the automotive sector and adjacent industries such as telecoms and the tech sector, to work together. The government's current commitment to the development and roll-out of CAVs, as demonstrated by the creation of the Centre for Connected and Autonomous Vehicles (CCAV) and its commitment to spend £100 million on research and development related to CAVs, is welcome. Going forward, the government must work with industry to address legal and regulatory challenges which could undermine the development and roll-out of CAVs in the UK.
3. The Society of Motor Manufacturers and Traders is one of the largest trade associations in the UK representing more than 650 automotive companies in the UK, including international manufacturers and companies throughout the supply chain. SMMT is taking an active role in the CAV agenda. In March 2015, SMMT published a major report on the economic opportunities presented by CAVs<sup>294</sup> and, through the SMMT CAV Forum, we lead cross-sector discussions on CAVs bringing automotive, telecom, the tech sector and government together. SMMT welcomes the opportunity to input into this inquiry.

### **IMPACTS AND BENEFITS**

***Q1. What are the potential applications for autonomous vehicles?***

***Q2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?***

4. The most commonly understood application of autonomous vehicle technology is in an individual's car. There is already a staggering level of connectivity and autonomy in vehicles on the road today. Autonomous emergency braking and lane assist technologies allow for safer driving, while internet connectivity over mobile networks provides critical real time information on road and weather conditions.

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<sup>294</sup> *Connected and Autonomous Vehicles - The UK Economic Opportunity* - <http://www.smmt.co.uk/wp-content/uploads/sites/2/CRT036586F-Connected-and-Autonomous-Vehicles-%E2%80%93-The-UK-Economic-Opportu...1.pdf>

5. However, autonomous technology can be applied more widely than this. Recent "platooning" trials have demonstrated that the delivery of freight by road could be revolutionised through the introduction of connectivity and autonomous technologies. Autonomous vehicle technology could also be applied to public transport.
6. The potential social benefits of the deployment of autonomous vehicles are considerable. We estimate that by 2030, connected and autonomous vehicles could save over 2500 and prevent 25,000 serious accidents<sup>295</sup>. More efficient driving, including through platooning, could reduce fuel consumption and emissions. Autonomous vehicle technology could increase the mobility of non-drivers (including the elderly) and boost productivity as people regain time that had previously been devoted to driving.

***Q3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?***

***Q5. What is the scale of the market opportunity for autonomous vehicles?***

7. The overall economic and social benefits of CAVs are expected to be in the region of £51 billion per year by 2030, with up to 320,000 new jobs being created in the UK. 25,000 of these jobs will be created in automotive manufacturing, with the remaining jobs created across adjacent sectors including the tech sector and telecoms.

***Q4. How much is known about public attitudes to autonomous vehicles?***

8. A number of surveys have been undertaken regarding public attitudes regarding CAVs. These suggest that while there is recognition of the potential benefits of this technological development there remains some concern regarding associated risks.
9. If the UK is to be a world leader on CAVs, it is important that the automotive industry and government work together to address the concerns being expressed by the public. In particular, it is essential that the public understand the potential safety benefits of connected and autonomous vehicle technology and the speed with which new technologies will be introduced to the road.

## **CREATING AN ENABLING ENVIRONMENT**

***Q6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?***

10. If the UK is to create a comprehensive offering in relation to CAV demonstration facilities, it must ensure that it provides for physical (both test facilities and on the road) and virtual testing environments.

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<sup>295</sup> Connected and Autonomous Vehicles - The UK Economic Opportunity - <http://www.smmt.co.uk/wp-content/uploads/sites/2/CRT036586F-Connected-and-Autonomous-Vehicles-%E2%80%93-The-UK-Economic-Opportu...1.pdf>

11. More could be done to expand and improve the UK's demonstration facilities. The creation of a unique CAV test-bed offer would help promote the UK as a world leader on this agenda. The majority of SMMT members believe that such a test-bed should build upon already existing areas of expertise thereby creating an ecosystem-based offering. This should incorporate both physical and virtual elements and create an integrated test-bed made up of coordinated hubs and flexible, reconfigurable nodes.
12. While it is essential that the UK build upon already existing expertise, it is equally important that the ecosystem does not become too dispersed and that critical mass is created in a specific location or locations. Some SMMT members therefore favour a test-bed that has a single city or region at its heart. Such an approach would still see the CAV test-bed draw on expertise that already exists in different locations in the UK but would aim to concentrate the majority of the UK's testing facilities in a single location.
13. It is also important that the UK's test-bed offer it easily recognisable internationally. This is essential if the UK is to promote itself as the best place in the world to test and roll-out CAVs. A "thin" coordinating hub or promotional organisation should be created that can act as single-point-of-contact for those wishing to access the UK's CAV test-bed ecosystem.
14. Two virtual features are also central to an attractive test-bed ecosystem: virtual design verification process (vDVP) capabilities and an integrated critical and safety events database. The former is still a rare, not easily replicable and non-substitutable offering, while the latter can potentially expedite the testing of autonomous vehicles. The Government should identify how it can support the creation of a vDVP sector within automotive through a mixture of investment and its convening power in bringing together expertise currently residing outside the automotive sector. The Government, either via one of its agencies or in collaboration with a neutral body, should invest and lead in the setting up of a central critical and safety events database to facilitate shared learning that contributes to the avoidance of duplication in tests and the speeding up of development cycles.
15. Finally, the Government should keep in mind that the development of CAV technology cannot be divorced from the development of other future car technologies, such as electrification. A coordinated approach is, therefore, needed to reap the full benefits of these technologies.

***Q7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?***

16. We welcome the steps that Government have taken to fund the development of CAVs and in particular, the creation of £100 million Intelligent Mobility Fund (match funded by the automotive sector). Given that a number of countries are trying to position themselves as world leaders in CAVs, the Government should consider now what future funding will be committed to CAVs once the Intelligent Mobility Fund is spent and where it will best be spent.

***Q8. How effective are Innovate UK and the CCAV in this area?***

17. We welcomed the creation of the Centre for Connected and Autonomous Vehicle (CCAV) and believe plays an essential role in joining government up on this important cross-cutting agenda. It is essential, though, that all relevant Government departments are fully involved in the development of policies related to CAVs, not just the departments for Transport and Business, Energy and Industrial Strategy. It is particularly important to involve the Department for Culture, Media and Sport given the prominent role that the telecoms and tech sectors have in the development and roll-out of CAVs.
18. Innovate UK are playing an effective role in managing and issuing Government funding in relation to CAVs. Extensive engagement and information sharing in advance of the launch of research and development and feasibility study competitions has been welcomed and should continue in the future.

***Q9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?***

19. While CAV technology is primarily being developed by global automotive manufacturers, there is a critical role to be played by the UK's tech sector, which is predominantly made up of SMEs. Through the SMMT CAV Forum we are already bringing automotive manufacturers and technology providers together to discuss critical issues related to CAVs, identify common ground and agree actions that will help ensure that the UK is a world leader in the development, testing and roll-out of CAVs. However, more could be done by Government, either through the Catapults or by central Government, to act as a convener and to make SMEs aware of the business opportunities resulting from CAVs.

***Q10. Will successful deployment of autonomous vehicles require changes to digital and physical infrastructure?***

20. CAVs cannot be developed and rolled-out in the UK unless the right infrastructure is in place.
21. Developing the UK's digital infrastructure is essential. Four key challenges related to connectivity will shape the speed and breadth of CAV deployment in the UK: coverage, reliability, bandwidth and capacity. Coverage is arguably the most pressing issue. the automotive industry's top priority. Currently almost 4,600 miles (2%) of British roads have no 2G coverage from any network provider, whereas only 43,000 miles (18%) and 119,000 miles (48%) have full 4G and 3G coverage respectively. If the UK is to be the leading market for deployment of connected vehicles and V2X<sup>296</sup> services in the first instance and CAVs thereafter, the Government must devise a strategy to ensure signal coverage, irrespective of the choice of technology, does not become the key stumbling block.

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<sup>296</sup> Vehicle to anything communication

22. Action also needs to be taken to develop and maintain high-quality physical infrastructure. Automated driving from SAE J3016 Level 3 onwards will rely on cameras, working in tandem with radar, Lidar and other sensors. While there may be the possibility to do away with signage and gantries on the road network in the longer term when dynamic information such as speed limits and temporal restricted access can be beamed directly to connected vehicles, this is predicated on ubiquitous connectivity on UK roads and a significant majority of, if not the entire, motorparc being connected vehicles. Given the current renewal rate of the UK motorparc this is unlikely to take place for at least twenty years, if not longer. In the meantime, it is essential that the Government ensures that the UK national road infrastructure, including as widely beyond the Strategic Road Network as possible, is of a high quality. Clear road markings are a priority, so as to ensure ADAS and automated driving functions operate correctly.

***Q11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?***

23. Several parallel developments are needed to enable effective and extensive deployment of autonomous vehicles.

24. The first is a gradual escalation up the SAE-defined levels of automation from where we are today, i.e. around Level 2-3, to Levels 4 and 5. While bypassing various ADAS functions, particularly those at Level 3, may help avoid the driver being lulled into a false sense of security and dependence on what is effectively only driver assistance capabilities, a quantum leap to Levels 4 and 5 may represent a step too far too soon for the majority of drivers who are accustomed to being completely in control of their vehicles today. Taking the consumer along in the journey of gradually increasing automation, along with a targeted programme of communication and public education, is probably most helpful in easing the public into accepting autonomous vehicle technology over time.

25. The second is a rolling programme of regulatory reform, which the Centre for Connected and Autonomous Vehicles has recently launched. Extensive deployment can be hampered by a number of regulatory barriers, such as those related to insurance, the Highway Code and Construction and Use Regulations. In addition, international regulation, such as those related to lateral steering manoeuvre, is pivotal for enabling the deployment of autonomous vehicles. While our national regulatory review is step in the right direction, the UK Government must play an active role at UNECE to drive forward international regulatory reform, the current pace of which is too slow in some critical areas to enable extensive deployment of new technologies in the near-to-medium term. Specifically, HMG should utilise its role as chair of the ITS/AD-IG and GRRF at the UN ECEWP29 to bring about the complete amendment of UN R79 for ACSF (including Category E). HMG should also initiate discussions to expand the scope of ACSF (Cat B2, D, and E) to all road types.

26. The third is the need to prepare national physical infrastructure. Autonomous vehicles rely heavily on a combination of multiple sensors, including high definition cameras,

Lidar and radar. Well maintained road markings and signages are pivotal for cameras to accurately perceive the path ahead and warnings of ad-hoc roadworks or disruption (e.g. lane closure).

27. The fourth is related to digital infrastructure, particularly on connectivity. Connectivity complements autonomy, and enables the autonomous system to be informed by a richer set of information from other vehicles and infrastructure (V2X), which can enhance the system's decision making. Connectivity also provides redundancy, or fallback, should one or more of the vehicle's sensors fail, e.g. cameras blanked out by drifting snow or blinded by the sun. Yet Ofcom data analysed by the RAC Foundation shows that only 18% of the entire UK road network has 4G coverage and 48% has 3G coverage. Safety related functions of CAVs may not necessarily require 5G, but almost certainly requires ubiquitous coverage.

***Q12. Does the Government have an effective approach on data and cyber security in this?***

28. Data collection, transfer and analysis is critical to the effective functioning of the digital economy. In vehicles, infotainment, telematics, vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-anything (V2X) communication all rely upon the collection and use of data. This data comes in many different forms and, even in one vehicle, can be generated by a number of different parties including the driver and the manufacturer. Businesses and individuals rightly expect their data to be dealt with in a secure manner which prevents unauthorised access to or use of that data. Equally, data is valuable. Its analysis can lead to new innovations, while open access can support competition and the development of new business models and services that promote growth. More needs to be done to create data framework that balances protection, innovation and competition and encourages the development of CAVs in the UK. Arguably the most critical issue is understanding how the General Data Protection Regulation will apply in the United Kingdom following its withdrawal from the European Union.

29. With regards to cyber security, we welcome the assistance that is being provided by the government. Increasing connectivity of digital devices including CAVs presents new challenges in relation to cyber security. A failure to ensure the security of a growing network of connected cars and devices that will increasingly be relied upon to ensure smooth traffic flows across the road network, will not only undermine public confidence in CAVs but could also present genuine risks to public safety.

***Q13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?***

***Q15. What does the proposed Modern Transport Bill need to deliver?***

30. Changes to regulation and legislation will be needed to create an enabling environment for CAVs and the first wave of these should be delivered through the Modern Transport Bill.

31. With regards to insurance, the automotive industry supports changes that expressly seek to encourage the uptake of CAVs by:
- Assuring the public that appropriate motor insurance cover is available for Level 4 or 5 autonomous vehicles;
  - Assuring motorists that obtaining motor insurance for an autonomous vehicle is akin to obtaining insurance for a conventional vehicle today; and
  - Ensuring the appropriate and fit-for-purpose regulations are in place by the time these vehicles enter the market.
32. The *majority* of SMMT members are in conditional agreement with proposals to extend compulsory motor insurance to cover product liability for Level 4 or 5 vehicles. Giving consumers the peace of mind and confidence to purchase these vehicles when they become available is critical to the growth of the market for this new technology. However, the support for this proposal is predicated on three important conditions:
- i. That amending primary legislation to extend compulsory motor insurance to cover product liability for autonomous vehicles must not result in unintentionally hampering consumer uptake of these vehicles through actual or perceived higher insurance premiums;
  - ii. That event data recorders ("black box") should be made compulsory in all autonomous vehicles; and
  - iii. That sufficient flexibility is created in the market for different motor insurance models for autonomous vehicles to be offered.
33. Several SMMT members do not agree with proposals to extend compulsory motor insurance to cover product liability for Level 4 or 5 vehicles. Instead, they believe that recourse through existing product liability laws is sufficient.
34. With regards to regulatory and legislative reform, changes are needed to encourage the development of new technologies and match the aspiration of consumers and vehicle manufacturers.
35. The Government recently proposed a programme of rolling regulatory reviews designed to ensure that the UK's legislative framework is fit-for-purpose in relation to near-to-market technologies. SMMT welcomes this approach, but believes that, as well as looking at near-to-market technology, the Government should take a far-sighted approach by incorporating flexibility and adaptability into the regulatory framework so as to ensure that it can respond to new technological developments.

***Q14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?***

36. Vehicle manufacturers seek to develop autonomous systems that are geared towards avoiding ethical dilemmas. With advances in sensor technologies, AI and algorithms, and ideally complemented by ubiquitous connectivity, CAVs are expected to be able to

perceive emerging risks, such as those associated with the Trolley Problem, from afar and adopt mitigating measures to avoid landing in ethical quagmire.

***Q16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?***

37. In order to facilitate ambitious growth for connected and autonomous vehicles in the UK it is critical that a holistic approach is taken to education and skills which focuses on both the shortage of people seeking to enter into engineering careers and the level and quality of training that is provided. Such an approach should include the ongoing revision of the curriculum to include and reflect the pace of technological development, adequate provision of careers advice information and guidance to ensure young people are aware of the opportunities available in these technologies (and that the right educational choices are chosen), and the delivery of high-quality higher and further education programmes, focusing on the skills and knowledge these technologies require.
38. It should also be noted that the skills required for the effective development of these technologies are wide-ranging and are not just those related to traditional engineering and digital skills (although these are highly important and must be prioritised). As the Transport System Catapult's recent report into Intelligent Mobility shows, a wide range of skills covering both STEM and social bases will be needed to ensure that the UK grasps the opportunities these technologies can provide.

***Q17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?***

39. The Government's work, principally through the Centre for Connected and Autonomous Vehicles, is commendable. However, it is not apparent there is a Government strategy in this area yet. The automotive industry and other key stakeholders in this area would benefit from a national strategy that joins up the disparate disciplines and various parts of the government machinery in a single streamlined vision and delivery plan towards capturing identified leadership positions in the CAV sector.

***Q18. What are the implications of exit from the European Union for research and development and the autonomous vehicles industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?***

40. While the terms of the United Kingdom's withdrawal from the European Union remain unclear, it is impossible to say what the precise implications will be for CAVs. However, since CAVs developed in the United Kingdom will inevitably be sold to markets around the globe the United Kingdom's regulatory framework must remain compatible with European and international standards (for example, the current regulatory framework under Article 20 of 2007/46/EU, should remain valid after the UK's withdrawal from the EU so as to avoid unnecessarily disadvantaging UK industry when they introduce new

technologies to UK and EU market). This is essential if international automotive manufacturers are to use the UK as a critical hub for the development and roll-out of their CAVs.

*26 October 2016*

**Society of Motor Manufacturers and Traders (SMMT), European Commission and ERTICO – ITS Europe (Intelligent Transport Systems) – Oral evidence (QQ 20-30)**

[Transcript to be found under the European Commission](#)

## **Southampton Marine & Maritime Institute, University of Southampton – Written evidence (AUV0028)**

1. This submission focusses on autonomous marine vehicles. The University of Southampton is one of the UK's leading universities for naval architecture and marine engineering, as well has having one of the top institutes for maritime law. Both of these form part of the University's Southampton Marine and Maritime Institute.
2. With 90% or more of world trade travelling by sea and with a global fleet of large ships greater than 90,000, there is a potentially lucrative market for the application of a wide variety of autonomous systems. Typically on-board personnel costs can form 40% of the operational cost of a ship and anything that can help make more effective use of ship board officers and crew, improve their working hours and conditions will enhance the sustainability of the industry. Crew numbers have reduced significantly in the last few years. For example in the extremely competitive container shipping market the recent high profile collapse of a major player indicates quite how sensitive their margins are and the pressure to reduce costs all round.
3. A recent workshop on Large Ship Autonomous Systems organised by the University of Southampton's Maritime Robotics Laboratory with the support of the Transport Systems Catapult brought together more than 50 key individuals from a wide range of industry partners to debate the technology challenges and other aspects associated with greater adoption of on-board autonomous systems.
4. There was wide agreement at this event that there is a significant operational benefit that can be obtained from developments of on-board systems that can support existing crew and also that these changes are already starting to happen and at a greater pace than would have been anticipated a few years ago. The technology already developed for small autonomous surface vessels, for example by companies such as ASV Global Ltd or by student project groups such as the University of Southampton's [Team Fortitude](#)<sup>297</sup> has the potential to make autonomous ship operation a possibility within a relatively short time frame (less than 10 years). The developments made in the commercial and academic sectors place the UK in a unique position to lead the future direction of maritime autonomy in a global context.
5. There are many tasks on-board ship which require a highly trained individual but only for relatively short periods of time. Watch keeping and collision avoidance would all benefit from improved systems that can support and potentially reduce the risk of human error whilst maintaining compliance with national, regional, and international requirements. Similarly many of the survey and inspection tasks that help ensure ship safety and maintenance are physically challenging and at times, dangerous so using

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<sup>297</sup> <https://en-gb.facebook.com/fortitudeASV/>

systems that can automatically inspect and monitor vital components of the ship's structure and machinery could significantly enhance ship safety.

6. While there are aspects of generic technology that can be applied across a number of transport sectors the maritime sector has some unique challenges. For instance, communication via satellite in the open ocean is both expensive and has limited bandwidth compared to the wireless networks that can be used on land and in coastal areas. In coastal waters the variety of sizes of marine craft and with relatively limited traffic control especially for leisure craft provides a complex environment in which to manoeuvre vessels which have relatively slow rates of response. Similarly the skills of pilots in navigating the currents and tides would be very difficult to replicate. The robustness of sensors and other systems has to be sufficient to survive the extreme storm conditions experienced in the maritime environment. While the challenges are significant, automation can be introduced at different levels ranging from partial assistance of specific functions to full autonomy. Each level poses operational benefits and a step-by-step approach to integration can accelerate the development of mature technologies. Furthermore, many aspects of automation can leverage existing digital and physical infrastructures (e.g. communications, ports) and so can be introduced with minimal disruption to on-going activities.
7. A key requirement is the necessary engineering expertise to develop and push the technical possibilities in this growing sector. It is interesting to note that a Master's level module [SESS6072 Maritime Robotics](#)<sup>298</sup>, introduced two years ago as part of the MEng in Ship Science degree programme for Naval Architects and Marine Engineers at the University of Southampton, is one of the most popular final year modules. Students combine their knowledge of maritime engineering with an ability to code distributed microprocessor systems. They are already aware that these are the skills that the successful Maritime services industry in the UK has a shortage of. It is also an area where there is considerable potential for the growth of entrepreneurial start-ups that can deliver systems which meet specific maritime industry needs in a short timescale with the potential to scale rapidly across many ships.
8. Policy decisions on how quickly and on what terms the new technology will be introduced in the commercial world and how it will interact with existing navigational and operational rules will need to be taken. These should be evidence based, ensure safety for human life and the protection of the marine environment, encourage innovation and efficiency and reduce the environmental footprint of marine activities. New regulations prescribing the construction, communication, navigational, operational and training standards for such systems and their operators need to be developed and complied with. These have to develop gradually in collaboration with the industry as otherwise they may be proven either too restrictive for technological development or too permissive and may create unnecessary risks. The use of new maritime systems with international capability also

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[http://www.southampton.ac.uk/engineering/postgraduate/taught\\_modules/sess6072\\_maritime\\_robotsics.page](http://www.southampton.ac.uk/engineering/postgraduate/taught_modules/sess6072_maritime_robotsics.page)

requires engagement with the international regulatory body for shipping, the International Maritime Organisation. Other fora, for example the European Defence Agency has also been exploring the legal position in relation to the development of such systems and need to be taken into account if the technological and regulatory offer is to have international scope.

*25 October 2016*

## **Professor Neville Stanton, University of Southampton – Written evidence (AUV0029)**

*Submitted by Professor Neville Stanton, Chair in Human Factors Engineering, University of Southampton*

1. Current technology is developing autonomous road vehicles with onboard auto-drivers which will take over the driving tasks. However, as things currently stand, there is both a legal and technological requirement for drivers to monitor their auto-driver, and take manual control if the situation demands. Research which I and colleagues have carried out at the University of Southampton over many years suggest a number of significant concerns with this approach.
2. As vehicles become fully autonomous, even the most observant human driver's attention will begin to wane. Their mind will wander, and they may start to mentally switch off from the job of driving. This is particularly true if they are engaging in other activities such as reading, answering emails, engaged in conversations with passengers, watching movies or surfing the internet.
3. Research at Southampton over the past 20 years demonstrates that drivers of automated vehicles are generally not as effective in emergencies as drivers of manual vehicles. In simulated emergencies, up to a third of drivers of automated vehicles did not recover the situation, whereas almost all drivers of manual vehicles in the same situation were able to recover the situation. This has been shown repeatedly in both driving simulators and test track studies. In particular, the research shows that drivers of automated vehicles take, on average, six times longer to respond to emergency braking of other vehicles compared to manual drivers.
4. Further studies show that continual monitoring of partial automation takes as much mental workload as manual driving, and that drivers cannot sustain this level of monitoring for long periods of time.
5. These issues have significant implications if the driver of an autonomous vehicle is still required to take back control in emergencies, and if s/he is still fully accountable for the safe operation of the vehicle, which are important policy issues for Government as the technology develops.
6. Current research at the University of Southampton suggests some ways forward. Firstly, we have evidence of human drivers and automated vehicles becoming unsynchronised, for example if the driver believes the vehicle has detected the presence of another vehicle when in fact it has not. Our research has shown that if we design the vehicle to provide continuous relevant feedback to the driver (a "chatty co-driver" rather than a silent auto-pilot), this error can be reduced substantially, as well as keeping higher levels of attention of human drivers during periods of automation.

7. Secondly, a graduated and gradual hand-over and hand-back of tasks between human drivers and automated vehicles allows drivers to slowly regain the full attention needed to drive safely, rather than moving immediately from not driving to driving.

*25 October 2016*

## David Starkie – Written evidence (AUV0033)

*Visiting Professor in Industrial Economics, University of Applied Sciences, Bremen, Germany*

**Addressing Real World Operations 10 and 11 (changes to physical infrastructure) but with a bearing on 1 and 2.**

### 1. Introduction

1.1 Although autonomous vehicle technology appears to be advancing very rapidly and is incorporated to varying degrees in current road vehicles, nevertheless there are significant outstanding legal and ethical issues concerning use of its full potential on the general highway. It is not the purpose of this contribution to enter into this particular debate but to assume that: there will in the future be a mix of vehicles with different degrees of automation operating on the highway (a mix that will persist for some time) and ethical and legal issues are going to impede the full exploitation of the new technology on the *general* highway. I want to suggest a means of bypassing these difficulties to enable capable vehicles (vehicles classed at the high levels on the SAE's classification) to make full use of their technology.

1.2 The Special Roads Act (1949) made possible the building of roads for the exclusive use of certain types of traffic, hence the introduction of motorways. By extending this approach and constructing roads for the *exclusive* use of vehicles driven in autonomous mode, current existential issues could be overcome. First, problems associated with the so-called 'trolley problem', should not arise. Second, and importantly, the driver by using the exclusive road would be recognised as formally accepting its 'terms and conditions of use'. If, on the other hand, the 'driver' wishes to maintain a degree of control of the vehicle, she/he can exercise that choice but, to do so, has to revert to using the general highway.

1.3 There are significant ramifications of this suggestion for road design. When motorways were first introduced in the UK, vehicle technology adapted slowly to sustained periods of high speed driving: between 1958, when the first motorway was opened, and 1965 there was no national speed limit. As a consequence, vehicle breakdowns were common due to over-heated engines and tyre failure. Vehicle technology, however, slowly adapted. With exclusive, autonomous vehicle highways (**AVHs**), this early post-war process of the vehicle adapting to the highway could be reversed. Road design could be adapted to the vehicle technology.

### 2. Highways Designed for Autonomous Vehicles

2.1 First, because of 'lane-assist' technology (already installed in some vehicle types) AVHs could be constructed with narrower lanes. Early motorways were built with 10 foot lanes rather than the now standard 12 foot lane. The AVH could revert to 10 feet, or possibly narrower lanes. Vehicles sizes generally over time have tended to increase, including their width, but the advantage of autonomous control is that the vehicle would be navigated automatically to highways of suitable width; if the vehicle was too wide for the lanes of a

particular AVH, its control system would foreclose entry to the vehicle. Indeed, one might envisage narrow AVH being constructed for exclusive use by vehicles of a narrow width.

2.2 Second, one can envisage exclusive-use AVHs being used at higher speeds than the current national speed limit; with vehicle speed being adaptive to, for example, the horizontal curvature of the road. Consequently, an AVH could be constructed through-out its length with the option of much tighter curvature than is currently standard on motorways (and access points), in the knowledge that the autonomous vehicle's speed would be continually adjusted to a safe operating speed.

2.3 Thus, this combination of progressive highway design features provides the opportunity to build AVHs that are much more sensitive to the visual environment than current highways. They would be narrower in cross-section and, for inter-urban AVHs, could follow contours of the land to a greater extent than current trunk roads. And, in so far as AVH were constructed within urban areas, such roads could wind their way more sensitively through the urban fabric, following lines of opportunity; perhaps following, for example, the route of old railway formations. Alternatively, tunnels of more limited gauge could be built more cheaply. An additional consideration is that on AVH there would be no requirement for road signage; the current smart motorways' electronic gantries, for example, would, in essence, be incorporated within the autonomously controlled vehicle. AVHs, therefore, would have a lower vertical profile than the current highway with its mass of signs providing directions and giving safety guidance: exclusive AVHs provide the prospect of a clutter-free highway.

### **3. The economic case**

3.1 The economic case for the construction of AVHs comes from the prospect of an improved benefit-cost ratio for AVH infrastructure. Reference has been made to removing the national speed limit from exclusive-use AVHs and therefore the prospect of vehicles operating at higher speeds, reducing journey times. The benefits come not only from higher maximum speeds but from the electronically disciplined nature of the vehicle's operation. All vehicles on an AVH will be moving at a uniform speed within any particular external road environment. That is to say, for a stretch of highway through hilly country, designed with relatively tight horizontal curvature, the operating speed regime might be 60mph, for open country, 100mph or higher. This controlled speed environment and the automatic adjustment of the vehicle will itself reduce journey times. In addition, there are important gains for the vehicle 'driver', who is now free to engage in work related activity on smart phones/ laptops, to use the same in leisure mode, or read books/newspapers.

3.2 On the cost side of the equation, the potential for narrow vehicle lanes will reduce construction costs, albeit marginally. But, a larger gain could come from reducing the number of lanes needed; the AVH lane will have greater capacity because of the electronic coupling of vehicles in close formation (thus forming a *de facto* vehicle train). Consequently, exclusive AVH would have much greater capacity than their current motorway equivalents; conceivably a dual two (narrow) lane AVH could have greater capacity (possibly much greater capacity) than an existing dual three lane motorway. Indeed, it is possible to conceive of no more than a single directional lane (with hard shoulder). Envisage a vehicle break down in such circumstances: faced with an obstacle on the carriageway, vehicles will

be automatically slowed and guided around the obstruction (via the hard shoulder or, in low traffic density, the opposing lane) before speeding up again. Thus, large capacities at lower costs are in prospect with AVH, especially if use of them is made more exclusive than current motorways (i.e. restricted, for example, to light vehicles only).

#### **4. Potential Case Study**

4.1 The Government is currently proposing to construct HS2 at a cost (including rolling stock) of between £50bn. and £60bn. This is planned to reach Birmingham in the mid-2020s and Leeds /Manchester sometime in the 2030s. The object of the scheme has vacillated, but the chief, current object is to provide greater rail capacity along these routes. Over such a long planning horizon (common to most major transport infrastructure) the world can change considerably, if not dramatically, such is the pace of technological progress and institutional innovation. (HS1 European passenger forecasts, for example, were impacted significantly by the unforeseen introduction on a substantial scale of low cost airlines). There is a major risk (borne by the taxpayer) that by the time the first train runs (especially to Manchester and Leeds) the project has become technically obsolete. One element of risk comes from autonomous vehicle technology (fleets of autonomous National Express coaches for example) which might chip away at the rail market.

4.2 Why not anticipate such developments and in the process help the UK to take a lead in autonomous vehicle technology? Turn the planned formation of HS2 into the world's first super highway for autonomous vehicles.

4.3 For reasons already explained, the HS2 rail formation will be wide enough to accommodate an AVH of at least a single directional lane and hard shoulder, and possibly more lanes (at least along certain stretches). The transformation will also overcome a major environmental drawback of HS2, its serious visual intrusion due to the size and number of electrification gantries required for high train-speeds. (The current electrification of the line from Paddington to Bristol and South Wales through some sensitive landscapes provides a good illustration of this problem). And, as for other environmental issues, it should be borne in mind that the road vehicle will be increasingly powered by electricity. From the point of view of the traveller in the autonomous vehicle she/he will be sitting in a formation of vehicles which at busy times will resemble a vehicle train (albeit running on electronic tracks), except in this instance the train seat will be substituted for by a private (vehicle) 'compartment'.

4.4 There appears to be a case, I believe a strong case, for the Government conducting a cost-benefit analysis on the HS2 conversion proposal (or on a similar exclusive AVH project) in the process taking into account the potential boost AVHs might give to Britain's hopes to be a world leader in the new technology.

#### **5. Summary**

- Ethical and legal culpability problems are likely to slow exploitation of the full potential of autonomous vehicles operating on the general highway.
- These problems could be circumvented by the construction of exclusive roads for use by autonomous vehicles operated in fully autonomous mode.

- The design of such roads could be adapted to autonomous vehicles and the ability of such vehicles to follow a precise track at speeds automatically adjusting to external conditions. Narrower, de-cluttered highways could thus be constructed with environmental gains.
- The narrower, exclusive AVHs could achieve substantial increases in capacity compared with an equivalent motorway.
- Higher speeds and higher road capacities (together with benefits to the ‘driver’) hold out the prospect of favourable economic returns from investment in AVH infrastructure.
- It is suggested that the Government conduct an evaluation exercise to test the proposal that the formation of the planned HS2 is used for constructing the world’s first super highway for the exclusive use of autonomous vehicles.

*25 October 2016*

## **Starship Technologies – Written evidence (AUV0072)**

### **4. What are the potential applications for autonomous vehicles?**

The Starship Technologies application is an ecologically friendly, inexpensive and largely autonomous ‘personal delivery’ service, which can also enable less mobile individuals to enjoy more independence and self-reliance at home.

### **5. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

Personal Delivery Devices (PDDs), such as the Starship robot, deliver goods across short distances of up to a couple of miles at very low cost, with large savings of time for suppliers and consumers and negligible environmental impact. Our conceptual aim is ‘zero pollution, zero time and zero cost’ – the financial saving being made through the fact that PDDs are much cheaper to operate than human delivery systems. The PDD sector, of which Starship is currently the primary example, offers the prospect of large-scale modal shift from human operated vehicles, such as cars and vans, to small, low ‘footprint’ devices which will measurably and safely reduce traffic congestion.

There are two further advantages. PDDs offer small businesses, such as sole trader shopkeepers, an affordable home delivery service. This means they can compete on a more level playing field with large retailers, without the need to employ human drivers and expensive, large vehicles. Secondly, citizens with mobility issues can live independently and with dignity at home for a longer period, instead of in staffed care homes, as the PPD’s can perform delivery services for them. This could save tens of thousands of Pounds per person per year, and sustain quality of life, which is cannot be quantified in pecuniary terms alone.

It is hard to see significant disadvantages with PDDs. They are not vehicles, they don’t use the roads, they don’t fly, they have little kinetic energy and they don’t carry people. PDDs coexist with pedestrians and always defer to humans, animals and other vehicles. They are extremely safe and will reduce the incidence of injury accidents on the UK’s roads by reducing traffic.

With the regulations for PDDs we propose, there should be no adverse effects from the PDD sector. As we will explain, this legislation is the single most helpful action the Committee could recommend to support the sector and ensure safe, responsible operations at no cost to the public purse.

### **6. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Various companies are experimenting with human-carrying autonomous vehicles. There is also a large body of information available in terms of sectors which already use large scale automated systems. These include rail-based transport systems, plus the passenger aircraft

industry, in which a Hawker Siddeley Trident aircraft made the first commercial automatic passenger-carrying landing on 10<sup>th</sup> June 1965. Thus there is already a significant body of evidence already.

Starship is now exploring the impact of the PDD with commercial testing running side-by-side with experimental research. The robot has operated autonomously in various geographies, including Estonia, America and the UK and the results are carefully recorded. The challenges for Starship are very much smaller than for human rated machines, which travel much faster and interact with other manually operated road vehicles. We now know enough to safely operate our device without incident.

#### **4. How much is known about public attitudes to autonomous vehicles?**

The Starship robot has travelled over 13,000 km and ‘met’ over 1.3 million members of the public, with a 97% approval rating. In the Royal Borough of Greenwich in London, which has been the lead location for our commercial trials, the public is now largely familiar with the existence and operation of the device - and the primary response is one of casually ignoring its presence, which one would expect as a new device becomes familiar.

Although it is not technically necessary to do so, Starship works closely with local authorities prior to commencing operations in any locality. Local authorities consistently register their approval for the robot’s operation in their jurisdictions. The firm also works with organisations such as the Royal National Institute for the Blind, to deepen our understanding of any potential issues, as well as benefits the PDD can provide to particular client groups. This work helps considerably in our understanding of the role of our autonomous device in the overall mix.

#### **8 What is the scale of the market opportunity for autonomous vehicles?**

Starship estimates the value of the sector at billions of Pounds per annum. The potential for replacing manually controlled deliveries with autonomous devices is so great that it will partially alleviate road congestion and air quality issues in urban areas. The commercial attraction of reducing the cost of deliveries by up to 90% will create a customer-led transition.

#### **Research and Development**

#### **9 Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

Starship is very satisfied with the current level of Government support. We are undertaking commercial operations with our business partners in the UK, and working with local authorities to ensure a partnership approach. Our exhaustive assessment of the law confirms our device can operate legally now, and thus we run it in the ‘real world.’ It follows that the PDD sector does not need additional facilities from Government. We also have our own private research facilities and other PPD makers are likely to have similar facilities.

**10 Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

Starship has developed its business without the need for Government funding. For the PDD sector, it would not seem necessary for public funds to be allocated to this application of autonomous technology. Regarding coordination, the best assistance would be setting wireless connectivity standards, plus the PDD regulatory framework.

**8. How effective are Innovate UK and the CCAV in this area?**

Starship has enjoyed very good relations with both bodies. We have made an extensive submission to the CCAV's consultation into autonomous vehicles, and also proposed a simple regulatory framework for the PDD sector, which, as already stated, we would be very keen to share with the Committee. The CCAV has been our main formal link to Government, and find the individuals proactive and highly accessible – with a 'can-do' outlook and culture.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

As a fast growing SME, Starship was sufficiently impressed with the UK business and regulatory environment to base its first international division in Britain – specifically at the Digital Greenwich offices on the Greenwich Peninsula. The Digital Greenwich staff and the local authority have been a case study in proactivity, and this adds to our impression of the UK as a superb place to do business with our PDD.

The enabling mindset of the Government, together with the fact that PDDs already fit within the existing UK legal framework, have made this country, to the best of our knowledge, the first in the world where regular commercial activity is taking place with a PDD system. The Government is honouring its promise to be a world leader for promoting autonomous technology.

**Real world operation**

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

The UK's digital infrastructure will need to be significantly expanded, to cope with the very large data requirements that extensive autonomous vehicle operations will demand.

Starship itself is a relatively small data user, but could face competition for bandwidth with other users as more devices come on-stream.

We wish to avoid at all costs any data outages which could compromise the efficiency of our delivery system. For Starship, safety is NOT the concern as the vehicle is intrinsically safe, and has extensive autonomous safety features which operate regardless of connectivity. Yet a digital infrastructure strategy at State level is highly desirable. For example, the Estonian Government has made a certain level of connectivity a 'human right' and acted accordingly.

Starship is already in conversations with UK digital infrastructure providers, and also with other autonomous device manufacturers, and we are happy to share our real world experience with the Committee.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

For Personal Delivery Devices, Starship envisages an organic transition, led primarily by our business partners and public sector bodies – both motivated by financial and service considerations. In addition, those responsible for traffic management in the UK will be attracted to modal shift towards PDDs so as to reduce commercial vehicle operations. Since the majority of Britain's pedestrian facilities are significantly underutilized, this shift will not cause congestion or inconvenience to pedestrians – a fact proved across thousands of kilometers of real world experience and over 1.3 million human encounters we have already recorded and analysed.

In terms of the milestones we envisage for PDDs, they are:

Phase 1: proof of concept through non-commercial trials;  
Phase 2: commercial trials;  
Phase 3: full commercial operations.

Starship is at Phase 2 in the United Kingdom, with actual commercial deliveries taking place. We are very willing to share our experiences with the Committee.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

Security of the software and wireless communications are of paramount importance for PDDs – and, for that matter, autonomous vehicles.

The Government should work with the sector to establish agreed levels of cybersecurity and, where appropriate, protocols which mean businesses will not be exposed to notional changes in cybersecurity requirements. As Estonia is a world leader in cybersecurity. Estonia was the first country in the world to suffer an extensive and malicious cyber attack. Very important lessons were learned and applied to national systems. Note that the founder of Starship, Ahti Heinla, was a co-founder of Skype and has extensive knowledge of this field. The Committee may find our insights useful.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

Starship has secured full Public Liability Insurance for its operations across over 30 countries, and as such we have demonstrated a model of insurance is possible without regulatory change. We have also fully addressed the potentially difficult question of liability. Our model is easily transferable to all autonomous device operators, should they wish to adopt a similar approach.

In terms of regulation, Starship has researched the current environment extensively and concluded that we operate within UK law. Were this not so, we could not have secured authorization to operate in the jurisdiction of local authorities, nor have secured our insurance cover. However, we believe it would be helpful to introduce a relatively straightforward regulatory framework for PDDs, and we have submitted our proposal to the CCAV. The framework is not specific to the Starship robot but, rather, generic to the Personal Delivery Device sector. Under these proposals, existing and future designers and operators of PDDs are all subject to a sensible, light touch regulatory framework which ensures the sector evolves responsibly and safely, thus preventing less scrupulous operators from gaining advantage by cutting corners on safety or good practice.

Starship is already operating with commercial partners. It would seem prudent to put in place this framework expeditiously as the sector is already demonstrably existent. *The single most helpful action which Parliament can take is to introduce the kind of statutory framework we have proposed – either as part of a larger Bill, or preferably sooner as a Statutory Instrument.*

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

The primary ethical consideration is one of liability. Starship takes a simple approach: the company accepts liability for the operations of all its robots. This is reflected in our insurance and also in our arrangements with local authorities. Our model holds that artificial intelligence should operate with the ultimate responsibility resting with a human. With our robot, the designated human controller can override the machine anywhere and at any time. Our device will never be 100% autonomous and this is a fundamental design feature built into our device and operating practice. The small level of human input resolves a very large number of practical and ethical challenges.

**Wider governance**

**15. What does the proposed Modern Transport Bill need to deliver?**

The Bill is, we believe, likely to focus primarily of large, human-carrying autonomous transport vehicles. As Starship already has a proposed regulatory framework, this could be incorporated as a section of the Bill, or alternatively passed as a Statutory Instrument separately from and in advance of the Bill. Starship strongly recommends this latter approach – which has the added advantage of providing further experience and knowledge of the effectiveness of such a regulatory system in the real world, in the case of PDDs with intrinsically safe devices which carry goods, not people. That may help Parliament with the framing of the Modern Transport Bill.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

Starship has had little difficulty in finding staff in the UK who are capable of displaying appropriate skills. Most design work has taken place in Estonia, but this process is helped by the UK team. Possibly, relationships between the autonomous sector and schools could help to deliver the right skills set for this growing sector, and keep the UK at the forefront of developments. Starship has begun working with schools to test the benefits of this. We would be delighted to share our experiences with the Committee.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

Starship has found representatives and elected officials at National and Local Government level very responsive to PDDs, as we explain, demonstrate and operate it. Our activities in various parts of the UK including Greenwich, Glastonbury, Milton Keynes and elsewhere show the Government has created an environment in which our device is successfully being brought to market.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

As long as the Government's attitude and actions continue to support what we are doing, Starship intends to continue expanding its commercial operations in the UK, and to work in partnership with the authorities to generate social, environmental and economic benefits to the country as a whole.

*26 October 2016*

## **Stewarts Law – Written evidence (AUV0054)**

### **About Stewarts Law LLP**

Stewarts Law is the UK's largest litigation only solicitors' firm and specialises in high value and complex disputes. The firm acts for both corporate and individual clients and has leading and specialist departments in aviation and travel, clinical negligence, personal injury, divorce and family, commercial litigation, competition litigation, international arbitration, investor protection and tax litigation.

Stewarts Law has strategic partnerships in place with other specialist solicitors' firms across the world, enabling its clients to take a global approach to litigation. The firm is top ranked in both the Legal 500 and Chambers and Partners, the leading guides to the legal profession in the United Kingdom.

### **Response to the call for evidence**

- 1      What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**
  - 1.1     The incidence of road accidents should, if anything, reduce as they often result from human error by drivers of both vehicles concerned.
  - 1.2     We do not anticipate that the deployment of autonomous vehicles will have the effect of increasing insurance premiums for conventional vehicles, despite concerns expressed that they might. It is also very unlikely that the cost of insurance products for autonomous vehicles will be higher than for conventional vehicles. In fact, they ought to decrease.
- 2      Does the Government have an effective approach on data and cybersecurity in this sector?**
  - 2.1     We agree with the Government's approach that in the event of third party hacking of an automated vehicle, the insurer of the vehicle should not be able to exclude liability. Victims should be able to readily secure compensation from vehicle insurers who can then pursue anyone they identify as responsible.
- 3      Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**
  - 3.1     Delays in the compensation of innocent victims and the increased costs of the legal process highlight the current inconsistencies of UK law with EU legislation and the need for the insurance framework to be changed. It is not just a matter of complying with EU law but, more significantly, about ensuring that innocent victims of motor accidents are compensated absent which a large part of the financial impact of their injuries will fall to the State.

- 3.2 In addition to the application of insurance/liability rules for automated vehicles, we also propose that strict liability should be imposed on motor insurers for any mechanical or technical defects in vehicles that are responsible for causing and contributing to the accident. For reasons of simplicity and consistency we think that this strict liability should be extended to all mechanical and technical defects in all vehicles, not just automated vehicles. That would also avoid any disputes over whether the vehicle in question was autonomous, or being operated in an autonomous or semi-autonomous way at the time of the accident.
- 3.3 The Government has already proposed amending road vehicle compulsory insurance primary litigation in Part 6 of the Road Traffic Act 1988 to include product liability for automated vehicles. We agree with the spirit of the proposal, but consider wider ranging reform to be necessary. It is essential that the cross-border scenarios are adequately addressed. Large numbers of vehicles regularly travel to and from the UK and the continent and the numbers may well increase with the ease afforded by automated and semi-automated vehicles. Adequate cover is therefore essential for English citizens who may be injured by European drivers/vehicles on our roads, or when travelling in Europe.
- 3.4 The current right of English resident victims of road traffic accidents to be able to bring their compensation claims through the English Courts should be retained. This right emanates from the European Motor Insurance Directives, but has only been partially implemented nationally by the The European Communities (Rights against Insurers) Regulations 2002, incorrectly limited to accidents within the UK. A new Modern Transport Act needs to fully implement the Motor Insurance Directives into UK law. In any event, it is likely that the EU will insist on the UK's full implementation of the Motor Insurance Directives if UK citizens are to continue enjoying the benefits of cross border remedies post-Brexit.
- 3.5 We disagree with the Government's proposal to limit product liability and insurance requirements for automated vehicles with the 'state of the art' defence. That would undermine the protection of victims and impose an expensive and potentially impossible evidential burden on them in this highly technical area.
- 3.6 We do not consider the introduction of a no-fault state compensation scheme, as in New Zealand, to be a suitable alternative. It does not provide full compensation, which is a bed rock of our civil justice system. Such scheme, including the CICA scheme for victims of criminally inflicted injuries here in the UK, tend to significantly under compensate those with serious and life changing injuries. In our view, there should be no erosion of the right of innocent accident victims to recover full restitutionary compensation.

#### **4 What does the proposed Modern Transport Bill need to deliver?**

- 4.1 The Modern Transport Bill needs to sweep away the many inconsistencies between the Road Traffic Act and the Motor Insurance Directives as further particularised in

the Consultation Response by Nicholas Bevan, Professor Robert Merkin QC and Dr Kyriaki Nousia, University of Exeter.

- 4.2 It also must be capable of anticipating the known forthcoming technological advances as well as simplifying, correcting and clarifying the existing law. To delay anticipating known advances would put a very heavy onus on the Government to react quickly to this rapidly developing technology.
- 5 **Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**
- 5.1 Whilst agreeing with the Government's proposed strategy for a staged approach to regulatory reform, we think it would be advisable to invoke a provision that clearly fixes the driver with liability in any scenario in which they would have been liable if they had been in full control of the vehicle without the semi-autonomous system. To put it another way, the law should be clear that use of a semi-autonomous system should not be a defence.

*26 October 2016*

## Transport for Greater Manchester (TfGM) – Written evidence (AUV0027)

Greater Manchester Combined Authority (GMCA) is the transport authority for Greater Manchester (GM). Supported by the Transport for Greater Manchester Committee (TfGMC), a joint committee of the GMCA and the ten constituent district authorities, its transport policies are delivered by Transport for Greater Manchester (TfGM).

In line with our recently published draft 2040 Transport Strategy, TfGM are dedicated to developing an innovative city region. This includes utilising new technologies and innovations that add real value to the customer experience, improve overall connectivity for passengers, and integrate services across modes and sectors.

As part of this, TfGM has developed an Agenda for Intelligent Mobility (AIM) which details the wider goals for technology and innovation in Greater Manchester, including utilising advanced solutions such shared mobility, giving public transport the opportunity to deliver first- and last-mile transport solutions, and being part of multiple collaborations to explore Connected and Autonomous Vehicles and the future opportunities and implications of their deployment in our city region.

### **What are the potential applications for autonomous vehicles?**

The potential applications for autonomous vehicles are numerous and varied, and offer a range of potential benefits, including: increased capacity, improved safety, and improve efficiency. TfGM sees one application of Autonomous Vehicles (AV) as a natural progression for public transport, complementing a wider transport offering, including systems such as rail, bus, light-rail, cycling and walking. The vehicles themselves could offer a range of diverse opportunities, including fixed route and demand responsive small vehicles that carry up to 20 travellers, and larger public transport modes such as buses, trams and trains. Alongside this, AV could enable a greater frequency of services for evening and weekends: times which have traditionally had lower patronage and as a consequence, costs are harder to cover with revenue.

#### Passenger applications

AV has the potential to facilitate a shift in how customers access mobility services. Private vehicles are parked between 90-95% of the time (80% at home and 16% elsewhere)<sup>299</sup>. AV, which can pick up and drop off travellers without needing to be parked throughout the day, could create an environment that provides door-to-door mobility opportunities whilst also removing the need to own a vehicle for a significant number of car owners<sup>300</sup>. This also presents a new opportunity to open up land which has previously been devoted to parking spaces. This has the potential to enable customers to utilise multiple mobility services as part of their journeys, without compromising on accessibility. TfGM, in line with the draft 2040 Transport Strategy, has already developed a detailed proposal for how Mobility as a

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<sup>299</sup> Royal Automobile Club (2012)

<sup>300</sup> Transport Systems Catapult (2015): Traveller Needs Study

Service might work in the city region, and we believe AV would complement the proposal, adding significant value in Greater Manchester's dense urban areas.

### Road Safety

Perhaps the most potentially important application for AV, is to significantly improve the safety of travellers using the road network<sup>301</sup>. Human error accounts for approximately 90% of road accidents<sup>302</sup>. AV would utilise multiple systems such as LiDAR, RADAR, GPS and, eventually, Artificial Intelligence, which will gradually remove the human element from key decision making. The vehicles would be connected to each other and to surrounding infrastructure. This will enable AV to have a wider awareness of the environment they are moving through, and the movements of other connected vehicles, and take this into account during the decision making process. The vehicles will also be able to make judgements quicker and more efficiently, and react at quicker than human speeds, potentially reducing the number of accidents.

### **What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

TfGM believe that the key social and economic benefits of AV lie in their potential to provide more efficient door-to-door solutions for public transport users and enable mass transit options access to more remote or dispersed communities and out-of-town employment areas, where it is currently unsustainable to provide a traditional public transport scheduled service. AV would also enable travellers to utilise services that traditionally may have been inaccessible due to the lack of viable public transport provision to their area of residence, work, or time of travel.

However, in the rush to deploy AV we should not be blinded by the need to justify the technology through a range of perceived benefits, without fully considering all potential impacts or consequences. In the case of deploying a technology that will have full access to our national road infrastructure, it is essential that all aspects of cybersecurity, and physical safety, related to AV are investigated and strict targets should be enforced to ensure both citizens using the vehicles, and the spaces around them, are adequately protected. The technology itself must also be rigorously tested, to meet the expectations of local and national government bodies, before it is trialled in an open urban environment.

### **How much is known about public attitudes to autonomous vehicles?**

While we believe the technology for AV to be already advanced, one important challenge in shaping a domestic market is consumer acceptance and experience. Also, it is important to understand the benefits to potential users and businesses. Therefore, we see research exploring how potential customers will interact with this new technology as essential to achieving acceptance. However, TfGM believe research into public attitudes of AV is

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<sup>301</sup> KPMG (2015): Connected and Autonomous Vehicles – The UK Economic Opportunity

<sup>302</sup> Yan, Ping and Liping (2013) Analysis of Road Traffic Accident Caused by Human Error. ICTIS: Improving Multimodal Transportation Systems-Information, Safety, and Integration

currently limited, and this would best be tackled through pilot testing in live environments where customers can interact with the vehicles, whilst also being assured the technology is being continuously monitored for their safety.

### **What is the scale of the market opportunity for autonomous vehicles?**

Changes in customer expectations and choices in how they access mobility in recent years has shown that travellers are progressive and open to new mobility configurations, including shared mobility, if they provide cost, time, reliability, ease of use and/or connectivity benefits<sup>303</sup>.

#### Shared services and alternative fuel types

Subject to the principle of asset sharing becoming more mainstream, the majority of AV will be shared, rather than privately owned, allowing users to share and reduce costs and access a range of modes as part of their journeys. Alongside this, in a public transport context, the savings from no longer requiring a driver to operate a vehicle will enable more marginal services to be maintained.

As the vehicles themselves are developed, a focus on fuel and energy types is being applied to the projects. Many publicly and commercially funded projects have featured electric only AV<sup>304</sup>. As the vehicles will be able to drive autonomously to electric charging point locations, and/or re-charge other cars that are in need of a top-up, this could play a key role in addressing how electric cars could be realistically adopted by the majority of customers.

As previously mentioned, AV could also provide transport authorities with the opportunity to offer door-to-door transport choices without the need to own a private vehicle. TfGM has already developed a detailed proposal for how a Mobility as a Service pilot might work, and this proposal can be tested in a pilot offering, in combination with other public transport services.

#### Freight and Logistics

AV could also provide delivery services during times when demand for vehicles from passengers is less. This opens up the opportunity to use AV as feeders for urban consolidation centres (and last-mile deliveries in cities), reducing the need for HGVs to move through dense urban spaces during certain hours.

In the short-term there are also opportunities for bus operators and the logistics industry to utilise autonomous systems that allow remote operation of the vehicles, enabling them to take advantage of significant operational savings and safety benefits without removing the human operator from the equation entirely. This will enable a smoother transition for users of the technology in a commercial environment.

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<sup>303</sup> Transport Systems Catapult (2015): Traveller Needs Study

<sup>304</sup> Transport Systems Catapult: Lutz Pathfinder. <https://ts.catapult.org.uk/current-projects/self-driving-pods/lutz-pathfinder-automated-pods-project-faq/>

## **Creating an enabling environment**

### **Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

TfGM recognise that testing facilities will enable the technology to be trialled in a variety of environments and situations, before then being tested alongside other modes. It must be noted, however, for a trial site to exploit and maximise potential opportunities it must be sited in an area that fulfils a number of essential criteria, such as a concentration of relevant skills and expertise, an area that already benefits from close public/private sector collaboration, and an area with strong local political support for the implementation of new technology and innovations in an urban context.

Alongside the above, it is also essential the UK has a long-term plan, which is supported with funding and supportive legislation, to ensure organisations, such as transport authorities are able to invest in safety measures, infrastructure updates, and customer acceptance and experience programmes at a level that ensures AV are introduced to cities and city regions across the country equally, sustainably and safely.

### **Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

The technology for AV is developing rapidly, and as such a collaborative approach is needed between cities and city regions to ensure experience and best practice is effectively shared. The Government will gain significant insight by continuing to work in close partnership with cities and city regions to understand the needs and challenges each area is facing and how AV could be used to combat these issues.

The Government would also improve opportunities if it recognised and supported areas which already display the capabilities and resources required for testing AV technology. Preference should be given to areas that demonstrate an ability to add to the AV sector, instead of being required to compete for funding based on project specifications which can limit instead of support innovation.

## **Real world operation**

### **Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

Some sections of the transport network and supporting infrastructure will require updating to support AV services. The most challenging environments for AV would require significant investment. Investment of this kind could see AV deployed in urban environments, where the greatest benefits will be realised, at an accelerated pace. However, questions relating to local or centralised control centres and the acceleration of AV technology past the point of

needing supporting infrastructure on highways rendering investment wasteful, will need to be considered prior to investment and AV deployment.

**How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

An essential area for consideration prior to the deployment of AV, at both small and large scales, is the supporting policies, regulations and guidelines for cities and city regions. These areas have densely populated, multi-modal urban spaces which will require AV to meet very clear safety restrictions to satisfy the local authorities and citizens moving around the spaces.

TfGM believe it is the role of Government to work with transport authorities to ensure AV are able to meet these safety restrictions from the outset, otherwise AV implementation will be fragmented and unsustainable. Transport authorities also require tools which enable them to ensure AV deployment is in the best interests of all residents, and does not positively impact a few users, while having a detrimental impact on others using the same spaces.

Key milestones in AV deployment include:

- Adequate testing in a variety of virtual environments (simulations);
- Research into customer expectation and acceptance of AV;
- Policy development which satisfies the safety concerns of local governments, organisations and travellers;
- Limited testing in urban, semi-rural and rural environments; and,
- Testing along different road corridors including congested urban areas and strategic highways routes.

These milestones will not be met by single projects operating separately and outside of a wider collaborative effort. Instead investment needs to be made in key areas which support AV and AV technology development, as part of a wider strategic piece which acknowledges the importance of partnership and information dissemination across areas directly and indirectly involved, and those not involved at all.

**Does the Government have an effective approach on data and cybersecurity in this sector?**

The rise of connected devices in recent years has opened up citizens to potential threats relating to their digital and personal security. It is imperative that Government works in partnership with a range of organisations to devise clear standards, regulations and legislation to protect citizen's information and safety.

To effectively approach data and cybersecurity, and implement sustainable measures that provide businesses, organisations and public bodies with the tools they need to adequately ensure citizens are protected, the Government needs to work collaboratively with a variety of organisations (including global corporations and SME's) to better understand the current

cybersecurity landscape from a transport and technology point of view, and the potentially threatening areas that must be focused on.

**What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

In 2014, there were 1775 reported road fatalities, and 195,000 casualties of all severities, reported in the UK<sup>305</sup>. While the number of accidents is falling, over 90% of them are still caused in some way by human error.

In the same way it is accepted there will never be an “absolute zero” fatality rate where human drivers are concerned, there will also be times when an AV has to choose between options which will ultimately lead to humans being harmed. TfGM acknowledge the importance of informed debate on ethical considerations relating to new technologies entering spaces which are occupied by people, and we recognise there are a number of questions currently posed to this form of technology due to the lack of trials on British transport networks. However, we also believe AV development should not become stagnated due to ethical questions which demand absolute safety in all areas. In this case, TfGM believe Government, and other public bodies, have a role in determining the future of these technologies operating in close quarters with citizens, and this decision should be based on evidence collected through pilot projects, research studies, and risk and safety assessments.

TfGM also believe it is important to remember one of the key differences between AV and human drivers that may positively impact road safety will stem from the lack of indirect actions that often cause a crash, for example, an AV will not fatigue, be intoxicated, distracted by other devices or passengers, etc. However, it is important to understand that AV cannot, and will not, remove every chance of danger for humans within the vehicle or around it, in all circumstances. That said, it is vital the technology undergoes rigorous tests to ensure high safety standards are met.

**Wider governance**

**What does the proposed Modern Transport Bill need to deliver?**

The Modern Transport Bill should examine the opportunities for AV, and other developing technologies, to add real value to the customer experience, and generate wider socio-economic benefits. Focus must be given on developments which enable cities and city regions to implement solutions to local challenges which enable all residents to benefit, and support an “all inclusive” mobility package.

In reflection of this, consideration may need to be given to the current vehicle sharing regulations, allowing amendments that endorse and facilitate new mobility patterns and car-share possibilities, which would support AV and enable the reduction of congestion and emissions pollution.

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<sup>305</sup> WSP & Parsons Brinkerhoff (2016) Making Better Places: Autonomous Vehicles and future opportunities

**How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

There is a significant skills gap in the STEM sector, in Greater Manchester and other city regions around the UK<sup>306</sup>. Investment is needed to ensure these career paths are highlighted to young people, those interested are able to access education to support these career aspirations, and for local government to ensure there are wider supportive services, such as transport, to enable residents to access education and training facilities. Local government also requires a range of tools to enable these sectors to flourish and retain the skills that have been nurtured in each area.

**Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

The focus of investment up to this point has been almost entirely on small, privately owned vehicles. TfGM believe a wider focus, including the development of autonomous public service vehicles (including road, air and water vehicles), is needed to ensure all potential opportunities are fully exploited and maximised. In particular, focus should be given to vehicle classes which ‘integrate demand’ for peak-time travel and off-peak last mile deliveries, such as mini-buses which carry up to 20 passengers. By focusing on AV which could be utilised for public transport now, there will be more time and opportunity to influence the regulatory framework with public transport included, otherwise the future of AV will be mainly shaped by the car industry<sup>307</sup>. Current regulatory frameworks should be adapted to enable transport authorities to launch public transport pilots which allow for the utilisation of innovations such as AV.

**What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

There are a variety of potential issues that may arise due to Britain’s exit from the European Union. First and foremost is the potential loss of funding, which is often collaborative with other cities across the continent, that offer a joint opportunity for research and development and information sharing. Opportunities for collaboration with European academic and research institutions may diminish along with the loss of funding, as they will continue to partner with funding consortiums. This in turn may cause a reduction in knowledge exchange and information sharing between the UK and European Countries. However, TfGM are aware the future economic and social implications are still unclear, and believe is it the role of Government to provide clarity on potential future implications, both positive and negative.

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<sup>306</sup> The Greater Manchester Strategy (2013): Stronger Together

<sup>307</sup> UITP (2016) Tomorrow's mobility: What should be the role of public authorities?

TfGM also recognises the step the Treasury has taken to ensure agreed funding commitments will be met. However, this is only a short term solution, and a commitment will need to be made, from the Government, to continue to fund research and development in this area, if the AV sector is a priority.

In future, TfGM will continue to work with international organisations to share best practice and ensure new opportunities in technology and innovation are fully exploited, to add real value to the customer experience in Greater Manchester.

*25 October 2016*

## **Appendix**

Greater Manchester Combined Authority (GMCA) is the transport authority for Greater Manchester (GM). Supported by the Transport for Greater Manchester Committee (TfGMC), a joint committee of the GMCA and the ten constituent district authorities, its transport policies are delivered by Transport for Greater Manchester (TfGM). TfGM oversees transport and travel across GM, home of the UK's largest city region economy outside London. It:

- is responsible for delivering the GM Transport Fund, a £1.5bn transport investment package comprising Metrolink expansion, new interchanges at Altrincham, Bolton, Rochdale and Wythenshawe and additional bus priority schemes
- owns and manages the Metrolink network, which currently covers 58 miles with 93 stops across seven lines – hosting 35.5 million passenger journeys every year
- is delivering the Metrolink Second City Crossing and is working on preparations for a new line through to Trafford Park
- has delivered a network of Quality Bus Corridors comprising bus lanes and high quality bus infrastructure and is now completing a further package of bus priority to improve bus links between Leigh, Atherton, Salford, Middleton, Parrs Wood and the Regional Centre
- builds, maintains and staffs bus stations, Travelshops and interchanges, and installs and maintains 12,000 bus stops and 4,400 shelters (the majority under contract with JCDecaux)
- works closely with over 30 bus operators
- is overseeing an investment of more than £40m into cycle routes and facilities, alongside a programme of cycling information, education and training
- works with Job Centres, job-seekers and local businesses to encourage sustainable commuting

- is a key partner in Rail North
- manages the Key Route Network in partnership with all ten district highway authorities and Highways England
- is developing GM's Transport Strategy, alongside district authorities and the GM Local Enterprise Partnership <http://www.tfgm.com/2040/Pages/strategy/index.html>

## **Transport for London (TfL) – Written evidence (AUV0087)**

### **1. Introduction**

- 1.1. We welcome the opportunity, as the Mayor of London's integrated local transport authority, to contribute evidence to this inquiry.
- 1.2. Our purpose is to keep London moving, working and growing to make life in London better. We deliver the Mayor's transport strategy to deliver a modern, affordable and sustainable transport network promoting public transport, walking and cycling. We reinvest all of our income to run and improve London's transport services.
- 1.3. The emergence of autonomous vehicles (AVs) is significant for transport. As stated in the Mayor's recent consultation 'A City for All Londoners', we want to ensure that our investment plans can adapt to technological changes such as these, and to explore and understand the opportunities they present.
- 1.4. Our response focuses on the roads, where the implications of the agenda may be the most significant. We manage the city's 580km red route network, operate all of the capital's 6,300 traffic signals, franchise bus services, regulate taxis and the private hire trade, run the Congestion Charging scheme, and work to ensure a safe environment for all road users. There are more than 31 million journeys on our road and public transport network on an average day.
- 1.5. We note that the Committee's questions refer to autonomous vehicles throughout. We believe it is useful to separate out some of the underpinning elements of what is still a rapidly evolving concept. Autonomous vehicles become possible as a result of a number of factors including better connectivity and sensing data, predictive analytics and the emergence of artificial intelligence, amongst others. If these features are combined, they can lead to fully autonomous vehicles. However, the various steps on the way towards this – such as the data and information available from connected vehicles, or the application of advanced driver assistance systems – are also potentially important in their own right.

### **2. What are the potential applications for autonomous vehicles?**

- 2.1. Areas for potential application are included in comments to question 3.

### **3. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

- 3.1. We will focus on three areas: road safety, the need to accommodate population growth and optimising the road network.

- 3.2. **Road safety** is a key component of the Mayor's vision to create 'Healthy Streets' – aiming to reduce traffic, pollution and noise, create more attractive, accessible and people-friendly environment, and ultimately to improve people's health. London's road safety record has improved significantly over time, but 2015 still saw 2092 people killed or seriously injured. No loss of life is acceptable or inevitable, so the Mayor has stated his wish to adopt a 'Vision Zero' approach to road safety, which puts the elimination of road danger at the very heart of the transport system. If autonomous technologies – not just fully autonomous vehicles, but also driver assistance or pedestrian protection systems – can help to improve safety, it could have an important role to play in our future transport system. It will be important to ensure that such technologies operate effectively in a mixed system, when some vehicles have these safety features and others do not.
  - 3.3. A further major theme in 'A City for All Londoners' is the need to **accommodate growth**. At 8.8 million residents, London's population is now larger than it has ever been; and is set to reach 10 million by 2030. By 2040, an extra six million trips will be taken every day in London, exerting increasing pressure on limited road space. It is, therefore, the Mayor's aim to encourage the use of more efficient, low-emission vehicles, and overall less car and van use. Our priority will remain to promote walking, cycling and public transport; and to bear down on congestion. It will be important to ensure that business models for deployment of autonomous vehicles do not detract from these objectives, working alongside public transport to enhance mobility in the city overall, and do not provide extra pressure on the network, particularly as the emergence of AVs could disrupt the traditional patterns of private car ownership and use. Where private car usage remains prevalent, if innovative autonomous options develop or can be shaped that promote shared use above low-occupancy or individual trips, with vehicles that are ultra-low or zero-emission, then these could help deliver transport and wider objectives, including tackling poor air quality.
  - 3.4. Bearing down on vehicle usage by changing the way we travel to be more active and increasing public-transport capacity will not eliminate traffic, nor will it solve the challenge of needing to manage our roads and transport networks effectively. We also need to **improve the reliability of existing road capacity and manage congestion**, so that we can make the most of limited space. Promoting smart systems for managing the network will be fundamental to this. We have an agreed Technology and Data Strategy, with a long and progressive track record of promoting open data and exploiting technology for effective management of the transport system, including for better network management. The connected aspect to future vehicle technologies offers significant opportunity in this regard. We see the potential of new data streams that could help optimise road space management, monitor and manage air quality, provide better information to users and help identify, respond to and prevent incidents.
4. **How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

- 4.1. This sector is in a nascent stage. Implications could be far reaching but are hard to predict in an area so innovative in nature and which is stimulating the exploration of disruptive business models. Impacts are being assessed through the multiple studies and research and development projects being conducted both in the UK and globally. We closely monitor the outcomes of this work.
- 4.2. As a place globally recognised as a home for innovation, a number of these studies and vehicle trials are being proposed or are being conducted in London, for example the ‘Gateway’ project in Greenwich and Volvo’s ‘Drive Me’ trials. Our approach as the responsible roads authority is to engage constructively with all such projects to ensure any trials will be carried out in a safe way, avoiding disruption, and to establish how we can utilise information and intelligence from them to help us develop our policies and approach to help meet the Mayor’s priorities.
- 4.3. From a city perspective, one consideration is the likely need for local or geographical variation. For a city or urban area of any scale, different areas will have different travel and transport requirements. ‘A City for All Londoners’ sets out the distinctions of Central London (a world-leading cultural and economic centre highly accessible by public transport); Inner London (a dense, mixed place to live and work with most travel by public transport, walking and cycling); and Outer London (a diverse place where the majority of Londoners live and a significant proportion work). Connected and autonomous vehicles will need to interact with each of these in different ways to ensure an effective and seamless system that delivers Mayoral priorities - for example, continuing to reduce car use in central areas, but seeking benefits from more shared ownership or use in outer London.

**5. How effective are Innovate UK and the CCAV in this area?**

- 5.1. For such a cross-cutting area, it is a sensible move for CCAV to attempt bring together the various streams of activity across central government. Our engagement has been constructive and it will remain very important for the central organisations to have high levels of engagement with local transport authorities and cities, as we will be the locations for early deployment.
- 5.2. With regards to operation of their research and development, retaining the facility for local transport authorities to claim 100 per cent funding for their participation in the CCAV and Innovate UK funded projects in this area is important to stimulate engagement at a time of wider financial constraints.

**6. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

- 6.1. The extent of changes required is uncertain. Some organisations or technology developers advocate the absolute need to connect to infrastructure; others believe in the capabilities for in-vehicle technology which creates a lesser requirement for

connected infrastructure. We believe that we must be prepared for all potential outcomes.

- 6.2. An example of our approach is that we have already connected the majority of the 6000+ traffic signal junctions across Greater London (both Borough and TfL Roads) onto a wide area digital network. While the primary purpose of this network is to centrally control existing traffic signals, we have used industry standard communication technologies which could also be used to provide connectivity for autonomous vehicles. Thus if the market decides that infrastructure connectivity is required, we have already taken the first steps towards being prepared. It is important to stress however that the nature of any future vehicle-to-infrastructure communications needs to be defined, for example to determine whether the direction of communications is one-way or two-way, and the scope of data to be included.
  - 6.3. There are further examples in our approach to our traffic management systems. We already have a sophisticated mechanism for dynamic management of the road network that combines data and information from a very wide range of sources, including sensor systems (such as 'SCOOT'), intelligent management of junctions and traffic lights, and information from our buses, amongst others. We constantly strive to improve our effectiveness, including through new partnerships such as incorporating data from the Waze road app into our traffic management. Looking to the future, our Surface Intelligent Transport Systems (SITS) programme is being designed to maximise road network capacity through exploring data partnerships and providing the ability for others to utilise our platform. This will improve our capability to use vehicle data in real time to manage London's roads. Access to flow data from connected and autonomous vehicles could be part of this system, improving our capability to provide effective traffic management to tackle congestion, improve safety, and manage incidents.
  - 6.4. When designing new infrastructure for the future, we will consider the potential impacts of autonomy and greater connectivity. Given the rapid pace of change in technology, we will do so with care to ensure our investment decisions are adequately future-proofed.
7. **How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**
    - 7.1. Some milestones will be led by the market and the emergence of available technologies, while others will be linked to the evolution of the safety debate.
    - 7.2. On the latter, the speed and scope of the internationally-driven vehicle approvals processes - for us in the UK this is delivered through the EU and the UN - will have a very significant influence on the pace of change and deployment milestones.
    - 7.3. Given the rapid pace of technology and business model development, it is important to ensure legislative frameworks, regulations and type approval mechanisms are able

to adapt at the right speed. Local and national governments, as well as the international regulators are therefore faced with the challenging imperative to work together to create a sufficiently responsive regulatory and operating environment.

- 8. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**
  - 8.1. Connected and autonomous vehicles may emerge in ways that create new forms of transport and alternatives to traditional vehicle ownership. It is important for national and local government to consider where new frameworks will be required. For example, if autonomous vehicles are deployed via rental or through shared ownership models, this would raise interesting questions about whether existing type approval mechanisms would be sufficient, or if additional approaches would be required for, say, operated fleets.
  - 8.2. Whether it is through amendments to existing structures or creation of something new, we believe regulatory frameworks will need to adapt to fit the needs of connected and autonomous vehicles in a way that allows us to secure the benefits they could offer as we pursue our policy objectives, this may include considering where the gaps are in regulation. Given the importance of local priorities and differentiation as set out above, we also believe it is important for local transport authorities to work closely with the DfT as this evolves.
- 9. What does the proposed Modern Transport Bill need to deliver?**
  - 9.1. We support the structured approach taken by the Modern Transport Bill, which seeks to address nearer term challenges and close-to-market technologies, whilst also giving flexibility for the future to allow innovation to flourish.
  - 9.2. As mentioned above, we believe it is important to retain an agile approach that is able to react rapidly to developments in technology or disruptive business models. Importantly, we also believe it is essential to ensure the active involvement of local transport authorities, who ultimately will be the entities most directly involved in ensuring these vehicles can be incorporated into transport systems, and to help us achieve our objectives in serving the needs of our citizens.

4 November 2016

## Transport for London (TfL) and City of York Council – Oral evidence (QQ 40-47)

### Watch the meeting

Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Baroness Morgan of Huyton; Lord Oxburgh; Lord Vallance of Tummel; and Baroness Young of Old Scone.

Evidence Session No. 5

Heard in Public

Questions 40 - 47

### Examination of witnesses

Michael Hurwitz, Director of Transport Innovation, Transport for London (TfL) and Darren Capes, Transport Systems Manager, City of York Council.

**Q40** **The Chairman:** Good morning, gentlemen. We are grateful to you for joining us. I should say that we are being broadcast, so if you would like to introduce yourselves for the record and if you would like to make an opening statement, please feel free to do so. Mr Hurwitz, would you like to start?

**Michael Hurwitz:** Thank you. I am Michael Hurwitz. I am director for transport innovation at Transport for London. By means of introduction, we welcome the opportunity to present to the Committee as the Mayor of London's integrated local transport authority. Our purpose is to keep London moving, working and growing, to make life in London better. We deliver the mayor's transport strategy to deliver a modern, affordable and sustainable transport network, promoting public transport.

The emergence of autonomous vehicles is significant for transport and, as stated in the mayor's recent consultation document, *A City for All Londoners*, we want to ensure that our investment plans can adapt to technological changes and new business models such as these, and to explore and understand the opportunities they present to us, as well as the risks.

We noted that many of the Committee's questions refer to highly or fully autonomous vehicles throughout, but we believe, as the transport operator, that it is useful to separate out some of the underpinning elements of this, which is a very rapidly evolving concept. Autonomous vehicles become possible as a result of a number of factors, including better connectivity, sensing data, the emergence of artificial intelligence and others. If these features are combined, they do indeed lead to a situation where fully autonomous vehicles are possible. However, the various steps on the way towards this, such as the data and information available from connected vehicles, or indeed the application of advanced driver assistance systems without full autonomy, also have potential benefit and implications in their own right, which we also believe are worth discussing.

Thank you again for the opportunity to contribute to the inquiry, and I am happy to comment on this or any other questions you may have.

**The Chairman:** Thank you. Mr Capes?

**Darren Capes:** Thank you for the opportunity to give evidence to this Committee. My name is Darren Capes and I am the transport systems manager for City of York Council. My experience is that of a traffic engineer working for smaller, non-metropolitan highway authorities, which are responsible for the majority of the country's roads. In England and Wales around 5% of the road network is under the control of Highways England or the Welsh Assembly Government. That means that the remaining 95% of the network is the responsibility of over 140 local authorities of varying size and capability, so I welcome the opportunity to be able to give evidence on their behalf to this inquiry.

Although trials are now under way, generally authorities need to understand what supporting connected and autonomous vehicles will mean for the policy and funding decisions that they need to make now. They need to understand what technology decisions need to be made as existing highway systems reach the end of their life and new systems are considered. They need to do this against a backdrop of pressure to reduce costs and find further efficiencies in delivering services. They also need clarity on how the co-ordination of countrywide delivery of connected and autonomous vehicles will be managed between national and local government and the public and private sectors. Connectivity and some degree of autonomy is inevitable and will be driven by industry, the motor manufacturers and public demand. However, I feel that most local authorities are not yet sufficiently prepared to deliver it.

Again, I welcome the opportunity to present to this Committee.

- Q41** **The Chairman:** Thank you very much to you both. I should make it quite clear that we entirely agree with you that we see incremental progress of assisted automation, and we have already, of course, a number of incremental automations, such as AEB and the like. It is not, as you have just said, a question of whether but of how these can be managed and what happens when we eventually get to the stage of fully autonomous vehicles, if we do. Perhaps we should have made that clearer in the call for evidence a month or two ago. Nevertheless, having established that we are looking at the various implications of incremental progress towards automation, what do you see as the benefits and drawbacks of introducing these technological changes to our vehicles, and what might be the impact on congestion or, for that matter, on safety?

**Darren Capes:** I think there is an obvious benefit in network optimisation. There is a benefit in being able to smooth out the way in which vehicles drive. That will allow vehicles potentially to drive more closely together and allow capacity in the current highway network to be increased. It will also allow for vehicles to behave in a more co-ordinated way, and it will also potentially have accident-reduction benefits.

With autonomy there are also benefits that are perhaps not often talked about in freight and delivery. Certainly managing freight deliveries in historic city centres is a real issue, and the use of small van deliveries for services such as Amazon and the

like is on the increase. Autonomy presents a way of dealing with that in a sensible and co-ordinated way, and using its benefits to much better co-ordinate how those services are delivered in cities.

**Michael Hurwitz:** I agree with many of those points. I wanted to talk a little about opportunities for road safety, and share a couple of data points that may be of relevance to the inquiry. Across London the statistics show that road safety performance is moving in the right direction: 2015 had the lowest number of killed and serious injuries since records began. Just over 2,000 were killed or seriously injured; there were 136 fatalities. In the context of over 5.5 billion road trips a year, that is a relatively small number, but every one of those is a tragedy to be avoided, and indeed one of the priorities for the new mayor is a vision-zero approach to safety on London's network.

I will, if I may, break down some of that information, as it provides a potential insight into the opportunities for road safety. As I have said, there were 136 fatalities in 2015, of which 66 were pedestrians. We have extensive analysis of road safety, which also looked at the number of collisions between vehicles and pedestrians. In total in 2015 there were 728, and of those the vast majority were a pedestrian crossing the road and being hit front on by the vehicle. That is the first data point and indicates some of the causes of serious injuries and incidents on the roads.

Another data point is a research study that we commissioned from the Transport Research Laboratory and published back in 2013. It investigated the potential for driver assistance systems to mitigate road safety risks and identified a number of key technologies that have the potential to reduce casualties in the coming years. There are examples of those which vehicles already have: emergency braking for pedestrian collision avoidance technologies; intelligent speed adaptation, ISA; and secondary measures so that if unfortunately there is contact, the vehicle is also adapted to protect the pedestrian in those circumstances. They started to put an empirical basis on the opportunity there. Those are the technologies that would be an absolute minimum requirement of vehicles with high-level or fully autonomous systems, so there is an opportunity, we believe, that has real road safety benefits.

**The Chairman:** Mr Capes, you said that many local authorities are not yet equipped or perhaps are preparing to be equipped for developing, delivering, managing these new technologies. What assistance or legislation, if any, do you think such local authorities would need from central government?

**Darren Capes:** To link that into the other part of your first question, looking at drawbacks, most of the drawbacks around moving towards full autonomy are in how we transition from the current environment to a fully autonomous environment. Most local authorities, York and similar authorities, have very little understanding of how a mixed fleet could operate on the UK road network, and we do not see a great deal of guidance or research to help us with that. There was a lot of research around the technologies, as Michael has just outlined, around autonomy and how they will work, but we feel that there is not enough evidence around how this transition will be managed. It is around how we manage the use of mixed vehicles in the same road space, whether we need to segregate them or not, how we manage autonomous vehicles with pedestrian and cycle flows, whether we need more

segregation between autonomous vehicles and pedestrians and cyclists or less. Obviously, in many urban centres at the moment there is a chaotic mix of pedestrians and cyclists, and that works quite well. Once the vehicle fleet becomes automated and reacts in a more autonomous way to pedestrians, and vehicles stop more readily when pedestrians step in front of them, it may well be hard to stop pedestrians doing that, and it will become part of people's psyche that they can stop the traffic by stepping into the road and autonomous vehicles would stop for them, so you may need to increase segregation; you may not be able to have city centres that look as they do now.

These are all issues that at the moment we do not feel there is enough research or any real guidance on, and this of course makes planning and developing city centres and developing policies for the next 10 or 15 years on how city centres will develop difficult, because it is likely that in the next 10 or 15 years we will be in a mixed environment and it is difficult to see how authorities should react to that.

**The Chairman:** Would you like to add anything to that, Mr Hurwitz?

**Michael Hurwitz:** I think the points Darren was making around how you integrate the developments into a transport system are really important and relevant to us, and indeed to all cities. When we look across London, essentially the priorities are for a healthy city, an active city, and also to allow people to visit, do their work and their leisure activities in a smooth and seamless way. And what you see emerging is a hierarchy; if you look at different parts of London they have different requirements. We want to make sure that we promote active modes—cycling, walking; and if you have to move people around in motorised form, mass transit, public transport is the most efficient. But if you look at the characteristics in outer London and in other areas, the percentage of mode usage is very different. In outer London over half the trips are still in private cars, and the latest data I have is that, of those private car journeys, 60% have one individual in the car. If it can be evolved and shaped in such a way that it is a complement to public transport, a complement to active modes; if it can be done such that it increases shared ownership or shared vehicle usage and higher occupancy and higher efficiency, it can be a complement. We would not want to see it evolving in a way that takes people away from the more efficient or healthier modes. Maybe we will talk later about the opportunities of regulation in the Modern Transport Bill but our approach is to make sure it is shaped in such a way as to complement the city objectives rather than provide a detriment to them.

- Q42** **Lord Oxburgh:** As you pointed out, there are many local authorities in the country and they are responsible for the majority of our roads. How can this diverse group of local authorities keep up with what is happening in technological development and regulation? Do you see potential clashes between a central approach and a local approach, because in many places there are local regulations for the management of traffic which are different from city to city? How do you see this system going, how do you keep in touch, and are there organisations for local authorities to talk to each other about this?

**Darren Capes:** To take your last point first, traditionally there have been groups and fora that local authorities met in, certainly around transport and the technology of transport. Over the last few years they have waned somewhat but now, as the challenges of connected vehicles and autonomy come, they are starting to re-form; and there are new groups such as the Transport Technology Forum, which has been started in the last 18 months, which is again trying to draw local authorities together, and draw together the whole range of interests around traditional transport technology and the new technologies that are coming. I think government has a role to play in seeding that process and arranging for those groups to form and be supported. If that happens, there are plenty of willing volunteers among the local authorities who would relish the chance to be involved in that, and that is the way that local authorities traditionally have shared experience and generated a base of knowledge about technology.

As to the support that we need to roll it out in a homogenous national way but still support individual authorities, again, that comes down to how national legislation evolves around road traffic and transport. The technology needs to grow in a way that allows autonomous vehicles to be able to understand the particular traffic regulation orders that apply in each city. Currently that is the way the mechanism works, so national law sets out, obviously, the general law of how we drive and how we behave on the road; laid on top of that, local authorities are able to use traffic regulation orders to ban particular movements, to make particular local provisions. The technology needs to grow in a way that allows that still to happen, and again, that may require some government-sponsored national database or national data standard that allows vehicles to readily access local information and comply with the standards.

I do not see the fundamental way in which the law applies to the highway changing for a very long time. The way it applies, and the way we have this national guidance and national law which applies generally, and the ability of local authorities to use provisions in the Highways Act to enact local traffic regulation orders, is a very sensible way of doing things, and I do not think autonomy needs to change that. I think autonomy needs to grow in a way that allows it to fit into that model.

**Lord Oxburgh:** Some roads have HGVs barred, for example. Would you envisage the possibility of autonomous vehicles being barred?

**Darren Capes:** In the short term you may, and again, this comes back to the question we have no answer to at the moment: how do we manage the mixed environment of autonomous and non-autonomous vehicles? Ultimately, of course, you would say no, you want autonomous vehicles to go everywhere, because you want them to be a viable choice for people buying a new vehicle or operating a new service, but in the short term you may well end up with a new category of traffic regulation order which bans or limits the use of autonomous vehicles. Again, enacting that is not a problem, because the mechanisms are there within law; it is how you get that information into the autonomous vehicle so it knows automatically which roads it is barred from or what restrictions apply to it.

**Michael Hurwitz:** To add to a number of Darren's points, London, by virtue of its size and scale, has a different circumstance and role. We are involved in the UK's Urban

Transport Group, UTG—we are full members of that; we engage directly with the automotive industry; we have our own automotive forum, but we are also engaged internationally. People come to us asking for our views, so we are on the board of ERTICO, who I believe presented to the Committee earlier. We also have other international activity. The Mayor recently signed up to Michael Bloomberg's Aspen Initiative, for city leaders to try to determine the appropriate mix of policies and regulations for this new set of developments.

On the point of routes and how it might flow out, there was a categorisation I first read of in one of the OECD reports about how this will evolve, and they talk about two factors. You will have everything, full autonomy, in some places, and partial autonomy everywhere. That is quite a helpful way to think about it, because on the latter you will start to have elements of autonomy or of driver-assist, or of greater connectivity rolled out into the general vehicle parc, into operations, and for our freight, private transport and indeed public transport movements. In many respects that will not be in any way disruptive, because it will improve safety, it will improve information, and it will provide opportunities for optimising the network.

When you talk about full autonomy, you will have that in some places, and it will start, as I think we are seeing—and we are very much in a development in a trialling phase—in certain environments. The GATEway example in Greenwich is a captive environment. It might move to campus environments, and then on to certain routes deemed as the most appropriate. In Singapore they have certain dedicated routes where the autonomous services are running, and we would do the same. I would say the process will be sequential and it will build up. We will actively manage a mixed fleet by engaging with the early deployments to determine the optimum way of incorporating those in the streets.

**Lord Oxburgh:** Do you see local consultations about its acceptability playing an important role?

**Michael Hurwitz:** Absolutely. Darren was mentioning it. Often you talk about technology and technology developments on this, but a big priority for us is to understand the consumer side, the citizen side, the operator side, where behavioural responses are not yet known. Even if you do current assessments of attitudes, right now, for many people, it is talking about a concept that has yet to be experienced, so this is fundamental. In any engagement with new technology in Transport for London, our approach is to engage extensively with customers, staff, and even unions.

**Lord Oxburgh:** Thank you.

- Q43 Baroness Young of Old Scone:** You have begun to answer my question, which is really about the way in which this thing will roll out, and particularly timeframes for eventually getting to highly automated vehicle deployment. Perhaps I could encourage both of you, in the context of your own city, to take a punt at predicting how this will go and at what pace.

**Darren Capes:** I think the difference between the majority of UK local authorities and Transport for London is that TfL is of a size where it can influence the market. Most of us are of a size where we react to what the market does. That is the way it

is, unfortunately, or maybe fortunately. For a city such as York, we are in the hands of the manufacturers and of the public and how quickly they want to take up this type of technology. We have been pulled in various directions. It will depend on how quickly legislation comes along, how quickly the UK defines a unified way of altering the highway to allow for autonomy, but ultimately it will be down to how quickly manufacturers bring this technology to market and have it approved, and how eager people are to start to use it. I feel we will end up having to react to that. It will be out of our control. Our job is to ensure we are scanning the horizon sufficiently well to see these developments as they come along, and see what the large beacon authorities such as TfL are doing, and make sure we are in a position individually as authorities and nationally as a collective of authorities to be able to react to that.

**Baroness Young of Old Scone:** In the context of York itself, before we go on to London, it is a fairly narrow, winding place with not much scope for adaptation.

**Darren Capes:** It is, and again, that will have an effect. There are some areas we would want to encourage early—freight and deliveries would be an area of autonomy we would want to see happen quickly, because that has an immediate benefit, as Michael has already alluded to; there is a benefit without many disbenefits there. I think there are some real obstacles to wider use of autonomy in a city like York. You could see certain captive fleets, such as bus fleets and fleets of delivery vehicles, moving fairly quickly to autonomy. In the private car fleet I think it will take a lot longer. There are ultimately benefits in that but, again, we do not yet have a clear view as to how you manage the mixed fleet of autonomous and non-autonomous vehicles in narrow streets and in a very congested city centre.

To finish that, the early stages of autonomy obviously are already with us; the advanced driver aid systems are already with us, and that is of more use in an inter-urban setting. The driver vigilance and lane discipline type tools that are already with us are very useful in an inter-urban environment. I do not think they are that useful in the city centre. It is very hard to predict how quickly the types of autonomy that would benefit traffic in a city centre will come forward. Again, I think that is an area that is quite hard to put a figure on.

**Michael Hurwitz:** I will start where Darren finished. A lot of things are happening now, and many of the incremental technologies will be dictated through the internationally run type-approval process. There are a number of things due to come to market in the next couple of years, such as highway assist, which is the kind of technology Darren was talking about, but also traffic jam assistance technologies and valet parking technologies. They will be coming in the next couple of years, and they are quite well publicised for most of the major automotive manufacturers.

As for when we will see more advanced things, London indeed is different. It is by no means the only place in the UK where there is a significant interest in trialling, research and development, and early deployment, but they are happening already. Lord Borwick is involved in the GATEway trial in Greenwich; Volvo will be trialling vehicles that run at least part of the way in fully autonomous mode on London streets from next year, from 2017; and there are a number of other research deployments or early trial deployments that people are considering in London, so you will see trialling and research happening very soon.

Our approach to that as the authority is that we engage with anybody who wants to work on our streets. As an example, we are responsible for all 6,300 traffic light junctions in the city, so if they are driving on a network, we need to make sure that we are engaged and ensure it works as safely as possible. Interestingly, and this is another value, we want to see what intelligence and data we can glean from those studies to help us promote our safety objectives, our environmental objectives, and learn what we need to about the policy as we develop it for future years.

In the longer term I think the safety debate and the approvals debate are very important in dictating those timeframes. I am sure Messrs Yarnold and Forbes, who spoke on behalf of the Government, will have explained the UN and EU approvals processes which dictate when the mass market options will be made available.

**Lord Vallance of Tummel:** I was quite taken by your model that you would have full autonomy in restricted environments but partial autonomy everywhere. When you were talking, it was about location, but when you were talking it seemed to be not by location but by fleet type, delivery, and so on and so forth, so you have two partial set-ups. What does that mean? Do they clash with each other? Is it very partial because it is both by location and by fleet type?

**Darren Capes:** I think they are complementary. The way I would see it developing in cities like York is that you would have certain captive fleet types that run at certain times of the day on certain routes. For instance, in York we have an extensive park-and-ride network, and we are very keen to use the best technology we can, so we are currently in the process of electrifying all the buses that run our park-and-ride service. That will be a very small, easily managed captive fleet that could move to autonomy. It runs on fixed corridors in a fixed part of the city. That would be a good candidate. Maybe, as trans-shipment services start to develop around the country, where deliveries are trans-shipped from large vehicles into small vehicles for the last mile into the city, you could see those small vehicle fleets being autonomous, running through the night, for instance. Then as you move on into wider trials and possibly the use of autonomy in privately owned vehicles, as Michael said, there is the idea of different levels of autonomy in different parts of the city.

- Q44** **Lord Mair:** My question relates to mobility services. Do you expect highly automated vehicles to enable mobility services that currently cannot be provided to be provided, or do you see mobility services as being very much improved or changed by autonomous vehicles?

**Michael Hurwitz:** I am happy to start on this. Let us look at both sides of that coin. I fundamentally believe that the rise of autonomy and greater connectivity will lead to new services and consumer propositions being developed. I noticed, around a week ago, that Nissan have started a model where, rather than owning a vehicle individually, four or maybe five individuals would jointly own a vehicle, which encourages lower private car ownership, which is a positive thing from a city perspective. You can see how autonomous systems, or a vehicle that might be able to take itself to a pick-up point, would encourage a new model of personal vehicle ownership such as this.

I think it will lead to developments in the evolution of mobility services. Now, this is hard to predict. It is an area that is rife with innovation and with very talented technology developers, so it is hard to predict exactly. One point I would like to make about another opportunity: the accessibility potential is significant. Again, referring to London data, those who are less able and older use public transport options less frequently. Of all Londoners, around 39% use the tube every week. That drops to 16% for the disabled community and 23% for those over 65. If there are ways in areas that are less well served with public transport, or less well served with active travel options, or for individuals who are less able to take those up, there is an opportunity we would want to explore about whether that could provide a complement to the wider environmental, healthy city, transport network objectives.

**Lord Mair:** The other side of the coin there is, might people in general become less incentivised to use public transport? Could this lead to more congestion because more people think it is more convenient to order up a private car?

**Michael Hurwitz:** Yes, and I refer back to the hierarchy that I was alluding to earlier. If the business models emerge in a way that is lower emission, that is better than traditionally powered vehicles. If it leads to shared ownership and high vehicle occupancy, that is better than private ownership. If it evolves in a way that provides, for example, a supply to public transport networks or a complement to areas that are less well served, that is a good thing. What we would not want to see is this leading to a rise in private vehicle ownership and use where the network is already crowded. That is the role for national government but particularly for local authorities and local transport providers, to shape that mix of regulations, incentives, approvals, to ensure it is a complement, not a detriment.

**Darren Capes:** I think that for groups that currently find it hard to use transport, and for rural authorities, one of the biggest gains in terms of access to transport is around autonomy. Certainly rural authorities are finding it increasingly hard to provide high-quality bus services into rural communities. The demographic of the rural communities is ageing faster than the city communities, and we face a real issue around how we provide transport for those communities. Autonomy has a real role to play in allowing people currently excluded from car-driving to have some form of personal mobility. For rural communities that is a real plus point.

To echo Michael's point, York has for a long time now had a hierarchy of road users, and it has tried to push people towards using healthy modes, such as cycling and walking, wherever it can. That is partly because it is difficult to accommodate more vehicles in the city, and we obviously want to reduce vehicle numbers, and that basic challenge does not change if those vehicles are autonomous; we still have a finite amount of road capacity we can fill in the city. It is also because of the health benefits. We would not want to see people starting to make choices to call up an automated pod to bring them into the city. We would rather they walked and cycled, and that has a great benefit for the health agenda in the country to continue to encourage people to do that. I think it is a real benefit, but it needs to be managed carefully, and the consequences need to be carefully considered.

**Lord Mair:** Presumably, from the rural community point of view, it will be a lot more convenient to call up a pod than waiting for a bus that only comes twice a day.

**Darren Capes:** Absolutely, yes. As budgets become ever more strained, and they will probably continue to be, the ability for authorities to afford to run meaningful, useful bus services into rural communities is more difficult. Again, this is a potential alternative to doing that. In a lot of cases now we are running large diesel-powered buses to carry three or four people, and that is a very inefficient way to provide transport. Autonomy offers a much more efficient way of delivering that service to small but very needy communities.

**Michael Hurwitz:** To build on that point, this is another area where the incremental developments have huge potential. You referred to the classic scenario of an under-filled service. Before you get to full autonomy there is a lot of development now around the area of demand-responsive transport, dynamic routing. All of these technologies, which do not require full autonomy but utilise some of the same algorithms about routing, and sharing of information and optimisation in use of the asset, can be applied to solving some of these problems on the journey towards a greater level of automation. Again, that is a really great point of areas where we need to look at how the latest technologies can help not just a very futuristic world, but to improve the effectiveness and the consumer proposition for existing services.

**Lord Borwick:** London was really a pioneer in getting wheelchair accessible public transport in the taxis and buses, way ahead of other cities around the world, I believe, but the recent growth in mini cabs and Uber has moved away from accessibility in the grouping of personal transportation. Of course, a large number of the users of wheelchair-accessible transport are baby buggies, babies travelling in wheeled transport. Do you think part of the possibilities for the future that you have just welcomed for wheelchair accessibility should include the use of bus lanes for such wheelchair-accessible transport, even though they are not licensed taxis?

**Michael Hurwitz:** You are asking me to make a very bold policy statement.

*[Laughter]*

**Lord Borwick:** I was asking you to predict the future.

**Michael Hurwitz:** In fact, predicting the future and bold policy statements are both quite challenging.

**Lord Borwick:** Indeed so, particularly the future.

*[Laughter]* **Michael Hurwitz:** I have to refer back to the answer I gave—that once we know more about the options, the business models and the challenges and dilemmas this will present, we can look at any given policy, in full consultation with stakeholders, the technology providers and the representative bodies. So I am afraid that I am going to say it will really depend and will be one for the future. It is an insightful question, and it raises another of the issues that this presents to all of us, as operators and policymakers, regarding some of the new challenges that we are going to have to adapt to, and potentially quickly.

- Q45** **Lord Hunt of Chesterton:** I was a city councillor in Cambridge in the early Sixties, when we had double-decker diesel buses going down very narrow medieval streets, and we moved to pedestrianisation—healthy Cambridge—but now my own interests is the question of development of modelling and simulation in urban areas.

Many boroughs of London have relatively standardised methods of dealing with traffic and air pollution, air quality, which is one of your things. I am just wondering, as you move forward, for all these different boroughs to have wide policies, is there a move to develop model simulation methods that a wide number of local authorities can use? If everyone has a different one, it would be very difficult to do. I notice from your CV that you are on the IET. Is IET encouraging a standardised or general modelling that local authorities can try out? As you say, you want to try out these new methods in simulation mode.

**Darren Capes:** I think this is more a question about co-ordination between authorities than modelling. There are a fairly limited number of modelling options. It is not that authorities are using wildly different ways of modelling; there are a number of accepted ways of doing it. It is how you arrange the organisation to tie authorities together. This is more a role outside London for the emerging combined authorities and city regions, the larger-scale transport bodies that are starting to appear around the country, to do that on a regional level. In the past, when transport outside London was dealt with by a small number of large shire counties, that would happen. In my previous experience working for a county we did county-level modelling. As local government has fragmented, that has been lost to a certain degree. I think the opportunity really lies with the city regions and combined government and the larger bodies maybe to a level of Transport for the North and the like to take that on again and use the modelling tools which already exist to do that. I do not think a great deal of it is being done at the moment outside the large conurbations.

**Lord Hunt of Chesterton:** Does not, for example, TRL have some role in developing a national system that everybody can try out?

**Darren Capes:** To refer you back to an earlier answer of mine, I think government has a role in promoting the types of fora that local authorities can get together in and discuss this thing. It is really about engineers within the authorities themselves deciding on the best tools to use for this. As I think I said earlier, there has been a move away from that kind of joint working over the years, and it is now starting to turn around and we are starting to see more of it. This is an important role for that type of forum as it develops to discuss standards and probably to set informal standards that authorities can use. That is now starting to emerge but it is not there yet, by a long way.

**Lord Hunt of Chesterton:** Can I raise one small last point? You mentioned Singapore. Singapore, of course, developed some of these earlier methods of congestion charging and indeed modelling. Are we learning something from Singapore that we can apply here in the UK?

**Michael Hurwitz:** We have an MoU with the LTA, the Land Transport Authority in Singapore, so we have close relationships with them, yes.

To add to Darren's point, I think there is a role for central government but there is also a role for local transport authorities to make sure we share. As Darren has alluded to before, we have significant capacity. We have not done the modelling yet but we are currently in an in-depth process of looking with our academic partners

and frameworks where we can do some more detailed modelling. We have a number of techniques that are worth sharing. We produced back in 2014 a number of categories called Street Types for London, where we look at the different balances between movement and then place, what the different road types in parts of the city need to perform. We are looking at how we would model various scenarios on those. It is not ready yet but we will be working on it and I think it is incumbent upon all of us to share this. I think it is very important to evolve this in a way that reflects the differences between cities. There is a capability issue in the small authorities regarding how you can stay ahead of the game.

**Lord Hennessy of Nympsfield:** Michael, when you were making your statement you said your purpose is to keep London moving. I was very struck with the verb “keep”, because my memory of London traffic goes back to 1951 and the last trams on Highgate Hill, as immortalised in the “Goon Show”. I remember the Buchanan report, the box motorway, a fragment of which was built with park and ride, and all sorts of things. We have always been behind the curve; all the estimates seem to have underestimated the congestion and so on. Looking at this inquiry, it seems to me that the possibility of having mixed fleets of non-, highly, and fully automated vehicles all operating at the same time raises the possibility of chaos on a truly heroic scale. I wonder if your modelling will look at the worst cases, because there is a danger—I do not mean to be disrespectful to anybody—by the very nature of this inquiry, that we will attract as witnesses evangelists for the future, which we are all very keen on but you can be slightly gung-ho. There is a slight sound of the tambourine being rattled sometimes.

**Baroness Morgan of Huyton:** Can I add to that, because I am interested in the London aspect as well? Are you also, thinking about the congestion, looking at a very radical approach of moving much more quickly in London—with all this stuff about public consultation—but really using it in a dramatic way to tackle congestion?

**Michael Hurwitz:** The answer to both questions is yes; and yes, there are opportunities but there really are risks. Our approach is that, because of the scale of London, you have the opportunity to shape the market in a way that others do not. You have to look at all the scenarios and understand everything, and we will absolutely do that. But, alongside that, we have the advantage of scale and influence. Particularly at the moment, when you have companies looking to early deployment, they are looking, obviously, to international regulatory bodies in terms of how this would evolve. But, frankly, they are looking to major cities, in particular the megacities, where we have quite extensive ranges of regulations, licensing or pricing, and of course we will model a completely unfettered situation or scenario. In the various studies done so far that we have seen, we have not yet found an approach that we like. They tend to say, headline one: “Here is the huge range of impacts that this could have”; and two: “But it all depends on the policy”. But the answer is yes, you can be reassured that we will ask ourselves as many difficult questions as enthusiastic ones, but we also recognise that we will have a shaping function to make sure it evolves in a way that we intend to be complementary to our wider goals.

**The Chairman:** Baroness Morgan, are you happy with that?

**Baroness Morgan of Huyton:** That is fine, thank you very much, yes.

- Q46** **Lord Hunt of Chesterton:** The other feature we have to ask here is the question of how the introduction of autonomous systems will interact with how the streets are designed, the signals, and the white lines. Do you feel that will all change dramatically, or will autonomous vehicles work within the existing system?

**Darren Capes:** I do not think there will be any great change in the short term, or even the medium term. I do not think, even with autonomy, we will be moving away from rubber wheels on tarmac roads for a long while yet. Even fully autonomous vehicles will probably take that form. The basic construction and form of streets that we have now will continue.

I also think, and I think it is the view of most authorities, that it will be a very long time before we start to dispense with lining, signs and traffic signals, because of course, in an urban environment traffic signals, lines and signs are also there for cyclists and pedestrians; they are there to aid other road users, other than just vehicles, so it will be a very long time before we get rid of those, because I do not see what the alternative is, for instance, to assist pedestrians in crossing the road to some form of green man-type pedestrian crossing.

I also think until you move to a situation of full autonomy, which is a very long way away, you have to configure a road network to allow vehicles to operate in un- or semi-autonomous modes, as they undoubtedly will do, and that of course means putting a human back in control again, and for that you will need to retain the focus we have at the moment on visual aids to allow that to happen.

I think there is an underlying point here that many authorities, like myself, are very keen to get across, in that you have talked about evangelising and the sound of tambourines. We have a similar concern that we do not look too strongly at this and forget the basics of road maintenance, mending potholes, keeping the roads working as they are now, and it is very important that we continue to receive suitable levels of funding to undertake that job, because, as I have just said, I do not think the basic form of how vehicles interact with the road will change massively in the medium term, even if the method of control changes.

**Lord Hunt of Chesterton:** Will you have much more data? Presumably this is an additional element to the whole system, and that requires a lot more data.

**Darren Capes:** That is a very insightful point. One of the very early wins with autonomy is data. Of course, for any form of autonomy to work, you need connectivity between the vehicles, and between the vehicles and the infrastructure. That immediately presents authorities such as York and others with much bigger data sets to use than we previously had, and that allows us to do things like configure the way urban traffic control works better, so we are not just counting vehicles passing over loops; we are able to see a much richer data set of what the vehicles are doing. It potentially allows us to extract much more data from vehicles about how they are behaving and where they are travelling over potholes—we will be able to see that from how the suspension reacts. Where groups of vehicles start to put their fog lights on, we will be able to determine where fog is on the highway. This is all data that is pretty much available now, because most vehicles, certainly

most high-end vehicles, currently collect that data using their own internal vehicle network. What they do not currently do is share that data with the infrastructure, and that is very possible technologically. Trials are already under way. Certainly, York is currently involved in a government-funded trial to see how large data sets potentially from connected vehicles could help influence the way we manage traffic signals in the city and the way we manage congestion. For authorities such as mine and TfL, that is probably a very early win in the move towards autonomy.

**Michael Hurwitz:** Can I add one point to that? York and London are doing similar things. I agree on the infrastructure requirements. One of the things we are all doing is ensuring that when we upgrade our systems, we now have all of our centrally controlled traffic lights wired up to a private broadband network. That is for control. That was done because SCOOT, the intelligent transport system we have now, already reduces delay by on average 12 seconds at the junctions we have. We are upgrading that anyway because we need to keep the network running, but also we make sure it is done in such a way that it could facilitate use of further data in future.

I really wanted to second what Darren was saying about the opportunities. You asked the question, Lord Hunt, around a significant amount of data. I think one of the routes to this is that it is easy to fall into the assumption that we will be showered with huge amounts of data that we may not be able to deal with. I genuinely believe an option to looking at this is on an exception basis. One of the conversations we have had, a further example, is on modern cars, for traction control, anti-lock braking purposes, they can tell you when the road surface starts to become slippery. That could be from ice, water, a spillage. What we do not need as the operator is to be told every second that everything is okay, everything is okay, which creates a huge storage and analytical problem. What we do want on an anonymised basis, is when it happens; because the management of incidents and the management of flow presents to us as a network operator a significant opportunity to predict and prevent the likelihood of a negative incident. Privacy will always be absolutely paramount, but data need not be overwhelming for an authority to deal with.

**Lord Vallance of Tummel:** This is a very interesting session because, if you will forgive me, it is where the rubber hits the road; it is the practicalities. Correct me if I am wrong, but the picture you both seem to be painting is one of incremental, piecemeal introduction over a long period. There will be trials and errors, some things will be put right and eventually optimal solutions will come. What you need to get started with that is a consistent framework and a set of standards within which to operate. Is that what it is?

**Darren Capes:** Yes.

**Lord Vallance of Tummel:** Some of those standards will be international standards for technologies, communications set-up and so forth, and some of them will be at least national, looking at legal, insurance and regulatory standards. Have I got that right—that the way that this is likely to develop is piecemeal, bit by bit; people will try it in different ways in different locations with different fleets, and so on, but to operate that you need to have a framework which is reasonably consistent?

**Darren Capes:** Absolutely, yes, and I think you are right to say that there are strata of standards, and certainly the motor industry, which operates on a worldwide level, will implement standards across the world. Certainly, at an operator level, at a local authority level, we will look to national and maybe even European standards to determine how data is presented between vehicles and infrastructure, and the UK has a role to play in that. There is a very important point there, and this is going back to data: there is a potential that the data that comes out of vehicles is commercial and is owned by commercial providers. This could be vehicle manufacturers, the mapping companies, the TomToms and Googles and so forth. That presents a real danger to how this rolls out and how we utilise that data. There is a real issue around how we deal with that and ensure that authorities have access to the data they need at an affordable level.

There is also a danger with specific manufacturers or specific groups of manufacturers in areas such as traffic signal equipment locking in certain standards to force authorities to have to buy a particular type of equipment to work with another particular type of equipment. It is very important that the UK continues to play—we do already—a central role in ensuring that the standards that are developed are as wide as possible, so the market is as big as possible, but ultimately open, so that we have the maximum choices we can possibly have for procurement, and we limit the degree to which we are locked into proprietary and potentially costly standards.

**Michael Hurwitz:** I would add to that the rider that it is an area where some of the world's greatest engineering and software development minds are active, and a lot of potentially disruptive businesses looking at where they can come. There is the process that we are talking about, which is orderly; but I have the sense that it is the traditional challenge of the regulatory bodies or the standard-setting authorities keeping up with a very high level of pace. Perhaps there will be an orderly process, but I think it will potentially be punctuated with rapid steps forward, quite ambitious early deployments, which I think will create a degree of, I hope constructive, tension. But I do not think it is necessarily right to say it will be a slow and incremental trajectory.

**Lord Vallance of Tummel:** I do not demean that by saying piecemeal. Yes, there could be leaps backwards and forwards, but it will not be a nice, smooth, planned process at all. This is a marketplace.

**Michael Hurwitz:** Yes.

**The Chairman:** I was going to ask about how we handle this data and how we secure it for public access, but I think we have dealt with that very well.

- Q47 Baroness Morgan of Huyton:** I think that part of my question has been covered as well. It was really about the regulatory regime, so it is going a step further than the conversation about standards perhaps. To what extent are you already having conversations about what sort of regulatory regime will be necessary, and is that at the national, European, international or local level? I am particularly thinking about insurance and liability perhaps, as well as technical standards, and driver licensing. We are interested in what sorts of conversations are already happening.

**Michael Hurwitz:** There are a lot of conversations for a local transport authority. You point to the ones most relevant to you and the ones that you have an opportunity to shape. You have mentioned a couple of those areas included in the Modern Transport Bill, which is looking at insurance liability first, and some of the nearer-to-market technologies as well. We are involved. Maybe we have slightly more capacity to be involved than others, because people look to us for our opinion.

There are a couple of important points to make on this. The first is that, as you said, because this is where the tyres hit the road, we will be the locations and the geographies for early deployment, and we need to make sure we have the right mix of regulatory levers, incentives, et cetera, to make sure it is not a chaos scenario but a positive scenario that we are aiming towards. It is important for central government to have an active, ongoing dialogue with local authorities.

The second thing is, on regulation—it is a real challenge, and potentially this is a discussion for national government—we have to retain the ability to be agile. I think there are new mobility services that are not covered by the current mix of regulation. To give an example, as we wrote in our submission in advance, the taxi trade, the private hire trade and the buses are provided for in regulations and other incentives; but if you have a rental fleet or a privately owned set of autonomous vehicles, I am not quite sure how that would be covered; whether the existing type approval mechanisms would be covered; or whether we as local authorities would want to have a requirement to encourage the hierarchy that we spoke about before. How can we make sure they are low emission? That they share a degree of data that we believe useful? That we promote shared occupancy rather than perpetuating private car use? There are gaps, and the real challenge for us is that we are going to need to make sure that that voice is heard and that, whatever happens on a national basis, we can react.

**The Chairman:** We have time for one last question.

**Lord Hennessy of Nympsfield:** Who do you think will be legally accountable for vehicles that think for themselves when there is a crash?

**Michael Hurwitz:** Can I refer back to the answer that Mr Ian Yarnold gave this Committee a few weeks ago? The system of law in the UK is that if an unfortunate incident happens, all relevant evidence will be presented to the court and they will take an informed view as to where that resides.

**Lord Hennessy of Nympsfield:** What do you think they will determine?

**Michael Hurwitz:** There will be greater information collected on incidents in reality. There will be a very active debate. Again, this is a very tragic scenario, but if you look at the debate currently going on within the incidents on the Tesla vehicles, where there was a fatality, maybe that is starting to give an indication of the kind of questions that will be raised when you have those incidents. It is a combination of what was happening in those circumstances: what is the right role of the vehicle, was an individual complying with what they were meant to do, how culpable was the decision-making algorithm, what was the sensing information that was being collected? It is a very important question and one that is very actively debated.

I have given a long answer. I was going to say I think you should refer to Mr Ian Yarnold. I thought he said it very well on the various factors that will be taken into account in the UK system.

**The Chairman:** I fear that brings us to the end of this session. We hope to visit the GATEway Project in Greenwich in December so that we can follow up and see at first hand some of the schemes that are being tried, as Mr Hurwitz has described. If there is anything on which you would like to send us further evidence as a follow-up, on reflection, please feel free to do so. You will of course have a transcript and if it is inaccurate in any respect, again, you will have an opportunity to correct it.

On behalf of the Committee I thank you both very much, Mr Hurwitz and Mr Capes, for joining us this morning and helping us with our inquiry.

## Transport for West Midlands – Written evidence (AUV0075)

### Impacts and benefits

#### 1. What are the potential applications for autonomous vehicles?

Autonomous Vehicles are set to bring transformational change into the urban environment. Increasingly automated driving benefits:

- Safety
- Convenience and comfort
- Accessibility
- Efficiency and co-ordination of traffic
- Environmental Impact

The major gains to be made in these areas are primarily via the reduction of vehicles in tandem with a move to full automation across all vehicles, regardless of mode, and the introduction of low or zero emission vehicles. This is a major ambition, therefore to ease the transition specific areas can be targeted to aid the public acceptance. The introduction in various public areas such as university campuses, tourist areas and shopping centres will aid public acceptance and build confidence – this is key to enabling the uptake of this technology. Public Sector transport services, for example adult day care transport, healthcare delivery, etc. can be some of the first vehicle transport to transition as confidence grows. Integration into the mass transit system is vital within city region areas, identifying areas that have low levels of public transport connectivity acts as both a social need requiring a solution, plus the ideal test areas to determine the business models that will support the move to autonomous vehicles, especially when monitoring the impact their introduction will have.

The full benefits will be realised at Level 4, full autonomy, according to an MIT study published in 2014 *Road Vehicle Automation*, Frazzoli and colleagues studying Singapore estimated that 300,000 driverless taxis, in theory, could do the work of the 780,000 privately owned cars currently operating today in Singapore, while keeping waiting times below 15 minutes. A 60 percent reduction in the number of vehicles operating in Singapore.

Effective taxi fleet management, reduction in personal car ownership and access to electric and hybrid vehicles without the worry of charging them could produce up to 94 percent less greenhouse gas emission per mile worldwide by 2030 when compared to conventional taxis according to a 2015 study published in *Nature Climate Change*.

#### 2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

As outlined above in the answer to question 1 the user benefits are:

- Safety
- Convenience and comfort

- Accessibility
- Efficiency and co-ordination of traffic
- Environmental Impact

When deployed as part of an integrated transport approach, regardless of urban or rural environment, the public will effectively have access to a demand responsive transport system. Providing user specific vehicles (for example catering for users with limited mobility) on demand, whilst maximising the use of such vehicles will provide an efficient, effective service to users.

The disbenefits are very much centred on the ability to balance transport on demand with the numbers of people travelling, therefore it is imperative to integrate with mass transit transport modes to aid the efficiency and reduce environmental impact. There is the potential of increasing user inactivity leading to wider societal problems, therefore where possible keeping the use of vehicles to sector specific needs and ensuring where people are being transported it is not necessarily a full end to end service.

### **3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

Research is being undertaken to understand the full impact of this technology. The West Midlands is already at the forefront of design, manufacture and testing of the vehicles. This incorporates:

**Digital Simulation:** Warwick Manufacturing Group has built and utilises a full digital test simulator

(<https://www.youtube.com/watch?v=XqJlfK3Hqj0&feature=youtu.be&noredirect=1>).

Utilising virtual simulation to lower the cost of prototyping, analysing human computer interaction and provide as real an environment as possible, the area is leveraging the digital incubator environment and creative skills that use data and design.

Within the Midlands area there is advanced transport modelling focussing on autonomous vehicle impact being undertaken at Horiba Mira Ltd. in Nuneaton. This is allied to the research strengths of the 12 universities and the science parks in Coventry, Birmingham and Wolverhampton all of which have intelligent mobility, cyber security, alternative fuel cell and human machine interaction specialisms. The Advanced Propulsion Centre at Warwick Manufacturing Group is a centre of excellence for low carbon propulsion and fuels positioning the region at the centre of this global industry.

There is the ability to take advantage of the local creative digital sector too. Harnessing user experience, games development technologies and agile processes to enhance automotive manufacture with an additional sector that the region shows strength in. This can enhance not only the virtual prototyping but also the human computer interaction with the vehicles. Visteon, lead partner on UK CITE, will provide the ‘infotainment’ aspect, unlocking the potential for a whole new economy within connected vehicles. The iVMS project is working with Serious Games International Ltd (SGIL) based on the Coventry University Technology Park. Birmingham, Warwick and Stratford upon Avon are one of the 12 games cluster hub for

computer games development enabling the use of digital technologies to facilitate behaviour change through gamification and incentivisation.

**Controlled Environment:**

The stage following digital simulation takes place on the off road test track, enabling further research and understanding to take place – again the West Midlands can call on a wealth of experience. Communication infrastructure, realistic test track conditions, safety critical feedback and technical expertise are all available in close proximity and in a collaborative environment catering for large OEMs through to SME sizes precision engineered car manufacturers.

**HORIBA MIRA Ltd :**

One of the UK largest transport systems R&D companies. It has a technical team of >500 staff, including dedicated teams focused on Intelligent Vehicles and Mobility, controls and electronics and safety. Specialist laboratories ranging from electro-magnetic compatibility laboratories, components and structures test laboratories, simulation and modelling facilities to climatic wind tunnels. Host Europe's first purpose built Intelligent Transport Systems (ITS) facility for developing and determining the system performance of mobility products and services. To date the main focus has been in the fields of:

- Connected and Intelligent Vehicles: Autonomous control systems; Co-operative control systems; Active safety systems; ECO driving solutions; Human Machine Interfaces
- Intelligent Infrastructure: V2V - V2I and mesh communications interface; Data management, trustworthiness security; Off-board control systems and cloud based modelling tools for transport management
- System Performance: Safety, system reliability, cyber security, performance and verification.

**Gaydon test track:**

The Jaguar Land Rover Gaydon Centre is one of the principal engineering centres of Jaguar Land Rover and the location of the headquarters of Land Rover. The site houses a design, research and development centre and extensive test track facilities and is used for the design and development of Jaguar and Land Rover vehicles.

**Jaguar Land Rover Fen End:**

The development is home to around 300 staff in its Vehicle Operations, a specialist group of automotive engineers which prepares and refines a range of vehicles for global events and product launches. 200-acre testing facility.

**BCU campus (Project Insight):**

Leading on the developments within the Knowledge Hub, Eastern Side (Enterprise Zone) laying out a vision for 7 new public spaces connected with a fleet of autonomous vehicles. Providing a test bed to trial CAV, provide a tailored digital infrastructure and align with investments in infrastructure.

The key aspects include renewing a Corporation Plaza, Aston Square, Jennens Park, Cinema Square (in Millennium Point), Typhoo Wharf, Eastside Locks and Curzon Street with an extension to Eastside City Park.

#### **4. How much is known about public attitudes to autonomous vehicles?**

Public attitude is the subject of most debate related to CAV. The impact of introduction is the subject of pure speculation during this testing and research period. The core CCAV and Innovate UK funded projects are all studying the impact of these vehicles on public attitudes, the studies are key deliverables and due to be shared publicly.

A major difficulty in understanding public attitude is due to the fact that the deployment and use of this technology is not well understood, therefore speculation is framed by our current understanding of cars and how they integrate with society. A great deal of written work and research is taking place from the likes of Elon Musk estimating the impact of Tesla autonomous vehicles, through to academic research studies in many high profile universities (MIT, Cambridge, etc.). In the West Midlands we believe that identifying our areas of mobility challenges, providing this intelligence to the pod manufacturers and companies that will provide services we can set up valid tests that meet real world problems and then determine the public attitude as this is likely to be a different response to the more basic question of replacing current driving with autonomous driving that operates within the same pattern of life.

Introducing autonomous features within vehicles will start to move the mind-set steadily. The introduction of certain vehicles in controlled environments again will build trust. The final act of moving to fully autonomous vehicles almost everywhere will take a major step as, unlike autopilot on flights, many people are already drivers and therefore understand the mental steps undertaken to drive a vehicle. Replicating this in a machine has understandably been met with some scepticism.

#### **5. What is the scale of the market opportunity for autonomous vehicles?**

KPMG forecast is that the annual economic benefit of connected and autonomous vehicles will grow to £51 billion by 2030. Most of the benefits accrue to consumers who experience a transformation in the ease at which they can travel, which in turn generates wider economic benefits, such as fewer accidents, improved productivity and increased trade. These benefits are unlocked both by connectivity and increasingly autonomous vehicles. For example, the development of vehicle to vehicle communication with adaptive cruise control and autonomous emergency braking can substantially reduce motorway bunching which reduces travel time and accidents. We also forecast the development of the UK as a centre of excellence in connected and automated vehicle technologies, increasing production to 2.4 million vehicles in 2030.

The global value of entertainment and wellbeing services in non-commercial vehicles is forecast to grow at 25% Compound Annual Growth Rate to \$18bn by 2020. Greater connectivity is an opportunity for mobile network (LTE) and WiFi network operators to increase the productivity of their asset base with a new customer segment. AXA (2015)

estimated the 10 year benefits to the UK haulage industry for Intelligent Transport Services and safety services at >£20bn, quantifying the opportunity is part of the UK CITE deliverables.

### **Creating an enabling environment**

#### *Research and development*

#### **6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

Work undertaken in and around the West Midlands is moving towards developing the best multi-level test environment for connected and autonomous vehicles. The access to digital simulation at Warwick Manufacturing Group, the controlled test environments at Gaydon and Nuneaton and finally the inter-urban area between Coventry, Solihull and Birmingham will provide a mixture of motorway and local roads to test the vehicles. The ambition is to tap into the existing skill base across many industry sectors and scales of firms, from tier 1 manufacturers through to the SME supply chain and innovation incubators.

This work requires national and international recognition, to enable it to be a focal point, in the case of the West Midlands there is political and institutional recognition that should now, with additional investment, go further. This should go beyond demonstrating the movement of the vehicles in real-life conditions, it should reflect all the proposed benefits and economic possibilities. The demonstration area should have the ability to trial and test business models that are aimed at connected vehicles; develop connected vehicle infrastructure; work in many mobility sectors such as freight; identify health benefits; have access to a professional services sector to recognise the financial and legal implications and whole host of additional testing and research.

#### **7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

Primarily the UK Government can offer support and promotion, understand and recognise that the devolved powers to the West Midlands Combined Authority can help to deliver this facility. Recognise that the Midlands Engine with its Transport Innovation ask can build on this area outwards from the West Midlands and further afield within the UK where there are pockets of automotive and research specialities. It should facilitate bringing together people for developing standards to allow information exchange, ensure that different vehicles can use the infrastructure and ensure that driver, passenger, information and cyber safety and security are paramount. Internationally through the Britain is Great brand promote the facility as a centre for testing, development and learning.

In terms of key coordination the cyber-security aspect is critical, it is the only body that can take a central coordinating role. The issuing of security certificates to vehicles requires a national, if not international body, that has to be closely monitored and validated. The implications of implementing poor security can take on a national significance from a Defence perspective. The ability of vehicles to cross borders to facilitate movement also

opens up a new area of cyber warfare. The UK Government is key to this and the decisions cannot be left to the industry, EU and international standards coordination or the devolved local highway authorities alone. This presents a massive opportunity to grow the economy by developing expertise, business and skills to take a lead on this.

## **8. How effective are Innovate UK and the CCAV in this area?**

Innovate UK and CCAV are providing a key focal point for the research and development of CAV. They have brought together industry, academia and the public sector. The next steps taken are vital to taking the sector forward and ultimately scaling it. Innovate UK can distribute more funding to build a research and development area that acts as the focal point for the industry in the UK, if not Europe. The West Midlands is well placed to be that area, due to the previous investment and existing assets, combined with a political will to make this the region for CAV.

CCAV can act as the international liaison body, promoting the UK automotive industry and facilitate the advertising of the UK research and development area to manufacturers, businesses and academia. Working with bodies such as Drive Midlands, CCAV should be in a position to bring a massive slice of the international market to the UK.

## **9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

The opportunity for SMEs supporting many different facets of the connected and autonomous vehicles industry is huge. Harnessing the supply chain of agile SMEs, who can develop and refine the techniques to build parts, components, digital technology, products and services aided by incubators and business support programmes will build on the existing and growing skill base, much of which is already based in the West Midlands. The University R&D hubs are at the heart of utilising new manufacturing techniques, such as 3D printing, to develop the technology and equipment to rapidly build quality materials and components, putting the region at the heart of the new manufacturing techniques that will need to be flexible and sustainable.

The concentration of large scale business and associated SME supply chain is a key facet of the Midlands Engine, covering the whole Midlands area, not just the West Midlands. This region has already attracted 880 Foreign Direct Investment projects creating over 48,000 new jobs and safeguarding a further 23,000. Evidence from Midlands Connect shows that improved highway reliability and regular average speeds across the Midlands along integrated transport can provide an economic benefit to the wider Midlands of up to £800m per annum by 2036 with 143,000 additional jobs when a 10% reduction in general travel times are achieved.

The key enabling activity for the multi-sector industries that are required to support autonomous vehicles is the UK and global recognition of an area being at the heart of the environment. An area, such as the West Midlands, acting as a focal point has the compound effect of utilising many existing skills and also growing the sector to attract new entrants.

*Real world operation*

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

The extent of the infrastructure upgrades required is the primary research goal of the UK CITE project. This will provide understanding in a mixture of technologies that are easy to deploy whilst ensuring safety and security through the collaborative work of Jaguar Land Rover, Vodafone, Siemens, Highways England and host of other companies.

The car, infrastructure, data and connectivity factors all require harnessing efficiently to ease the deployment of this technology and aid the scaling up of the industry. Therefore changes will need to be made along the major routes, the key is matching the appropriate technology to the appropriate use of the vehicles. This demonstrates that greater research is required to identify viable business models that allows the deployment of CAV to meet specific needs in a cost effective way. During this research the opportunity to exploit new data sources, interactions between vehicles and service providers has to be harnessed to release further capital in order to improve the physical and digital infrastructure.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

This is a key aspect of the research needed to fully understand deployment. Trialling the vehicles with a view to understanding the public attitude, the integration with existing transport, the ability to solve mobility challenges and ultimately identify viable business models is key to enabling wider deployment. It is estimated that the major benefits will accrue once there is fuller automation, combined with improved fuel cell technology, the ability to get there is mostly dependent upon the behaviours people show when moving. Is there widespread agreement on car sharing and demand responsive transport? What is the appetite for uptake? How to incentivise travel behaviour change to create a more efficient network? The management strategy required will only be possible to develop once the implications have been tested. The proposal to identify a plethora of challenges across the West Midlands will aid this understanding. This is the key milestone to enable fuller deployment within the existing transport infrastructure.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

In terms of key coordination the cyber-security aspect is critical, it is the only body that can take a central coordinating role. The issuing of security certificates to vehicles requires a national, if not international body, that has to be closely monitored and validated. The implications of implementing poor security can take on a national significance from a Defence perspective. The ability of vehicles to cross borders to facilitate movement also opens up a new area of cyber warfare. The UK Government is key to this and the decisions cannot be left to the industry, EU and international standards coordination or the devolved local highway authorities alone. This presents a massive opportunity to grow the economy by developing expertise, business and skills to take a lead on this. The UK Government currently requires more work in this area, bringing together experts in various fields to

capture the best possible approach, building a central body that takes responsibility and can be held accountable.

The approach to data is currently lacking and if left to the automotive manufacturers alone the full exploitation may not be recognised and therefore more costly further down the line.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

The professional support services are already actively engaged in the research work around connected and autonomous vehicles. The financial, legal and insurance models are being defined and evaluated. They will need to be flexible to adapt as the market grows in maturity. Risk and responsibility is perhaps the largest and most difficult question, this is where the UK Government has to lead the way based on the existing research and working closely with industry bodies. The trial deployment is already challenging the responsibilities of the automotive manufacturers, infrastructure providers and the public highway authorities. The technology to capture and understand problems and ultimately assign responsibility is developing along the lines of the aeronautical sector, with black boxes recording conditions and helping to determine faults. This alone has implications in terms of both cost and time, but ultimately it is a challenge that paves the way for further economic growth. The country and companies that understand the methods needed to unpick this and work with the legislative authorities will undoubtedly stand to gain financially from this expertise.

The potential economic cost of mitigating risk, accepting liability or defending actions has to work in a way that does not deter the deployment of these vehicles. The UK will face a risk of being behind the international development opportunities if it is not at the forefront of this sector. The focal point of research and development from the manufacturing perspective and can also act as a focal point for the professional support services, again the West Midlands is well placed for accountancy, legal and insurance professionals.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

The deployment approach is again a huge influence on the ethical issues to be addressed. The level of complexity of deployment will invariably affect the complexity of the ethics. This requires research of practical infrastructure based deployment, public acceptance and professional service guidance around liability. The West Midlands does not believe there will be a one size fits all approach to the ethics and judgement issues. Deployment of vehicles in a sectioned off infrastructure will invariably lead to different judgment and liability decisions, perhaps akin to the current rail industry.

The judgment criteria is a major factor in public acceptance, therefore a simple framework of understanding based on deployment environment and intended use will aid the uptake. The level of complexity around deployment will be a major learning form deployment across a research and development area when it comes to the crucial aspect of sustainable

business models. Therefore we would repeat the call that further research is required that is built upon the excellent work undertaken so far.

*Wider governance*

**15. What does the proposed Modern Transport Bill need to deliver?**

The key to unlocking the benefits of autonomous vehicles is via the integration with existing transport infrastructure. Developing demand responsive travel in line with mobility as a service utilising market-led initiatives that incorporate public policy is key to the effective deployment of this technology. The Modern Transport Bill needs to deliver the environment in which to legitimately test the market in public with autonomous vehicles. Leadership from central government on the approach to cyber-security acting as a trusted broker to monitor security but respectful of personal privacy. The UK government should facilitate integrating payment and back office market places to create incentivisation for car share, multiple modes and active travel ensuring a seamless experience of ticketing for the customer, providing correctly tracked payments for the service provider and providing the information for effective transport planning. The data standards and financial monitoring to allow this should be led by government to ensure an open and competitive marketplace. The UK Government can guide the market using open standards and enforcing adherence, this will provide a more open market for new entrants, ensure greater competition and create specific marketplace solutions to ensure mobility options in areas where existing transport is seen to be uneconomic.

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

The autonomous vehicle industry covers a wide array of skills and sectors, encompassing engineering, digital skills, business development, management, financial, legal and a whole host more. The advantage of this sector is that it can act as a catalyst to inspire career choices to work in a technology area, no matter a person's background. The advantage of the multi-disciplined requirements is such that connected and autonomous vehicles can act as the focal point in an area to upskill the workforce, however the sectors are so varied that it will maintain diversity should there be unexpected turbulence in the marketplace, ensuring sustainable skills and continued employment to the people trained for this industry.

The West Midlands has suffered as a result of its focus on manufacturing once this sector declined. The history and association with the automotive industry is renowned, the autonomous vehicle industry provides an opportunity to build for the future whilst reflecting the past. There are already educational schemes at schools, colleges and ~~at~~university level that are aligned to the HS2 scheme. The same approach could be undertaken for autonomous vehicles. Identifying dedicated courses, apprenticeships and research projects for this sector could be achieved in a similar manner. As with HS2, this action has to take place now. Aligning this educational support to the proximity to a dedicated research and development environment will serve to catalyse and enhance further the offering in the region, enabling the economic goals of the West Midlands Combined Authority to be

achieved and act as a tremendous demonstration of how devolution can work in practice to support not only the local but also the national economy.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

The investment that the government has taken so far is welcomed. The UK is now catching up some of the leading countries in Europe, notably Germany and France. The connected vehicle trials around Coventry will in fact be leading the way in creating a large real world test environment, many other countries have focussed purely on the ability of a car to drive itself. The UK does however have some way to go in catching both the US, Japan and Singapore. These leading countries are looking at commercial deployment of the vehicles, they are consolidating tech companies, purchasing software and integrating rideshare and mobility as a service models. The deployment, peripheral businesses concerned with legalities and insurance can be further developed. Connected vehicles offer a whole new market that is currently untapped and can be further explored. The infrastructure, manufacture and deployment is a sector that could also flourish, developing low cost, low power, easily deployable components that can work globally in retrofitting infrastructure in developed cities through to low cost installation in the developing countries. The West Midlands would encourage greater investment in the infrastructure, public attitude, in-vehicle connectivity and professional services to take advantage of the existing research in this region to ensure that the UK is at the forefront of this sector.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

Automotive production is a truly global industry, Brexit poses a challenge for the existing sector let alone the future research and development. Connected and autonomous vehicles require a collaborative approach to standards to ensure that the full benefits can be achieved. The EU has lead the ETSI standards working with the Car to Car consortium to help design a European approach to connectivity and autonomous functions that unites the member states and also acts as a counter point to the US led standards. The nature of transport is cross-border, it is expected that vehicles will move from country to country and there will be an expectation that the connected and autonomous or driver assist functionality will also work. This presents challenges to infrastructure, cyber security and personal data. In a post Brexit environment the UK Government is urged to continue to keep and attract further autonomous research and development to support the existing market and to grow it for the future. The incentives to retain the key tier 1 manufacturers are vital, additionally the funding to participate in collaborative efforts to develop a standard approach to connectivity, data exchange, privacy laws and crucially cyber-security is also vital. In the short term the UK commitment has to be demonstrated in order to ensure that the Brexit negotiations are favourable to the industry and that the right skills and funding are retained here. We would recommend the following specific actions:

- Favourable conditions to retain the Tier 1 manufacturers (and therefore the dependant supply chain)
- Commitment to EU standards for connectivity and autonomous features
- Cyber-security leadership that works in partnership with the EU to ensure freedom of vehicle movement across border whilst ensuring a robust defence mechanism should cyber-attacks be conducted via vehicle based technology
- Creation of a world leading test environment to encourage the international motor manufacturers to the UK to test all aspects of the autonomous vehicle industry, including mass-transit, business model opportunities, car to car communication, car to infrastructure trials, professional services and skills. A truly world class test environment would keep the UK at the forefront of the sector irrespective of the Brexit implications

*26 October 2016*

## Transport Systems Catapult – Written evidence (AUV0071)

### Impacts and Benefits

#### 1. What are the potential applications for autonomous vehicles?

The attached CAV Value Chains report, authored by the TSC considers five main ‘scenarios’ or use cases.

Scenario 1: Privately Owned Passenger Vehicles with Advanced Driver Assistance Systems (ADAS) (SAE Levels 1-2);

- Scenario 2: Privately Owned Passenger Vehicles with Connectivity;
- Scenario 3: Highly Automated Privately Owned Passenger Vehicles (SAE Levels 3-5);
- Scenario 4: Highly Automated Heavy Goods Vehicles (SAE Levels 3-5);
- Scenario 5: Low Speed Urban Pods (SAE Levels 4-5).

#### 2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?

The CAV Value Chains report goes into these in more detail for each scenario listed above, but can be broadly summarised as:

**Direct market value** - Value from the provision and supply of technology and associated services, which could be exported internationally as well as sold in the UK.

**B. Wider socioeconomic benefits** - Use of the technology and associated services to the benefit of the UK economy, prosperity and quality of life.

The latter type of value could be realised in terms of:

- More productive time available (e.g. for leisure activities / working / resting etc.), time that had previously been spent actively driving;
- Fewer or reduced severity road collisions;
- Easing of traffic congestion;
- Potential reduction in emissions and energy use;
- Increased mobility and accessibility, especially for those that are unable to drive.

Also: <http://www.telegraph.co.uk/news/uknews/road-and-rail-transport/11403807/How-a-driverless-car-will-benefit-you.html>

**3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

**4. How much is known about public attitudes to autonomous vehicles?**

There is already considerable public interest in autonomous vehicles and a number of surveys have been carried out in locations around the world (as well as online) to gauge public attitudes towards the technology. Generally, these surveys have shown that the public are still mainly sceptical about “driverless” cars – with usually something like a 60:40 split between those who would be reluctant to use autonomous vehicles and those who would be keen to. Having said that, the circa 40% favourable figures are widely seen as impressively high for a technology that is not yet available to consumers and whose benefits have not yet been fully demonstrated.

The Transport Systems Catapult’s own **Traveller Needs Study**, carried out in 2015, considered attitudes to self-driving vehicles within the study’s wider remit of examining attitudes to travel in general, and found that of the 10,000 people surveyed in the UK, **39% would consider using a self-driving vehicle, rising to as high as 62% among young professionals living in cities**. See [here](#) for more details.

The TSC’s **Automated Transport Systems (ATS) team also carried out a survey in January 2016**, with the support of YouGov to look at whether familiarity with the technology helped to improve attitudes. Independent polling, carried out on a nationwide basis and also specifically in Milton Keynes, where the TSC has been trialling autonomous pavement-based ‘pod’ vehicles found that **61% of adults in Milton Keynes would be interested in using the pods, compared to a national baseline figure of 38%** (which is strikingly similar to the 39% of the Traveller Needs Study). See [here](#) for more details.

In terms of current live programmes, further public attitudes surveys are planned as part of the GATEway project in Greenwich, and also within UK Autodrive (for which the TSC is leading on dissemination and communication). The UK Autodrive survey is a comprehensive online questionnaire comprising 48 questions, the first wave of which was launched on 7<sup>th</sup> October. See [here](#) for more details.

**5. What is the scale of the market opportunity for autonomous vehicles?**

The TSC Technology Strategy states this is currently worth GBP 4.8bn per annum in 2016, rising to over GBP 50bn per annum by 2025. This is a conservative estimate, and the pace of change in this field is advancing and expanding so swiftly that it’s not unreasonable to expect this to grow somewhat faster and larger in the coming years.

**6. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

Not in the UK if we want to be world leaders. There has been a recent Government consultation on “UK testing ecosystem for connected and autonomous vehicles” [www.gov.uk/government/consultations/driverless-vehicle-testing-facilities-call-for-evidence](http://www.gov.uk/government/consultations/driverless-vehicle-testing-facilities-call-for-evidence) which asked a similar question. In response, the TSC and others have called for the “UK Offer” to have a small organisation/function to offer a clearer, more coordinated one-stop shop to access the many world class testing, engineering and academic minds the UK has. To market the UK offer globally meaning the UK can continue to progress and keep clear water between itself and other global competitor countries in the CAV sphere.

**7. Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

See the TSC testbed UK response.

**8. How effective are Innovate UK and the CCAV in this area?**

Both are great, but need more resources if the UK is to compete more effectively on the world stage. The UK currently punches well above its weight in the CAV arena, with much of that due to the good CAV investments of Innovate UK, and through the Government taking a global lead in establishing a cross government departmental policy unit in CCAV. Confidence in the UK’s ability to deliver in the CAV sector has increased faster because of these investments. The UK capability and advantage could be accelerated even faster if more resources were available. But that advantage gap has been closing ever faster, and may well be completely closed soon, as other countries invest more heavily in CAV solutions.

**9. Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

Some good UK examples exist e.g. Five.AI, Oxbotica, RDM, etc. But more are needed. Also scale-up finance and access to start-up capital is patchy at best, and requires a lot of time, effort and skill to extract funds in the UK. This has started to lessen in the last one or two years, especially as the TSC has become more well-known for its role in championing CAV, through LUTZ Pathfinder and seconding senior staff into the CCAV start-up team. TSC has also convening consortia comprised of SMEs, industry and academia, and for the TSC’s neutrality in its approach to IP management etc.

**10. Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

The potential impact of CAVs on the physical infrastructure debate will go on for some time. Whether there is V2V, V2I, V2X and/or all three, what is clear is that infrastructure that is being imagined, designed, and built now, needs to have capability for future compatibility and functionality built-in from the get go. Rather than trying to expensively retrofit and/or create new digital architectures to allow the systems and the physical infrastructure to communicate. What is perhaps clearer is that digital capacity, communication certainty, and speed of services will all come under huge strain in the near, medium and longer terms as

more and more ‘things’ become connected, which may dilute communication bandwidths/speeds/certainty levels etc, just when CAVs are needing them most to satisfy safety cases, use cases, consumer needs. Power generation is a stark example of this, as the move towards more electric vehicles and more home and public charging points increases the pressures on the UK power network will continue to be challenged. Add to that the likely high (and separate grid??) power generation needs for HS2, and a series of digital delivery capability and physical infrastructure demands start to become into starker focus.

**11. How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

Key milestone is permitting deployment of highly automated vehicles commercially in mixed traffic. For this we need a method for verification and validation of software safety, a large naturalistic driving study in the UK to act as a benchmark and solutions to deal with difficult driving situations, such as traffic management measures, adverse weather etc.

**12. Does the Government have an effective approach on data and cybersecurity in this sector?**

With increasingly sophisticated mobility systems, complex and interconnected networks across sectors and services, there are unique challenges for security in intelligent mobility.

eight key drivers of change for intelligent mobility and cyber security:

1. Technology is becoming more integral to mobility experience
2. Technological innovation in cyber security is accelerating
3. Internet connectivity is expected – and everywhere
4. An industry-wide approach to cyber security is shaping up
5. Transport is a critical infrastructure
6. Sector vulnerability and cyber threats are evolving
7. Safety and security are interdependent
8. Privacy will be an ongoing consumer debate

While the UK faces considerable challenges progressing the intelligent mobility market in a secure way, it is well placed to be a global leader.

five fundamentals of this unique emerging sector:

- **Intelligent mobility is a new cyber security proposition that is defined by the convergence of automation, new mobility models and smart ecosystems.**
- **The rapidly changing security and mobility landscape is likely to mean more cyber-attacks, more often, and potentially with more severe consequences.**
- **Understanding the nature of the existing issue is still a challenge.**

- The UK is well positioned to respond to the challenge as it already has strong capability in cyber security.
- The technology the UK needs is not an issue – secure intelligent mobility requires a robust strategy and cultural focus.

**13. Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

See answer to 11, and TSC response (attached) to the Government's recent "Advanced driver assistance systems and automated vehicle technologies: supporting their use in the UK" consultation which asked the above.

**14. What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

Potentially the emergence of these technologies operating in their fullest and greatest forms may actually negate the need for such discussions of ethical decisions over "which person or persons the vehicle will choose to avoid or save". Getting to this stage is many many years away, but testing the ethical concept against technological advances and safety and use cases already forms part of the insurance risk cases surrounding CAVs, and will be an interesting area to keep abreast of in coming months and years.

**15. What does the proposed Modern Transport Bill need to deliver?**

Light touch regulation, with an open and fleet of foot testing and investment environment to encourage continued UK company investment and increasing levels of Foreign Direct Investment into the CAV space in the UK

**16. How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

The soon to be published (2<sup>nd</sup> November) Intelligent Mobility (IM) Skills Strategy produced by the Transport Systems Catapult concludes that the UK must close the skills gap in the emerging autonomous and connected vehicles market or risk relegating ourselves to the back of the pack for decades in a global transport technology race. If no action is taken across the entire skills pipeline, £50 billion in GDP per annum could be lost. The UK faces a potential skills gap of 742,000 people by 2025 across the diverse IM landscape with around 200,000 of those being in the 'Disruptive STEM' high value digital skills arena - the top ten skills needed in automotive are future-oriented skills.

To address the skills shortfall, the report recommends an integrated range of interventions with transport industry experts strongly preferring higher-degree apprenticeships as part of the mix. In addition, new and novel ways of rapidly developing people with digital skills can be adopted in the UK if there is the appetite to challenge our current education system.

**17. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

The government's strategy in this area is very deliberate in focusing on the area of greatest UK advantage (road) as well as understanding how technologies and services can work in this most competitive and complex of environments will still allow for technology transfer across to other modes/sectors to occur when appropriately mature. That said there could be more focus on aerial vehicles, rail, maritime, hyperloops etc.

**18. What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

Access to the single market and freedom of movement of workers are key elements that will need to be reflected in the realities of the post Brexit UK CAV economy. As these, among others, will have implications on the level of skilled workforce, pricing structures, business models and operating models, and therefore overall UK competitiveness in the global export markets, and impact the level of existing and any new Foreign Direct Investment in the UK.

TSC welcomes the Government's commitment to support UK H2020 and other European funding programmes financial commitments in the short term until Article 50 negotiations are completed. However, anecdotal evidence suggests that despite this some existing consortia agreements have failed to progress due to other member states nervousness about UK involvement, with some other potential consortia not entertaining a UK presence at all. These may be immediate knee-jerk reactions or isolated examples, but they bear noting and keeping a close eye on. These issues were noted more in the wider innovation and Catapult context with the letter from a number of Catapult CEOs and Chairman that was sent to Simon Fiander the House of Commons Science and Technology Clerk on 15<sup>th</sup> August 2016 (also attached). While this was a broader than just CAVs Brexit response, the main issues and arguments apply just as well to this specific area of focus.

References and Appendices

**References**

Reference 1 – TSC CAV Value Chain Report – available on request - as we were not allowed to attach standalone documents

Reference 2 – TSC Technology Strategy for Intelligent Mobility – [tsctechstrategy.co.uk](http://tsctechstrategy.co.uk)

Reference 3 – TSC response to the “Advanced driver assistance systems and automated vehicle technologies: supporting their use in the UK” consultation submitted online via textbox – complete text available from DfT

**Appendices**

Appendix 1 – Joint Catapult CEOs letter to House of Commons Science and Technology Committee [not published]

Appendix 2 – TSC response to the “UK testing ecosystem for connected and autonomous vehicles” consultation [not published]

*26 October 2016*

## TRL (Transport Research Laboratory) – Written evidence (AUV0039)

*Submitted by Nick Reed, Richard Cuerden, Peter Vermaat & Alan Stevens*

### About TRL

TRL (the UK's Transport Research Laboratory) is a centre of excellence for research into all aspects of surface transportation. Founded in 1933, it was privatised in 1996 and is owned by a non-profit distributing organisation. TRL has contributed research to many of the most significant transport safety developments in the UK and internationally including the rules around drink driving, seatbelt use, mobile phone use and the EuroNCAP vehicle collision standards. It has been working on vehicle automation since the 1950s and has a growing and varied programme of research into the development and implications of connected and automated vehicles.

### Summary

**0.1** Connected and automated vehicles (CAVs) are developing along two converging paths. Fully automated vehicles operating in increasingly sophisticated environments and road vehicles in which automated systems take responsibility for greater parts of the driving task. The applications for CAVs are as broad as any situation in which people, goods or services need to be moved representing an enormous market opportunity.

**0.2** Potential benefits include improved safety, accessibility, emissions performance and asset use but these must be weighed against potential disadvantages including user confusion, changes in opportunities for employment and threats to equitable transport provision.

**0.3** The commercial benefits of truck platooning may result in this emerging as one of the early applications of vehicle automation technology with upcoming UK trials providing insights to its viability.

**0.4** Questionnaire surveys to date have been dependent on respondents imagining what the future may be like using automated vehicles. This may be subject to inherent biases that do not accurately represent the true picture. Current UK trials of automated vehicles will provide additional evidence on public perceptions based on real world experience of the technology.

**0.5** The UK government approach to date has delivered regulatory guidance, a dedicated policy unit (CCAV) and research funding to support developments of automated vehicle technology. This has enabled significant international impact, the development of interesting collaborations and support for developing SMEs in this space but the UK is lacking an equivalent to Silicon Valley in terms of investment, community and risk-taking approach.

**0.6** To maximise UK impact in this area, it is vital that the key organisations working in this area are provided with an environment in which they can successfully achieve international ambitions from a domestic base.

**0.7** Automated vehicles will be developed regardless of changes to digital or physical infrastructure. However, the deployment of automated vehicles may be significantly enhanced by having supporting digital and physical infrastructure available.

**0.8** The key objective in progressing towards higher levels of deployment of automated vehicles is that safety, security, privacy and network performance are not unacceptably compromised by their deployment.

**0.9** Insurance is a critical enabler for our road transport system. Regulation may be required to compel vehicle manufacturers to make data relating to incidents occurring in automated driving modes accessible. These data would need to be of sufficient scope, resolution and validity to allow an insurer to form a view on their liability for an incident.

**0.10** Ethical dilemmas faced by automated vehicles make interesting thought experiments but will not present as big an issue as it is sometimes perceived to be.

**0.11** It will be important to ensure the public are engaged in the increasing adoption of automated vehicles to maximise their likely uptake and deployment benefits.

**0.12** The most challenging outcome of Brexit would be the loss of the UK's ability to type approve vehicles for sale in Europe.

### **Full response to the inquiry**

#### *Impacts and benefits*

##### **1 What are the potential applications for autonomous vehicles?**

**1.1** There is a huge range of potential applications for connected and automated vehicles (CAVs). It is important to recognise two convergent trends in the development of automated vehicles. On one path, regular cars are being fitted with increasingly sophisticated driver assistance systems that are gradually automating more and more aspects of the driving task. Although other manufacturers have technology that may be more sophisticated, the vehicle maker that has had the greatest market prominence with driving assistance systems is Tesla through the deployment of its 'AutoPilot' system. This system supervises the vehicle on suitable roads (typically highways), including the ability to overtake slower moving traffic on multi-lane roads when instructed by driver (using the indicator stalk). It is important to recognise that the AutoPilot system requires the driver to be alert and attentive at all times should they be required to resume control at short notice.

**1.2** The other path towards automated vehicles is the development of highly automated vehicles that are designed not to have a human operator. Many such vehicles are already in service (e.g. Docklands Light Railway, Heathrow Ultra PRT). By the application of advanced

sensors and software, the scale and scope for the use of such vehicles is growing rapidly. It is this approach that we are testing in our project in Greenwich called GATEway, that is co-funded by Innovate UK and commercial partners.

**1.3** The applications for CAVs are as broad as any situation in which people, goods or services need to be moved. There are two important considerations that should be borne in mind. Firstly, it is vital to remember that the way a service can be delivered may be dramatically different if a human operator (often a significant cost in a vehicle service operation) is not required. Secondly, many of the benefits of automation can be accrued on both of the pathways described above before we reach the situation where vehicles are capable of driving in an automated mode all of the time.

**2 What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

**2.1** There are many potential user benefits of automated vehicle technology. One benefit is safety – 1.25 million people die on roads around the world each year and our own research has demonstrated that in the majority of these collisions, human error is the cause. Automation is addressing this driver error as a cause of road collisions. Two caveats – firstly, although we anticipate many fewer collisions with the advent of automated vehicles, we can also envisage new categories of collision that are caused directly by the use of automated systems and so we must be prepared to provide evidence and reasoning as to why the use of automated systems is of overall benefit from an ethical perspective. Secondly, whilst the number of casualties is too high, driving represents a remarkably safe system when one considers the quantity of driving that is undertaken. In terms of fatalities, if one uses the UK Department for Transport statistics to divide the number of vehicle miles driven per year with the number of fatalities per year, we find that there is around 180 million miles driven per fatality – which, if driven at a constant 60mph, would require more than 340 years of continuous driving (24 hours per day, 365 days per year) per fatality. This sets a very high bar achieving absolute proof that automated vehicles are safer than human drivers.

**2.2** A second benefit is accessibility – we have a growing, ageing and increasingly urbanised population with existing transport service provision already under pressure. Automated vehicles may offer new ways in which to achieve mobility across a city in a manner that is complementary to existing modes, may help to improve road network performance and could support active travel policies. In addition, automated vehicles can open up independent mobility for elderly and disabled travellers to help them achieve better health, social and economic outcomes.

**2.3** A further benefit relates to emissions and asset use. Automated vehicles make the development of car-sharing and/or ride-sharing services increasingly viable. This means that individuals can use vehicles that best suit their individual journey needs rather than the situation today in which a vehicle user selects a vehicle that best suits the majority of their mobility needs – resulting in many large family cars and SUVs being driven with single occupants (i.e. the driver) on many journeys. The ability to optimise vehicle choice against journey purpose raises the prospect of smaller, cleaner vehicles being used for short journeys whilst larger vehicles could be used more sparingly for longer and/or group trips.

**2.4** A disadvantage of automated vehicles relates to the long period over which we will see non-automated, partially automated, highly automated and (eventually) fully automated vehicles co-existing on our roads. This may present a confusing situation for vehicle users. A driver must always be aware of the extent to which their attention and input is required to maintain safe control of the vehicle as a function of the level of automation available. A mismatch between user expectations and system capabilities can be seen to have contributed to a recent high profile fatal collision involving the Tesla ‘AutoPilot’ system. Such issues (extensively studied in aviation in relation to automation of the flying task) are likely to emerge with drivers, especially since, as a population, they are typically less well trained, regulated, motivated or rewarded in comparison to pilots. In a similar way, pedestrians, cyclists, sensory impaired groups and other road users may also need to adapt their behaviour and expectations to accommodate the conduct of the various types of automated vehicle.

**2.5** It is often the case that emerging technologies change the employment market. Whilst a new system may make workers redundant (e.g. the use of heavy machinery in agriculture), it also creates opportunities in new areas. This can be expected with the growth of automated vehicles and their potential to replace driving jobs across the transport sector. This may eventually include delivery drivers, taxi drivers, lorry drivers, forklift truck drivers and public transport (bus, train, tube) drivers. However, the transition will not happen overnight. Many of the processes around goods deliveries and vehicle operations depend upon human operators for tasks other than driving at varying points in the chain and organisations employing drivers will have time to adjust, retrain and redeploy employees where possible.

**2.6** Numerous organisations have for many years claimed that some form of usage based road pricing would provide the best mechanism for managing congestion. The use of connected automated vehicles as a service would provide their operators (and regulators) with the means to apply dynamic charges for road usage with minimal additional infrastructure costs (i.e. identification, usage and charging can all be managed through app-based data). Charging may be varied according to a number of parameters including congestion, air quality, time of day, urgency of trip, route selection willingness to be shown adverts and total vehicle occupancy. There is a hugely significant role for national and/or regional authorities in regulating the delivery of transport services by such mechanisms to ensure that our roads provide adequate mobility for the broadest section of society. A city criss-crossed by so-called ‘Lexus lanes’ – routes where only the highest earners can achieve easy, free flowing transportation may benefit a minority but these must be weighed against potential adverse consequences to broader mobility across the city.

### **3 How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

**3.1** It is unclear to us how much is known about the impact of deploying automated vehicles in different sectors. Clearly, there has been much press coverage about the potential for deploying automated vehicles on roads (and the partnerships that have emerged between large industry players to develop the vehicles). Although the market is gradually seeing lower levels of vehicle automation that bring some driver comfort and safety benefits, the technology to achieve road vehicle automation that does not require at

least some input from a driver is not yet mature. At that stage, some of the more significant and transformative impacts are likely to occur.

**3.2** One likely early use case of vehicle automation (and connectivity) is truck platooning – the concept in which a lead truck can be followed at very short range by one (or more) other truck(s) forming a ‘platoon’, resulting in aerodynamic efficiencies and significant fuel savings for all participating vehicles. In a low margin industry where fuel costs represent a large proportion of costs, the commercial case for platooning is strong. The government is about to commission trials of platooning to understand the extent to which fuel savings achieved in technical demonstrations are achievable safely on the public roads with real trucks, real loads and real drivers.

#### **4 How much is known about public attitudes to autonomous vehicles?**

**4.1** Many questionnaire surveys have been undertaken and the impression that they give is that the public is broadly in favour of the safety benefits that automated vehicles may bring, particularly where the ability to operate a vehicle in an automated mode is an option over which they have full control over when, where and the extent to which the vehicle is automated. Surveys also suggest a less positive response towards vehicles that are fully automated with no opportunity for driver intervention.

**4.2** However, whether these surveys measure true public attitudes to autonomous vehicles is questionable. Firstly, they tend to be produced by organisations that have established interests in existing transport systems and so the questions may not be pitched in ways that are truly objective. Secondly, it is difficult to say whether the survey results give an accurate reflection of real attitudes to automated vehicles when none of the respondents to such surveys have experienced travel in an automated vehicle. This underpins the purpose of the TRL-led GATEway project in Greenwich. By giving members of the public the opportunity to ride in an automated vehicle and see them operating as a service in an urban environment, they may be able to access a truer perspective on how such vehicles could play a significant role in future transport.

#### **5 What is the scale of the market opportunity for autonomous vehicles?**

**5.1** The market opportunity for automated vehicles is no less than every motorised surface transportation system and indeed, many of the technologies developed for automated road vehicles such as artificial intelligence and computer vision are applicable to aerial and marine vehicles as well. The market is therefore sufficiently large to make accurate estimates of its size challenging. That should not discourage the UK from taking a prominent role in the technology that will deliver vehicle automation. In doing so, care is required to ensure that UK-based pioneers of the technology do not automatically seek for their company to be bought out by international corporations but that the environment in the UK is sufficiently connected and appealing to ensure that they can achieve their international ambitions from a domestic base.

#### ***Creating an enabling environment***

##### ***Research and development***

**6 Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

**6.1** Based on attending many international meetings, symposia and conferences related to CAVs over the last five years, the UK's current position on CAVs is one that is admired and indeed has been imitated by other nations. It has been established by three precepts; firstly, the government undertook an extensive review of regulations around the testing of automated vehicles and subsequently produced a code of practice for testing automated vehicles that provides straightforward guidance for organisations wishing to test automated vehicles on UK roads. Secondly, the creation of the Centre for Connected and Autonomous Vehicles (CCAV) has provided a focal point for the development of policy, regulation and research on CAVs in the UK and a conduit for international outreach, encouraging overseas organisations to bring their R&D, investment and jobs to the UK. Thirdly, it has provided seed funding for research through Innovate UK and CCAV to enable tests to get under way and to build momentum and capability in the UK for research and development in this area.

**6.2** The programme of research that has emerged from this work has broadened in scope and ambition as organisations within the UK have become energised towards this agenda. The initial three projects (including GATEway) focused on the automated vehicles in the urban environment. This distinguished the UK's innovation activities from those of many other countries. Following funding calls have provided broader scope for connected and automated vehicle research and development. It should be noted that whilst the investment from government (matched by industry) is very welcome, it is dwarfed by the research and development budgets of the major vehicle manufacturers and technology providers working in this space. A critical next step therefore is to attract major CAV research investment in the UK that complements and augments the developing indigenous capabilities in this space.

**7 Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

**7.1** Relative to other international governments, the coordinated actions described above indicate that the UK government is doing a good job to support research and development on autonomous vehicles. There is always more that could be done and there are two factors that are missing compared to other nations. Firstly, we do not have an equivalent of Silicon Valley – a region (and community/culture) in which technology start-up businesses can access huge sources of funding – some will fail (and fail fast) while a small proportion achieve exponential growth and become nationally and globally relevant.

**7.2** Secondly, whilst there are major motor manufacturers that provide thousands of jobs in the UK, none are domestically owned. Even if the UK can create the software that underpins all automated vehicle operations, we are (at present) highly dependent on overseas companies to manufacture the vehicles that will operationalise software that UK organisations may create.

**8 How effective are Innovate UK and the CCAV in this area?**

**8.1** The Innovate UK competitions that are funding projects related to connected and automated vehicles seem to provide an appropriate balance between encouraging the required research and delivering the required innovation to achieve significant return on

investment. Importantly, they provide a forum in which academic, research and commercial organisations from related sectors (e.g. communications, insurance, energy etc.) can form new partnerships that will enable the most interesting and (commercially and academically) profitable projects to be delivered. The CCAV team have reached out across the UK and internationally to coordinate CAV activities with enormous energy, dedication and openness. There is much more work to do and their continued support by government is recommended.

**9 Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

**9.1** The funding competitions run by Innovate UK and CCAV seem well positioned to support SME development. This is achieved in three ways; firstly, the gearing applied to the funding that enables SMEs to recover a higher proportion of their costs than larger organisations; secondly, the consortium building events that are coordinated by Innovate UK and CCAV provides fora in which SMEs can present their capabilities to a broad array of potential partners (and investors); and thirdly, the evaluation of Innovate UK funded project proposals can favour those that have well justified and commercially viable involvement from select SMEs. The ‘GREAT’ campaign and support from the Department for Business Energy and Industrial Strategy and the Department for International Trade also provides opportunities for SMEs to make connections they might otherwise miss.

**9.2** As stated in the answer to question 7, we are missing a UK-based technology start-up/venture capitalist culture that can provide a real springboard to turn SMEs into large and highly profitable organisations creating hundreds and eventually thousands of technology related jobs.

*Real world operation*

**10 Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

**10.1** Automated vehicles will be developed regardless of changes to digital or physical infrastructure. However, the deployment of automated vehicles may be significantly enhanced by having supporting digital and physical infrastructure available. This could enable the UK to achieve the predicted (societal, commercial, safety etc.) benefits sooner than other regions.

**10.2** It must always be the case that automated vehicles, in the absence of any data connectivity, must be able to navigate safely. However, information gleaned from external sources (whether physical or digital) may improve their operation and management. Physical infrastructure is typically built with a lifespan of decades in mind making it impossible to construct in a manner that can accommodate future (unknown) technologies. For the foreseeable future, it will therefore be desirable simply for infrastructure to be constructed that is consistent with design guidance such that automated vehicles find the environment predictable.

**10.3** Digital infrastructure – highly detailed 3D maps, annotated with important features of the operating environment – is likely to be a critical component of the deployment of

automated vehicles, which will rely on having this as a reference map in which to localise itself, navigate the desired route and detect deviations which may represent potential hazards. Significant questions remain over who has responsibility for collecting and updating the map data, how this map is refreshed sufficiently frequently, at sufficient accuracy and how mapping information is communicated rapidly and effectively to millions of vehicles as required.

**11 How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

**11.1** The key objective in progressing towards higher levels of deployment of automated vehicles is that safety, security, privacy and network performance are not unacceptably compromised by their deployment. Provided this objective is met, there is a critical role for transport authorities to regulate public and privately operated automated transport services to optimise equality of mobility across all sectors of society.

**12 Does the Government have an effective approach on data and cybersecurity in this sector?**

**12.1** The National Cyber Security Centre provides a good starting place for an integrated and coherent cyber security policy. The threats to connected and automated vehicles are technically similar to other cyber environments, though the consequences of successful penetration are unique. Hence the technical mitigation can easily be derived from existing guidance, and the threat analysis needs to be dedicated to the sector.

**12.2** Wireless connections to connected vehicles provide the most likely attack vector into a vehicle, but automation provides a target which can be easily exploited by allowing the attacker to potentially take control of the vehicle. As mentioned earlier, while automated vehicles do not require connectivity, there are such significant advantages that it is almost certain that automated vehicles will also be connected.

**12.3** TRL is supporting UK activity on the cyber-vulnerabilities of connected vehicles. In addition, there is a significant effort underway in the EC to address the cyber vulnerabilities of connected vehicles.

**13 Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

**13.1** Insurance is a critical enabler for our road transport system in which the driver of a vehicle is insured against damages occurring as a result of their operation of the vehicle.

**13.2** In an automated vehicle, or vehicle operating in an automated mode, the ‘driver’ or vehicle occupants may not have direct control of the vehicle at the time of an incident involving damage or loss.

**13.3** In such cases the owner or operator of the vehicle would need appropriate insurance for damages or loss from the event. It would be reasonable for existing motor insurers to take on this role and this approach was suggested during the government’s recent consultation.

**13.4** However, in taking on such a role insurers may find that access to data relating to the operation of an automated vehicle system during an incident is controlled by a manufacturer. If the insurer deems that the manufacturer may be at fault in an automated vehicle incident then a conflict of interest may thus arise between manufacturers and insurers.

**13.5** To assist insurers in providing insurance services to operators of automated vehicles, regulation may be required to compel vehicle manufacturers to make data relating to incidents occurring in automated driving modes accessible. These data would need to be of sufficient scope, resolution and validity to allow an insurer to form a view on their liability for an incident and to initiate action to recover their costs against other parties where appropriate.

**13.6** Accessible event data of this type would also provide essential transparency with respect to the real world performance automated driving systems which would be beneficial from a policy development and public confidence perspective. Bi- or multi-lateral event data sharing agreements between insurers and manufacturers without the opportunity for independent oversight may not best serve the public benefit which these technologies promise.

#### **14 What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

**14.1** The ethical dilemmas faced by automated vehicles make interesting thought experiments and it is true that automated vehicles will encounter situations where a collision is unavoidable and that choices made by the vehicle control system will influence the casualties (individuals affected, severity of injury etc.) resulting from a collision. However, there are two key reasons why this will not present as big an issue as it is sometimes perceived to be.

**14.2** Firstly, it can be anticipated that automated vehicles will be programmed to behave in a manner that better estimates the extant collision risk and provides adequate response time and space for the vehicle to respond in the event of emergency situations arising. As a result, it will be many times less likely that an automated vehicle will encounter an unavoidable collision scenario when compared to human drivers.

**14.3** Secondly, an automated vehicle will have a range of sensor equipment recording the driving situations that the vehicle encounters as well as recording the decisions applied by software to operate the vehicle in response to the sensor data. In the event of a collision, the recorded data will provide an evidence base from which liability in the crash can be determined. This objective evidence can be also be used to determine whether the vehicle behaved in a manner that could be considered most ethical. If an investigation or court decides that this was not the case, it may be possible to apply software updates such that vehicles using the same control system will behave more appropriately when encountering the same situations in future (though care must be taken to ensure that adjusting vehicle responses for a specific situation does not compromise vehicle performance in a range of other similar situations, resulting in an increased collision risk). Continually iterating this update loop in response to crash and near crash situations will enable vehicle control

systems to achieve optimised ethical performance. Note that different nations and regions may vary in the conclusions they reach about what constitutes ethical vehicle behaviour and manufacturers must account for this in their vehicle control systems.

*Wider governance*

**15 What does the proposed Modern Transport Bill need to deliver?**

**15.1** The Modern Transport Bill needs to provide the freedom that enables innovation to proceed such that UK businesses can outperform rivals but without compromising safety, security or privacy.

**16 How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

**16.1** The education system is capable of delivering people with the right skills to enable the development of the automated vehicle sector. However, greater issues are how to deliver the numbers required to continue (and accelerate) the current pace of development and how to ensure domestic organisations can provide a work environment such that UK-trained engineers and scientists are not tempted by opportunities overseas.

**17 Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

**17.1** In successive funding rounds, the awarded projects have broadened in scope and brought in expertise from adjacent sectors. Based on organisations showing interest in the latest funding round, this trend appears to be continuing. A possible shortcoming of the current strategy is the absence of a campaign to win over public 'hearts and minds' towards the use of automated vehicles. If the position is that they are genuinely going to play a critical role in our future transport systems, then a supporting case that aims to build momentum in their use could be helpful in achieving public trust and acceptance sooner.

**18 What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

**18.1** The most challenging outcome of Brexit would be the loss of the UK's ability to type approve vehicles for sale in Europe. The ability to test and validate the performance of automated vehicles (including physical and virtual testing) will be a vital step in certifying a vehicle as being capable of operating on real roads and mixing with real pedestrians, cyclists and vehicles. If an organisation wishing to access the European market could do so by bringing it for testing (and development) in the UK, achieving certification and then selling the vehicle in the 28 EU countries, this would represent a significant market opportunity (and failure to do so would be a significant lost opportunity).

**18.2** The European Commission is indicating that significant investment is going to be made in automated vehicle research. Exclusion of UK organisations from large scale European research programmes on automated vehicles may result in a reduction in the level of influence that the UK has on future research directions and regulatory outcomes.

*26 October 2016*

## **UK Space Agency – Written evidence (AUV0074)**

*Submission by: Daniel Jones, Space Robotics SRC Business Partner, UK Space Agency.*

### **1. Introduction**

1.1. This report provides an insight into some of the commonalities between space robotics and driverless vehicles, and where activities that align these two subjects are taking place in the UK. This report does not represent a complete reflection of the areas in which Space has an impact upon the development and operation of driverless cars and other autonomous vehicles. As such, it only responds to a small portion of the questions posed by the Lords' Select Committee on this matter, though does raise some other points of pertinence. The report answers the Select Committee's questions first, in Section 2, and then offers some added evidence, from Section 3.

### **2. Lords' Select Committee Questions**

#### **2.1. Creating An Enabling Environment: Research & Development**

##### **2.1.1. Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

2.1.1.1. Within the Space Sector, HRAF (the Harwell Robotics and Autonomy Facility) – which is under the custodianship of the Science & Technologies Facilities Council (STFC) in Harwell – has been defined by the European Space Agency to address a lack of infrastructure to support the Validation & Verification (V&V) testing of autonomy components at a mission level. Critically, as terrestrial sectors face similar problems, it is a core part of HRAF's remit to provide infrastructure and testing facilities for terrestrial (non-space) users. The connection between autonomous vehicles and space is already understood. The HATS (HRAF Autonomous Transport Systems), funded by the UK Space Agency in 2016, has demonstrated the use of autonomy frameworks for Pathfinder Pods in a simulation of Milton Keynes City Centre using V&V architecture derived from that used for Mars Rover simulations. This activity has brought together the UK Space Agency, STFC, and the Transport Systems Catapult, who led the project; evidence that Government stakeholders have recognised this link and developed the understanding.

#### **2.2. Creating An Enabling Environment: Wider Governance**

##### **2.2.1. Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

2.2.2. The space robotics sector may come to play a vital role in the operability, efficiency, safety and reliability of autonomous vehicles in the future.

Government strategy reflects this through the role the UK Space Agency is taking within the EC's Horizon2020-funded Space Robotics Strategic Research Cluster. The UK Space Agency is leading activities on the identification of technology transfer activities within this project.

2.2.3. Space robotics are most commonly used in orbital missions (such as on board the ISS) and planetary surface exploration missions (such as Mars Rovers). Some of the underpinning technologies required for these missions has been shown to be transferable to autonomous vehicles.

2.2.4. Within the Space Robotics SRC, the UK Space Agency is the Task Leader for creating a report into the “spin-in and spin-out” potential for space robotics. That is, how effectively space robotics technologies could be commercially applied in other sectors, and where other sectors could provide technologies and expertise to space robotics. The report will be published in February 2017.

2.2.5. This spin-out report identifies transport, including autonomous vehicles, as an area where some space robotics technologies may be adapted and applied commercially. These include:

- Advanced Data Fusion Framework: software that fuses data from a variety of sources, including sensors, LIDAR, and various cameras, to build a reliable and robust holistic model of its surroundings, in real-time. The model will be used by the vehicle to make decisions on paths to follow, hazards to avoid, and tasks to take. The Martian landscape may not seem to have much in common with complex environments on Earth, but the means by which vehicles will assess hazards is similar and transferable. An advanced Data Fusion Framework will be operable in multiple domains and environments, and various terrestrial vehicles, on the road and off, will make use of it.
- Advanced Autonomy Framework (AF): the decision-making core of the robot, or vehicle. The AF makes decisions based upon the model of its surroundings and in accordance with its objectives: on Mars this may be to move to a waypoint; in a car on Earth this may be to avoid a hazard while remaining on the road. The decision-making component of the vehicle is highly complex and an area in which the UK excels. The **ERGO** project, funded by the EC, features four UK organisations (**Scisys, King's College London, GMV UK, and Airbus Defence & Space**) is developing an advanced AF for the Space Robotics SRC. The technology may be used for future Mars exploration missions, but the project is also tasked with defining the areas where it could be exploited on Earth.

### **3. Satellite-Based Capabilities Supporting Driverless Cars**

3.1. Space-based capability is essential for the development and safe and reliable operation of driverless cars. The position, navigation and timing (PNT) capabilities of

satellite-mounted technologies will be required by autonomous vehicles to provide assured positioning and location information. The UK Space Growth Strategy is reaching to applications beyond the core space sector so as to be commercially viable, and the autonomous vehicles market is a potentially large customer for space-based PNT services.

- 3.2. The Space sector currently provides PRS (Public Regulated Service) PNT services through the Galileo programme, but its use is restricted to Government, and hence not for general use by the public. However, the technology is such that it would be highly desirable for manufacturers, owners and other users of driverless cars to have access to the ability to provide assured positioning of autonomous or other vehicles top public authorities may be undoubtedly helpful for anything from emergency services response to dynamic road traffic management and flexible vehicle taxing models.
- 3.3. Autonomous vehicles would be an undoubtedly good use-case for an authenticated PNT service, and a two-step service could be provided by the Galileo Commercial Service, which will offer similar services to that offered to Government, but at a cost.

*26 October 2016*

## **United Kingdom Atomic Energy Authority (UKAEA) and Remote Applications in Challenging Environments (RACE) – Written evidence (AUV0032)**

*This evidence is submitted by Dr Rob Buckingham FREng, Head of RACE.*

RACE, the centre for Remote Applications in Challenging Environments ([www.race.ukaea.uk](http://www.race.ukaea.uk)) is part of the UK Atomic Energy Authority ([www.gov.uk/ukaea](http://www.gov.uk/ukaea)).

Other evidence that is relevant but not repeated here for sake of brevity includes:

- UK RAS Strategy, July 2014
- Lloyds Register Foundation Foresight Review of Robotics and Autonomous Systems, Oct 2016
- RACE submission to the HoC S&T SC, April 2016
- RACE submission to the CCAV Call for Evidence, July 2016

### **Key message**

In order to lead, the UK should establish world class, real, permanent test facilities for robotics and autonomous systems. They will provide a forum to assess the impact of robotics well beyond driverless cars. They will attract and fix global talent and global investment in the UK. This is achievable and fundable. This market is moving at pace so time is of the essence.

### **“Freedom of Movement”**

There are two dominant models of transport usage. The first is to buy a bicycle, motorbike, car, lorry and just go, anytime, anywhere.

The second model is mobility as a service. Hailing a cab or buying a ticket for a boat, plane, train or ... SpaceX. Jump in, sit back, take in the view and arrive in style.

Life is a journey. How we travel is part of the adventure.

In one hundred years time we will be using autonomous vehicles. It seems unimaginable that we will not have the computers, sensor and software to solve the remaining challenges. We can see an end state.

But when will the transition occur and which of the many final potential scenarios will win out?

We don't know.

We don't know which multinationals will dominate the supply chain. Maybe none that exist today.

## United Kingdom Atomic Energy Authority (UKAEA) and Remote Applications in Challenging Environments (RACE) – Written evidence (AUV0032)

In a period of immense and serial disruption there is a role for government (of and for the people).

Is this role that of an observer only?

Is this role that of a regulator?

Is this role that of an investor?

Of course government will be a user.

My personal view is the UK will do well to stay in the leading pack of nations and that this will be enough. We should however aim to be #1 in certain elements of a RAS-enabled economy, based on our current capability and our ability to recreate ourselves by investing in skills and identifying future opportunities.

In my evidence to the HoC S&T SC on Robotics and Autonomous System I used the phrase 'stick and stay in the U.K.' In an age when technical experts work globally we need to find ways to make the UK attractive for long term research and innovation and commercial operations. Features of a successful strategy include consistent funding and clear annunciation of a shared vision. In the UK RAS Strategy we suggested investing in tangible and intangible 'RAS-assets': using 'immovable' infrastructure and national regulation to create environments where complete solutions can be implemented. We need numerous 'living labs'. The fact that global automotive OEMS are planning to conduct AV testing in the UK is a sign that this strategy has merit.

Over the last year I have led a project called PAVE: People in Autonomous Vehicles in Urban Environments. Our partners are Amey, Siemens, Orobotica and Westbourne Communications. We have used the UKAEA's Culham site (10km of roads within a fenced government owned site with 2000 working adults) to test Orobotica's driverless vehicles that are at the heart of the Milton Keynes and Greenwich AV projects.

<http://www.bbc.co.uk/news/technology-36810842>

[https://www.youtube.com/watch?time\\_continue=11&v=UxJLr378u00](https://www.youtube.com/watch?time_continue=11&v=UxJLr378u00)

<https://www.technologyreview.com/s/601910/roboticas-new-autonomous-vehicle-software-learns-as-it-goes/>

We have also been engaging with different stakeholder groups, the public, the UKAEA's employees and 'interested organisations' including local government and public services.

The excitement around Driverless Cars is palpable but there are also lots of questions and concerns. For the public, **cars are the first robots**. This is the first time the public will engage with the next generation of robots on a regular basis. Not only that, we will climb inside these machines and instruct them to take us to our destination.

How we respond to these machines will affect how our society develops. The user interfaces that we will be developed may well read and copy human emotion and be much more

intuitive, using the latest ‘artificial intelligence’ algorithms to make decisions. But the impact goes well beyond mobility. The sensors in the cars may well be used to collect health data, which could be a component of a move toward increased responsibility for our health and preventative, lower cost healthcare. It is also expected that driverless cars will increase mobility for the less mobile with consequent impact on quality of life, especially into older age. We also recognise that intelligent mobility is a key part of future community design with changes in ownership and usage impacting on house design and transport policy.

The primary area of interest for RACE is the use of autonomous vehicles (sometime called mobile autonomy) in **challenging environments**, particularly nuclear environments. The key drivers are decreasing cost and risks where the existence of an unavoidable hazard means that people are unable to or should not physically intervene. This is an area where we would expect people to remain ‘in charge’ although we expect that we will move from remote **operation** (working at a distance) **to** remote **oversight**, with increasing levels of autonomy being embedded into tools conducting the work in the challenging environment. The sectors for initial focus are nuclear, petrochemicals and space. RAS will also allow us to move out of our temperate comfort zone increasing our ability to work in our oceans, polar regions and in space. By enabling access to these challenging environments RAS will increase opportunities for new activity, leading to economic growth and both wealth and job creation.

As one example, the nuclear industry will adopt robotics technologies in order to increase safety and productivity of operations in nuclear facilities. This includes decommissioning end of life facilities. Robotics has increased productivity in other sectors by as much as 10%. Applied to decommissioning which is >£100billion liability (=market opportunity), this likely productivity gain should justify significant investment. Life extension of existing nuclear assets and the complete lifecycle of new nuclear, both fission and fusion and both small (e.g. SMR) and large reactors, will be impacted by development of robotics and AI.

At a technical level all of these issues have one thing in common: increasingly capable sensors feeding complex software running on ubiquitous computing hardware making decisions. This reinforces the idea that cars are the first robots. The tech that will be developed for driverless cars is directly relevant to all robotics. We need to ensure that robotics technology does not become sector-siloed.

There will be changes in employment patterns. This is potentially an opportunity to ‘rebalance the economy’ if we can encourage more of our talent to focus on STEM subjects. We need to imagine a society in which digital professionals are the highest paid and the most valued by society as a whole.

Having spent my career working in robotics, I am increasingly in awe of what people achieve routinely. Our ability to adapt and create is unparalleled. We should see RAS as the next generation of human-made tools that increase humanity’s ability to achieve amazing things. It’s all about people...

The remainder of this evidence focuses on the questions posed around ‘Creating an enabling environment’.

### **Creating an enabling environment**

1. The UK should invest in world class, real permanent test facilities. Robots operate in physical environments: e.g. roads, nuclear power plants, hospitals, and refineries. These environments have generic requirements (e.g. the need to localise and map) and specific challenges (e.g. pedestrians, radiation, patients and flammable products). Value can only be secured when complete solutions are available in the market. This means combining components to make systems and developing the operating principles and methods to deliver solutions.
2. Using driverless cars as one example: the focus to date has been on the car/pod and the agenda has been largely driven by the automotive OEMs. However, cars and other transport solutions in public and industrial environments operate within transport systems which have many components (many of which are hidden and highly interconnected). The interconnections between the mode of transport and their environment are a critical area that needs further attention.
3. There are a number of proposals in this area from around the country. Taking two from Oxfordshire: there are plans to provide a pod service in the heart of Oxford from the new railway station to the new Westgate centre and also in and around Didcot Parkway and Didcot Garden Town. Immediately these types of project are proposed it becomes clear that the mode of transport is only one issue amongst many.
4. The PAVE consortium, funded by CCAV/InnovateUK, has carried out research into testing public perceptions of driverless vehicles and the appropriateness of the UKAEA's Culham site as a test location for autonomous vehicles before going into Oxford and Didcot. This work has, to date involved both quantitative surveys and workshops with the public, members of staff who work on site as well as local and regional stakeholders, including elected councilors, business representatives and technical consultants. This work, which is ongoing, has established that there is strong support to use the Culham site for long term AV testing (88% of a significant sample of respondents to an internal survey were in favour) and that the investment in Culham will lead to benefits for the wider region. There is strong support from the local and city councils (Oxfordshire County Council, South Oxfordshire and Vale of White Horse District Council, Oxford City Council) and backing from Oxford University, STFC, Satellite Applications Catapult, MobOx, Smart Oxford, Siemens, Amey and many more.

### **Reasons for investing to establish world class test facilities include:**

5. Showing and demonstrating solutions in a realistic environment enables a conversation between stakeholders: regulators, insurers, users, investors, component and solution suppliers, and the ESPECIALLY the public.
6. Long term demonstration and test generates data that supports evidence based decision-making and investment.

7. Demonstration builds trust. This is vital for both public and private engagement and investment. We need to express our concerns and focus on real rather than hypothetical issues.
8. Testing in a real environment is essential for establishing and addressing weakness in the proposition that may be technical, commercial or social. Laboratory testing is not enough.
9. Open demonstration builds understanding at all levels: schools, universities, industry, and government. We need to explain the opportunity and the solutions – so that we remain an advanced technological economy ready to use the latest technologies.
10. Test facilities support skills training. Hands on exposure to robotics will encourage the next generation of entrepreneurs.
11. Test facilities attract global interest – e.g. the best academics and multinational R&D dollars will be drawn to facilities that generate activity (invention, start-ups, new products and services...)
12. Test facilities are geographically located. Test facilities act as nucleation sites for clusters, particularly if established close to global brands (cities, universities...).
13. Once established they are difficult to move. Long term facilities are hugely important to anchor a technology in a country and then attract and fix the more mobile aspects: software, finance, insurance, training, regulation.
14. Investing in test facilities is a cost effective, achievable ambition. The UK can develop these assets to encourage this technology to stick and stay in the UK.
15. Government involvement is essential for the following reasons:
16. The Government is able to seek assurances regarding widely held concerns including safety, ownership of data, privacy, security, regulation, cost, competition etc.
17. The Government will need evidence to support a conversation with the wider public and other stakeholders. Having direct and independent access to such data will increase the veracity of such data.
18. The Government will be a user of AV (e.g. DoH, DfT, MOD etc.).
19. Government involvement signals intent to 3rd party investors.
20. Government investment will create a valuable UK-owned asset.

**PROPOSAL 1: Invest now to create world class real test facilities which have open access for developers and end users. Use existing, accessible Government owned infrastructure and facilities to enable maximum engagement and nucleate clusters.**

21. CCAV is sending a very strong signal globally that the UK Government is engaged in shaping regulation to allow autonomous vehicles to be tested in the UK first. CCAV has already conducted an extensive consultation around the need for a ‘Flagship Test Facility for Autonomous Vehicles’. CCAVs evidence based proposals should be funded as quickly as possible.

**PROPOSAL 2: Reinforce and build on CCAV to maximise impact and share learning across Government (health, defence, energy...)**

**What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence**

22. We should be expected to ask whether driverless cars are safe or safer than current technology. In practice this issue will be rapidly resolved as the statistics show that autonomous vehicles are safer and insurance premiums (or cost of travel) reduce accordingly. Ensuring that the statistics are collected by trusted third parties and exposed to thorough scrutiny is a role of Government. There are perhaps parallels with testing a new drug. However, initial engagement should be light-touch.
23. The idea explored by some that software should or could make a decision to drive the car into a pedestrian and/or another vehicle raises some deeply philosophical issues, although further examination shows that these issues have been faced in other situations with our legal and insurance system adapting to manage, mitigate and share the risk. But, this question is itself based on a flawed understanding of what the new technology should offer. We should be writing and testing software to make sure that vehicles can stop before hitting anything. Vehicles will be able to sense the road conditions (weather, temperature...), each other (speed and path) and others including cyclists and pedestrians. Furthermore it is easy to imagine that each bicycle and pedestrian will be equipped with a beacon (i.e. a mobile phone). This raises questions about acceptable human behaviour (all pedestrians ‘must’ carry the requisite beacon) and how these ideas are socialised.
24. All of the above should be tested in representative environments.

**PROPOSAL 3: Establish a high level forum to monitor, pre-empt and respond to social, legal and ethical issues.**

#### **About RACE**

The UKAEA received £9.8million funding in 2014 from BIS and OxLEP (Greg Clark, City Deal) to establish a new centre for ‘Remote Applications in Challenging Environments’ – RACE. The inaugural Director of RACE, Dr Rob Buckingham FREng, was a lead author of the UK RAS Strategy, July 2014, and the LRF Foresight Review of Robotics and Autonomous Systems,

United Kingdom Atomic Energy Authority (UKAEA) and Remote Applications in Challenging Environments (RACE) – Written evidence (AUV0032)

October 2016. Jo Johnson opened the RACE facility in 2016 and the team of 85 engineers represents one of the largest robotics groups in the UK focused primarily on remote handling and robotics for nuclear applications.

*25 October 2016*

## **UK Atomic Energy Authority (UKAEA) and Professor Simon Blackmore, Harper Adams University – Oral evidence (QQ 11-19)**

[Watch the meeting](#)

Tuesday 1 November 2016

Members present: Earl of Selborne (The Chairman); Lord Borwick; Lord Cameron of Dillington; Lord Fox; Lord Hennessy of Nympsfield; Lord Hunt of Chesterton; Lord Mair; Lord Maxton; Baroness Neville-Jones; Lord Oxburgh; Viscount Ridley; Lord Vallance of Tummel; and Baroness Young of Old Sccone.

Evidence Session No. 2

Heard in Public

Questions 11 - 19

### **Examination of witnesses**

Dr Rob Buckingham FREng, Director, UK Atomic Energy Authority (UKAEA) and Professor Simon Blackmore, Head of Engineering, Harper Adams University.

**The Chairman:** I welcome Dr Rob Buckingham, from the UK Atomic Energy Authority, and Professor Simon Blackmore, from Harper Adams University. Would you like, first of all, to introduce yourselves for the record—we are being broadcast—and if you would like to make any introductory statement, please feel free to do so. Would Professor Blackmore like to start?

**Professor Simon Blackmore:** Thank you very much. My name is Professor Simon Blackmore, professor in robotics and automation at Harper Adams University, also in the new Agri-EPI centre being set up. My specialist area is in precision farming. I am director of the National Centre for Precision Farming but my technical interest is in developing what I now call robotic agriculture.

I was in the back just now listening to some of the questions, and the one point I wanted to make at the outset is that the work we are doing is not necessarily of benefit to the UK in terms of producing robot tractors. The benefit of our work is to make the crop production system significantly more efficient than it is at the moment. The benefit to the UK of introducing robotic agriculture is to make the whole crop production system more efficient and more sustainable, and so on and so forth. There are a lot of very good reasons for doing it. Fundamentally, that is the direction we are coming from.

**Dr Rob Buckingham:** Good morning. I am a director of the Atomic Energy Authority and I head up a new centre called RACE, Remote Applications in Challenging Environments, which received City Deal and Oxfordshire LEP funding. Prior to rejoining the Authority—I started there when I was 18—I have been an academic and also set up my own business, so I have been a bit entrepreneurial over the last 20 years.

**The Chairman:** Lord Vallance is going to open the batting.

- Q11 Lord Vallance of Tummel:** As a general starter, I wonder if each of you could outline how far along the road, or perhaps the off-road, the mainstream use of autonomous vehicles in your sector is, and what is the time-frame for deployment? Perhaps as a supplementary on that, could we both set up an industrial base, if you like, in the UK to manufacture the sort of kit you are talking about as well as helping UK agriculture?

**Professor Simon Blackmore:** As with a number of universities around the world, we have robotic tractors running around. Tractors have had auto-steer systems on them for many years. There is a very big difference between automatic steering and autonomous. Automatic steering is what I can get my students doing after a couple of weeks' teaching; we still do not have full understanding of autonomous yet. We are trying to work out exactly what that means and what is required. Technically, a lot of these things are available. I did hear, literally this week, that two autonomous tractors have now been sold in the UK for delivery in 2017. I have not seen them, I cannot assess them and I do not know what safety systems they have in them, but I am in discussions regarding them. We have demonstration of these vehicles running in controlled situations. As Lord Fox mentioned a moment ago, some of you may have seen in the *Times* today there is a spread on what we now call the "Hands Free Hectare". For the first time in the world we are now going to try to grow a commercial crop in the UK without anybody going into that hectare. We will do that through robotic tractors, robotic harvesters, drones and whatever else it takes to achieve that. Technically we are nearly there, and I am sure we will discuss the next stage in more detail as we go through, but there are a lot of other issues as to why we are not commercialising it right now.

**Dr Rob Buckingham:** We are at a very early stage in this technology. It is going to make huge strides over the coming decades, so we should not see ourselves as being out of any game; we are in a good position to make the most in this field, and we have to work out how to do just that. In the nuclear field, in petrochemical markets, in other challenging environments, we can see that there are real opportunities for this sort of technology to help us. This is not a replacement; this is an extension of human capability we are working at, so that we can work in challenging environments generally. It is very early days. If we look at, for instance, decommissioning at Sellafield or decommissioning in the North Sea, all these things would benefit from more efficient processes and tools. It is early days and all to play for.

- Q12 Lord Hunt of Chesterton:** It is very interesting to hear what you are concerned with. Can you describe the environmental factors that will limit it? I am a fluid dynamicist, so the notion of commercial shipping dealing with very large waves without anybody on the ship seems quite remarkable. Presumably in your dealing with these nuclear reactors and so on they are going to have special features that will make having autonomous systems quite tricky. Can you generalise the whole approach that, as it were, the system will apply to all kinds of applications?

**Dr Rob Buckingham:** You cannot generalise. That is one of the big differences between what you were talking about in the last session on driverless vehicles and doing things within an industrial facility. Those industrial facilities are optimised for safety, for productivity, whatever is required for that thing to function efficiently. It is very difficult to generalise when you come to the specifics. However, there are lots of very broad principles which are highly relevant. It is important to note that cars are the first robots. I look at the tech coming out of the autonomous vehicle piece as being highly relevant to anything that is happening in the challenging environment space. All the artificial intelligence and machine learning work that is going on—all the work on sensors, liability and all the other issues you talked about—is highly relevant to anything that is working in challenging environments. A key point here is that we must not make a disconnect between what is going on our roads and what is going on in our industrial, defined spaces, because that is where you start to get the bleed-through with technology transfer, and that is where you can start to build a viable ecosystem in the UK. These examples of extreme environments where people cannot or should not work are going to be users of this underlying technology.

**Lord Hennessy of Nympsfield:** Were the robots we developed for decontaminating the Windscale piles the world leaders? Is this where the pace was made for the whole business of AI and robots?

**Dr Rob Buckingham:** The nuclear sector has always required robots because of radiation. They have generally been robots operated by people, so we talk about remote operations: people with long tongs, or whatever, so you separate the person from the hazard. We are on a journey of moving from remote operation to remote oversight. We do not need to take people out of the loop completely; what we want to do is use the human brain and make sure that that is part of the loop, but enable the tools that those people are using to be more efficient and to get on with more of the job autonomously. That is the transition that is going on. It is not as dramatic as the transition in driverless cars; we are adding capability to those tools so that they work better.

**Lord Fox:** In its heyday in the North Sea, the subsea industry and ROVs were, if not the leading, a leading industry. Taking it from ROV to the next step, as you have just described, for subsea, is there crossover between what you are doing and what the subsea industry is doing? Is there a future there as well or has that now gone?

**Dr Rob Buckingham:** No, there is absolutely a future. Unfortunately, David Lane, who was meant to be here today, has been stuck in fog. He is the expert on underwater stuff and launched a company that was sold to Subsea 7, et cetera. Absolutely there is crossover. The challenge with robots is you have to know where you are and what is around you, and then you have to decide what to do. It is the same challenge, whether it is a car, a tractor, an underwater vehicle or a flying vehicle. There is lots of bleed-through, and one of the ways in which the UK can win in this area is by ensuring that we do not become siloed. We are talking around things such as assets—RAS assets was a word we used in the UK RAS strategy in 2014—the point being you need a farm, you need a hospital, you need Schiehallion, you need a nuclear power plant where you are testing these things for whether they

work. You are then trying to share knowledge between those areas so that you make progress faster. We do not have enough people in every single sector to win in every single sector, so we have to work smart to maximise the gain. We should perhaps come back to the question of how you make money out of all of this, which I think is the most pertinent issue in this.

**Lord Maxton:** Professor Blackmore, obviously you are more advanced in agriculture in automated vehicles than anywhere else, but at some point or other most agricultural vehicles have to go on the public roads. How do you get round that particular problem if you are ahead of the game in automation?

**Professor Simon Blackmore:** I mentioned in my written evidence that at the moment I do not currently support the use of robotic tractors on the road. Cars and lorries are designed to go on the road, the tractor is designed to work in the field.

**Lord Maxton:** If you are moving an automated tractor you would have to put it on some form of—

**Professor Simon Blackmore:** It would either have to go on to a trailer, or something like that, or be driven in the normal way.

**Lord Maxton:** That is fine if it is a tractor, but if it is a combine harvester?

**Professor Simon Blackmore:** Good question. There are still issues here. As I say, these machines are designed for off-road use so we need to be very careful how they are being used on the road, and transport is certainly a major issue.

- Q13** **Lord Mair:** In a previous session I asked a question about test facilities. My question to you is: are the Government doing enough for your sectors? What are your views about the need to invest in world-class test facilities, as far as your sectors are concerned?

**Dr Rob Buckingham:** My view on this is that test facilities are absolutely essential, but we must come back to how you convert that into jobs and growth. So not yet, but there are discussions around some major investments in this area, and if there are major investments announced then some of that money should certainly go into test facilities. This is about opening up places and spaces that are then used to test not just the technology but everything that sits around it—the insurance, finance and all of that. Are we doing enough? Not yet. That does not mean that we are behind the curve. Now is a very good time to make a serious investment in this area.

I will give you a couple of examples. In the nuclear space we should be doing something around identifying a building, for instance at Sellafield, which we take down using the latest technologies. On my site we are now running autonomous vehicles around it. This is a government-owned site which has 10 kilometres of roads inside a fence. Orobotica, the company you heard mentioned earlier, is using that site to do its pre-road trials. That is a site with 2,000 people and that is a really interesting mix of ingredients that allow you to start testing the vehicles, the people and everything that sits around it. Those are two examples. If David Lane were here he would say, “We should be identifying something in the North Sea which, instead of taking it apart, we use to develop these innovative techniques”. We need to make

sure that we put some of our money into the innovative part as well as doing the day job.

**Lord Mair:** Do you think the Government need to put a lot of money into such test facilities? Is that what is needed now?

**Dr Rob Buckingham:** I would make sure that part of the money going into infrastructure is for smart infrastructure. You can apply this to roads, to rail, to nuclear systems, or whatever you like. If we are just using that money to reinforce what we have done before we are not going to learn. We have to be willing to take some risks and ensure that some of that funding is used for the innovative piece. Government procurement is a very important tool to get traction in this area.

**Professor Simon Blackmore:** From the agricultural sector, every farmer I have spoken to has volunteered his or her farm when we are talking about laser weeding. We do need this opportunity to demonstrate equipment more than we are getting at the moment. I mentioned the “Hands Free Hectare”, which is the first start of this. The disruption that robotic agriculture will cause within agriculture and within the machinery sector, the advisory sector and so on, is difficult to overcome by itself. It requires a lot more demonstration before people will be convinced, because it is so disruptive. Therefore, I believe there is a role for the Government to be able to fund the development of this disruptive technology to make it clear to all those other potential investors that there is a significant opportunity here for them.

- Q14 Viscount Ridley:** In contrast to vehicles on roads, a lot of the things you are talking about here are either wandering around in the same space or fenced in with a geofence, or something. I would like to get an understanding of how different the global versus the local awareness of the technology has to be. What are the differences here? Also, we have heard talk of swarms, much smaller vehicles, doing things. One of the points that Harper Adams made in your written evidence is that the only reason tractors are so huge is that you are trying to get the maximum output from one man, and that you could go back to lots of smaller vehicles operating co-operatively, not competitively. Can you give us a picture of how different that world is from what we are talking about on the road?

**Professor Simon Blackmore:** When we talk about swarms, quite often we are talking about reducing the intelligence within each individual and allowing them to work together, as a bee or wasp, and so on, will do. We do not necessarily need to go to that level because each machine can be controlled by itself anyway; that is what we are doing now with these machines. We have the ability to allow multiple machines to work together: this machine will go down that row; that machine will go down that row; and make sure they do not meet each other down the same row. We have the capability to co-ordinate all these machines together. In doing the tasks we have already identified, as with any automation, we are looking at the highly repetitive, semi-skilled labour, and this is the easier-type situations we need, and we do not necessarily need advanced machine intelligence to do this; it is what we call deterministic. The other side of it is being able to be reactive. A lot of the operations are in semi-controlled areas, a field, and the public normally are not there. We can have fairly straightforward behaviour and safety systems to allow these machines to

work by themselves without having to rely too heavily on great levels of artificial intelligence.

**Viscount Ridley:** You can already buy a lawnmower that wanders around your lawn and does not go outside an area. Is that a model for the way these things operate?

**Professor Simon Blackmore:** No, because you would not want to plough your field randomly.

**Viscount Ridley:** A good point. Why not?

**Dr Rob Buckingham:** In my field, I am interested in finite numbers of devices that communicate. We want to use mobile vehicles with drones, with arms; the right tools to get the job done. This is a challenge-led issue; we are solving an engineering problem by using these tools to make the place as safe as possible and work as efficiently as possible. It is a very pragmatic approach. It is very focused; it is very controlled. We are making a managed assessment of the risk/reward.

**Lord Hunt of Chesterton:** One of the most major scientific challenges is perhaps not climate change, as Lord Ridley might agree, but dealing with our huge nuclear waste, where we may have waste lasting 10,000 years or more. One of the ways of doing this, of course, is transmutation, and transmutation has been made possible with fusion and fission systems. With your autonomous, much more complex systems, it will be of tremendous economic advantage, presumably, if we use this technology to get rid of, and possibly make energy value out of, all our nuclear waste over the decades to come.

**Dr Rob Buckingham:** Certainly we have some very valuable materials that we do not quite know what to do with. The robotics part of it is absolutely essential. Our futures will become increasingly nuclear, that is obvious.

**Lord Hunt of Chesterton:** Could you put an economic price on that? Let us suppose you could find a way of, as it were, using our waste. As you say, some of them are quite exotic materials. Obviously, people would sit up and take notice.

**Dr Rob Buckingham:** That is probably a topic that is not quite the same as this one. Fourth-generation nuclear power solutions and the like is probably not an area I am going to go into today. You are absolutely right. My point is that the robotics part of making that toolkit work is an essential component in making this whole sector work. As we think about the latter half of this century, we will have to have the robotic tools which will deal with these very unpleasant materials. Equally, we will want to use those tools to go and explore space and the oceans. All the places where humanity is limited at the moment will be the places that we start to gain access to in the latter half of this century and into the next. This is about enabling us to explore and make the most of these new places and spaces.

**Baroness Young of Old Scone:** Correct me if I am wrong, but the impression I am getting is that there is a fair amount of oomph globally and in the UK around developing autonomous road vehicles and that there is quite a strong government programme, a lot of interest and it is moving at quite a rapid pace. You are saying that we are at the beginning of this in your sectors. Do you think that enough

government attention is being paid to your part of the picture? If you could have more government attention, what would it be?

**Dr Rob Buckingham:** Ask me in six months' time. There is a lot of stuff going on behind the scenes, and we shall see what happens. If in six months' time a lot more is not happening then I will say that we are not doing enough.

**Baroness Young of Old Scone:** What would a lot more look like?

**Dr Rob Buckingham:** We would both say—I do not want to put words in your mouth—that we would want to accelerate the pace in these areas. The reason why the driverless car tech is taking off is that, in some respects, it is relatively easy because roads are flat. In other ways it is really difficult because it involves interaction with people. In our environment, you take those people out of the way and that reduces a lot of the concerns, and you have a different attitude to health and safety and all those sorts of things.

In some ways, our challenges are more technically challenging; fields are not all the same, nuclear reactors are not all the same. We need the tech to get to a mature level where we can trust it. We have just completed some work with the Lloyds Register Foundation, and there was a Foresight report on robotics and autonomous systems. A key word that came up in that was "trust". This is around people who are investing to get a return on their investment, whatever that means [however measured], and they have to trust those robotic tools so that they get that return. You are building the evidence base on which to do that.

**Baroness Young of Old Scone:** When you are looking for government support is it more money for research, is it bringing industrial and research interests together, is it more work on the regulatory system? What is your Christmas shopping list?

**Dr Rob Buckingham:** I would put it in the innovation space, so we need to be making more from our research. That does not mean stopping the research, it means making more from the research and making sure that gets into industry.

**Professor Simon Blackmore:** From the agricultural sector, when I compare the two sides, I see that we have cars before they have been robotised and cars after they have been robotised and they are still doing the same job. But in agriculture the whole mechanisation system will now change, and we are only starting to see what those requirements are and coming up with some of the prototype machines. From my point of view, we have a number of Innovate UK projects on the go at the moment, which we find very successful. The Government were very good with the agri-tech strategy; but now that that is coming to an end and it is all being pooled, my concern is that whereas we had that amount of money pointed in this direction and it stimulated the growth and interest—without that money this would not have happened—that money is now coming to an end and being pooled with everything else.

**Lord Hunt of Chesterton:** Do you mean pulled or pooled?

**Professor Simon Blackmore:** Pooled. It is being joined into the general funds. Well, it is being pulled because—

**Lord Hunt of Chesterton:** Being pulled has the connotation of being stopped.

**Professor Simon Blackmore:** The agri-tech strategy funding is coming to an end now, and any further funding is in a more general area. I would like to be able to see robotic agriculture being a named area that then will be recognised equally with medicine, transport and all these other things because the opportunity for British agriculture is so huge. If the funding were to slow down or stop then a lot of this innovation would slow down and we would not overcome the disruption. It is essential that this money is kept going to allow us to get to the point where every farmer can see the benefit of it or we can get more companies involved in making these machines.

**The Chairman:** The Government are expected to formulate an industrial strategy. Do you expect that strategy to be as specific as to refer to robotics in agriculture?

**Professor Simon Blackmore:** From what I have seen, no, but I would advocate that certain areas would be either priority or ring-fenced. As we know, agriculture is sometimes seen as the poor cousin; medicine or transport are seen as the big industries, and agriculture tends to follow along afterwards. I would like to see this type of research brought up to the same level of priority. Now that we have started the ball rolling, I would like to see it continue for a few more years. I am sure then we will get the industry to buy into it fully.

- Q15** **Baroness Neville-Jones:** I must say if an industrial strategy is going to be worth anything it needs an implementation plan that indicates what we are going to be doing, as distinct from where we think we might be heading in a few years' time. Your point is extremely well taken. Could I revert briefly to the question of regulation? You mentioned the word "trust", which seems to me quite important in this world. The environments we are talking about here are not so disrupted by unreliable humans wandering around the place. On the other hand, you said that technically it is quite challenging. What is the role of regulation in the areas we are talking about here? Is it more technical regulation or is it the context in which these robots are used? How important is that in the cycle of development? Do you do the trials first and then draw the regulatory consequences, or do you have to have a regulatory framework before you can do that? How do you see that sequence developing?

**Dr Rob Buckingham:** Historically, the regulations have grown up around the fact that we are protecting people: the people who are doing the work and the people who might be affected in some way. One of the issues with robotics is that we need to avoid requiring the robots to have the same amount of regulation that a person doing the same job would. That is an interesting challenge. What I am saying is that robots are way more expendable than humans. That is an interesting one because many industries are built up on the basis that a person is going to be doing that job—an inspection and maintenance job, a non-destructive testing job—and therefore everything is built up around what a person is able to do and therefore what is acceptable. If a robot is able to do more, how does that change the regulatory environment? There are some really big issues around all of that.

Moving from people doing everything to robots doing part of it is a bit of a transition. It is not so much of a problem within these sectors because they are well

managed and self-contained, so to speak. There are regulatory frameworks which are very well established, so we need to amend those regulations a little, but that will happen over time. I do not see a big issue with that.

**Baroness Neville-Jones:** You would go ahead with trials?

**Dr Rob Buckingham:** Yes.

**Baroness Neville-Jones:** In the absence of knowing precisely where the regulatory environment is going to end up?

**Dr Rob Buckingham:** For instance, we have principles such as ALARP. You are trying to minimise the risk, and you would still have detailed safety cases and HAZOP assessments, and all sorts of things like that, to make sure that you were behaving in a safe way.

**Baroness Neville-Jones:** Can that be UK based or does it have to be international?

**Dr Rob Buckingham:** No, UK and international.

**Baroness Neville-Jones:** You have both?

**Dr Rob Buckingham:** Yes.

**Professor Simon Blackmore:** In the agricultural sector there is a draft ISO standard 18497 for highly automated agricultural vehicles, which I think has given us some very good guidelines. There is a corollary in terms of regulation, and that is when we are using herbicides and pesticides at the moment, the legislation is tied up in terms of how it is applied.

**Baroness Neville-Jones:** Process.

**Professor Simon Blackmore:** But now that we have the ability to use machine vision to recognise 26 different species of weeds, we then have the ability to put chemical only on to the leaf of the weed, so 100% of the chemical goes on to the leaf of the weed. We are also getting the issue where a lot of the weeds are now herbicide resistant but the chemical companies have a lot of active ingredients that they are not allowed to use now because they must not put them through a 36-metre boom sprayer. As technology moves ahead, we have to allow those active ingredients to be used when they are applied in these new ways. There is a whole set of other ramifications from this type of work that needs to filter out to be able to cover the agricultural sector.

The same with the drones; we are testing for spraying chemicals with drones, but we are working with the Civil Aviation Authority and the Chemicals Regulation Directorate, and they are very supportive of doing this. Whatever legislation we come up with, it must not embody the particular technology we have now because the technology is always changing so quickly and that then stops the innovation. We need to deregulate these areas to allow this innovation to flourish.

**Baroness Neville-Jones:** Or you need a different approach to regulation which is more outcome-based.

**Professor Simon Blackmore:** Yes, exactly.

**Q16 Lord Hunt of Chesterton:** You are touching on this question, but do you feel on this whole development of autonomous-plus applications we have the right training and skills of students? Are universities moving in the right direction? Obviously, you are talking about capabilities stretching out for decades, and universities last hundreds of years. It seemed to me, from the way you were describing it, that there is a need for quite a strategic view of how this fits into the educational/university model.

**Professor Simon Blackmore:** As a university we do this research and the training, so our students learn how to make a tractor robotic, and so on, as part of their undergraduate degrees. That capability can then run all the way through. The issue is how do we understand the disruption of this new system? As I have said on a number of occasions, using robots in agriculture is going to be very disruptive. We need to retrain the farmers to learn how to use the machines in a better way. We need to upskill the current tractor drivers to become robot operators.

There is another, adjacent part to this, and I do not know whether it will come up in questions so I would like to raise it now. Many of the farmers dealing with high-value crops at the moment are using seasonal labour, and with the advent of Brexit and possible limitation of seasonal labour a lot of the farmers I am speaking to are very nervous about this; their business is predicated on this. But there is this opportunity, coming back to, maybe, the funding and the opportunities within the UK, to replace significant numbers of seasonal labour with highly automated machines. Some of the work we are doing on strawberry harvesting and other types of harvesting are lending themselves—

**Lord Hunt of Chesterton:** The level of skill and knowledge will have to be raised considerably, will it not?

**Professor Simon Blackmore:** I do not think you need a PhD to run the sorts of robots we are developing or envisaging.

**Dr Rob Buckingham:** There is a massive transformation going on here. We talked about robotics being the arms, legs and eyes of the internet. We are at an early stage of major change, where artificial intelligence and machine learning are applied to all sorts of tools which will enable us to do a variety of tasks in different ways across a whole range of sectors. That means that we are going to have to have loads more STEM-educated people. There is no doubt, if we are going to make progress in this, we need to massively increase the number of software and electronic engineers, et cetera, across the piece. The whole STEM piece is going to become absolutely essential because so many of these jobs will start to use this new generation of tools, these new smarter tools.

**Lord Cameron of Dillington:** I was an early user of ground source heat pumps, and one of the problems was that it was almost impossible to get a local plumber to sort the blooming thing because there were not the technicians available. Are you, within your different fields, collaborating to make the technology standard so that different people can be used to mend and service your different equipment in all the different fields where they will be used? Can the same person apply themselves to servicing both sets of equipment?

**Dr Rob Buckingham:** Not yet. We should do.

**Professor Simon Blackmore:** As always, we all want to have standards but I think it is way too early for that, at this stage.

**Lord Fox:** To be clear, coming back to the skills side, there are two sets of people: what I will call the traditional agricultural workers, and then the people you are describing who will service this new industry. First, is there any crossover between these people, or are we essentially leaving that group of people behind and saying that there will be no more traditional agriculture jobs—and what is the impact of that? And are we expecting the new agricultural workers to be the software engineers and the electrical engineers of the future? Where is the crossover between those developing this technology and those who will be out in the field, literally?

**Professor Simon Blackmore:** To be honest, I think a lot of that exists already. When you think about the new combine harvesters, they have 18 computers and they are all running with CAN buses, so that is already out there. The manufacturers are then having to train the technical staff not necessarily to reprogram the computer but to take the black box out and replace it with a new black box when it is not making sense any more. Regarding the ability to deal with more intelligent vehicles, certainly in my view the agricultural machines always need to be in communication via Wi-Fi to be able to transmit data backwards and forwards. Again, in my system, although we talk of robotic—again, this is different from the vehicle area—and consider that that is taking the person out of the system, we are not doing that, we are taking the person out of the vehicle. The idea is that I could perhaps be sitting here or in my university talking to you and then I have a smart phone and there is a heartbeat going backwards and forwards to the vehicle to show that I am in charge of that vehicle. I am not quite sure what the on-road sector is going to do when there is an accident, but it is the operator's responsibility not to send it out in a hurricane or when it has flooded or it is snowing. A person has to make some local decisions about how to operate the machine.

**Lord Fox:** It is not self-deploying, or anything like that.

**Professor Simon Blackmore:** Exactly. It is just that you do not have to have a person hanging on to a steering wheel any more.

**Lord Fox:** I understand.

**Professor Simon Blackmore:** There are these different roles, but I do not see any reason why we cannot have the best technologies in the world being embedded within these machines. You do not necessarily, as I said before, have to have a PhD to be able to run it, you just need a new set of skills to understand the capability of the machine and how to make sure it is operated in the correct way.

**Lord Fox:** I heard yet another cri de coeur from Dr Buckingham for STEM people. We hear it in lots of other fields as well, so that is clearly something you are all shouting for.

**Professor Simon Blackmore:** We always need good people to develop these things, yes, definitely.

**Q17 Lord Oxburgh:** We have been talking about regulation, and of course the question of

legal liability follows on from that. Dr Blackmore, you have partly answered that because, with your smart phone giving you the heartbeat of the machine, you are responsible. We are talking here about a great range of possible applications for these technologies. It seems to me that the question of liability and responsibility is, in fact, going to differ in each of these, whether one is looking at drones, at agricultural vehicles in fields or at underwater activities. It seems to me, and I do not know whether you would agree with this, it is the person who deploys the robot to do a particular job that carries the ultimate responsibility.

**Professor Simon Blackmore:** To be honest, it is a balance between the two, and the way that we have designed our autonomous tractor is to be able to work in exactly the same way that we have products now. Some of the liability of our cars is within the realms of the manufacturer and some of the responsibility is with us in operating them. It is exactly the same scenario with autonomous vehicles.

**Lord Oxburgh:** If we stay with your autonomous agricultural vehicles for a moment, it seems to me that there are always going to be situations in which they get stuck, for example, in heavy ground. Are people going to have to dig them out, and make them happy again?

**Professor Simon Blackmore:** We have these strange, science fiction thoughts going round our heads that robots are going to take over the world. I am afraid I cannot see that happening; these are pretty dumb machines. You only have to kick it and it stops; you only have to pull a cable out and it falls over. The robots we are developing now are very useful in that they can do a particular niche task, but they have to run within a human-supported environment. The person who is in charge of the machine has to be able to refuel it, service it, pump up the tyres, dig it out of the mud—all these things. Nevertheless, it can still have a good impact on the tasks we are trying to achieve.

**Dr Rob Buckingham:** In some environments that human intervention becomes impossible, such as in space or, indeed, in nuclear environments. There you have a different set of challenges, where you have to think about how to operate with zero intervention. That is a real challenge because you have to make sure your systems are highly reliable but also recoverable—because they will fail—and self-recoverable. In nuclear spaces, those are the very hard questions you have to address: when things go wrong what happens when you cannot get in there to fix it? It is hugely challenging because you have to think very carefully about the design of the system and everything that flows from it. It does mean that you are very challenge-led, so it is a great area for finding out what is possible; we are able to push way beyond where we are at the moment. That is what we hope.

**The Chairman:** We have probably just about come to the conclusion. I began to think I should have declared an interest which I have not, and that was as a fruit grower.

**Lord Cameron of Dillington:** I should also declare an interest as a farmer.

**Lord Hunt of Chesterton:** Do other organisations have some input or steering? For example, does the International Atomic Energy Agency now have a panel or a group

that is, as it were, producing long-distance targets for how we will use autonomous systems to deal with nuclear waste?

**Dr Rob Buckingham:** I have three days with the IAEA next week or the week after, so we are absolutely starting to think about those things in detail. The other thing is we must set up this RAS—robotics autonomous systems—leadership council. That is what the House of Commons Select Committee called for, and this is one of the ways where we can start to co-ordinate all these efforts, both nationally and internationally. That group is going to be key in this area because it is going to pull so many different strands together. Without that co-ordination we will remain completely siloed and we will underperform.

**Lord Hunt of Chesterton:** The Commons is producing an all-party group on artificial intelligence. That is different to what you are producing?

**Dr Rob Buckingham:** Artificial intelligence in robotics is the software you will probably use to make your robots more efficient. Artificial intelligence, as algorithms that solve discrete problems in the digital space, is a separate field, but they overlap.

**Baroness Neville-Jones:** I think this is potentially a huge topic, but can I have a rapid reaction from you? Nobody has mentioned cost in all this business of transition. Is the capital cost of these robots going to be a barrier to their adoption or not?

**Dr Rob Buckingham:** When you look at a driverless car, the tech associated with the autonomy piece is only going to be a few hundred dollars, because of volume. You have some software and some sensors—they may even not be new sensors and you may end up using parking sensors—so the tech is going to end up being yay big and not very expensive. That is why it is important that these sectors which have mass volume pull this stuff through to the market. If we tried to do that in, say, nuclear or in space, you can add a couple of noughts on to the cost of these things. A lot of the tech will become much, much cheaper over the course of the coming years and decades.

**Baroness Neville-Jones:** Your robotic tractor is not necessarily going to be significantly more expensive than your existing one?

**Professor Simon Blackmore:** Farmers invest huge amounts of money, hundreds of thousands of pounds, on tractors and combines already, but quite often with these operations the most expensive part of it is the person sitting in it. Therefore, by being able to do things in a radically different way using a lot less energy, doing things faster and smarter, although the base machine is expensive now, prices will come down. The machine costs very little but it is usually the sensors and the systems on it which cost the most amount of money.

**Baroness Neville-Jones:** When you take the human fruit-pickers out and you employ a machine where you have not employed a machine previously, what is the situation there?

**Professor Simon Blackmore:** We can look at the economics of replacing seasonal labour with these machines, and it is something we are looking at now. The farmers I am talking to believe intuitively that this is going to be a good thing and we need to do this, because it is more than just the cost; it is the risk of not being able to get the

labour. That is the major factor. As we know with all these technologies, as they become more mature the price tumbles. We are talking about research machines at the moment, but once we get into mass production I believe that there is a significant opportunity for the UK in the agricultural robotic area. Companies producing robot tractors now do not have joined-up thinking; this is just taking a person off, not going to the whole hog and being able to come up with a complete system. I believe the robots we are talking about now are worldwide commodities, so the same robot would work in South America, North America and northern Europe. In northern Europe, referring to an earlier question, we have the technology to support these things. It will not be the big tractor manufacturers that are going to produce these things, because they are too linear thinking; it will be the start-ups. There is an opportunity—

**Baroness Neville-Jones:** Or a data company.

**Professor Simon Blackmore:** —to get this going in the UK and then being able to produce millions of these things that will then be exported around the world.

- Q18 Lord Vallance of Tummel:** Dr Buckingham, you touched on the leadership council idea. I was going to ask Professor Lane about that, had he not been fog-bound, because it is in his written submission. He says, quite clearly, that the existing structure of looking out for all this is not quite up to it and it needs something rather different, and that perhaps a catapult centre is not designed for this. Could you tell us a little bit about the leadership council? Specifically, is it going to look at the commercial aspect as well, or is it just technological and development?

**Dr Rob Buckingham:** No, it has to look at the commercial aspects, absolutely. We have to make some money out of this.

**Baroness Neville-Jones:** Hurray.

**Dr Rob Buckingham:** The problem with RAS—robotics and autonomous systems—is that it is a general purpose technology which has many applications across lots of sectors. As we are pointing out, it changes the way things happen as well as just being a thing that you sell. The interaction of driverless cars with the way we design houses would be an example. There are huge and very widespread impacts in all these sectors. The challenge here is how do you decide where to invest your finite amount of money? Where do you get your best return? How do you migrate great research into industry? Our view is that a leadership council should be a Minister with money convening. That is the power. You should also have a co-chair who is an industry figure—probably from one of the large multinationals—who sees real potential in a particular area. You would then have a group of 10 to 20 people who are predominantly industry but you would have some academics and people from the Ministry of Defence, the Atomic Energy Authority and others like those involved as well to represent all elements of government. It has to be a group which is focused around the economic impact.

**Lord Cameron of Dillington:** I was going to ask Professor Blackmore who was going to build his first commercial mini-tractor. Where is the money coming from? Last time we spoke, you were a bit concerned that the only interest you seemed to be

getting was from China. Is that still the case? How are we going to commercialise all your inventions?

**Professor Simon Blackmore:** Due to the agri-tech funds over the last few years, a lot of people from outside the agricultural sector are now looking into this. With the facilities we are getting within the new Agri-EPI Centre at Harper, along with Cranfield and SRUC as well, we are now getting significant private money looking at this area. Whether that is enough to make it happen or not I do not know, but I think it is only going to be the start-up companies, which have no legacy and no vested interests in the past, that are going to adopt these technologies fully. The tractor manufacturers have such a legacy and their existing business models that they are very reticent to adopt something that is going to disrupt their business.

**Lord Cameron of Dillington:** I would be very surprised by that because, going back to my earlier question about servicing these machines around the world, they must have huge networks of technical servicing.

**Professor Simon Blackmore:** They do.

**Lord Cameron of Dillington:** You would have thought the Massey Fergusons of this world, the biggest tractor builder, I think, would be moving straight into this field.

**Professor Simon Blackmore:** All the big tractor manufacturers know all this—I am in discussion with them and we talk about these things—but it is too disruptive for them. They will wait until a start-up company comes and produces these things and then they will probably buy them after they have started to be successful.

**The Chairman:** Professor Blackmore, you mentioned the benefit of technology bleed-through from roads to non-road use. Is this something that Innovate UK or other government departments are encouraging and championing?

**Professor Simon Blackmore:** We have a community where we share, but I think there are more things we could do, certainly. Where more money is thrown there is more advancement, usually; the more money that has been put into certain areas the greater the results we have ended up with. I think the agricultural sector could benefit from utilising some of the tools and techniques that have been developed elsewhere, perhaps more than we are at the moment.

**Dr Rob Buckingham:** You heard from Iain Forbes earlier about CCAV. If you think of connected and autonomous vehicles not as driverless cars but as autonomous vehicles, that could be a way of broadening the impact across many sectors. For instance, if we are thinking about autonomous delivery of food and drugs in hospitals in the future, you should have somebody from the Department of Health who is part of that group who is at least thinking about the implications for this new technology within that sector, and the same in the agricultural, military and transport fields. You could strengthen CCAV to make sure that we have a big impact in the whole “autonomous vehicles on the roads” field, but be aware of the impact into broader government issues. The Government have a number of key roles here: as investor, and obviously as representative for and of the people, but also as a user. The Government will be a major user of these technologies, and we hope that that will be a way of delivering better services and bringing down costs.

**Q19 Lord Hunt of Chesterton:** We had some discussion about the United States having a long record on autonomous vehicles. Are there programmes in America or investment by DARPA, and so on, in these areas? Once they find their money, there is so much money it becomes difficult for the UK to remain competitive. I wondered what the situation is.

**Dr Rob Buckingham:** Yes, they are; yes, they will spend an awful lot of money; yes, we have to respond.

**Lord Oxburgh:** Who are our major competitors in this area as far as automated agriculture is concerned?

**Professor Simon Blackmore:** The market itself is very low at the moment because it has not been commercialised.

**Lord Oxburgh:** Who are your competitors, as people who are developing the technology?

**Professor Simon Blackmore:** As with most university research areas, we talk to each other around the world. Japan is obviously very advanced, Denmark is very good and the US is very good. Coming back to the previous question, the difference is not necessarily the technologies—because we learn from each other as academics what all the new technologies are and how they work—but a different cultural way of thinking in terms of investment. There are quite a number of agricultural start-ups in California that are now getting \$16 million here and \$15 million there to get these things going. Of course when you put that amount of money into it, it is going to happen; it is just making it happen. We are always scratching around for £100,000 here and £100,000 there and it limits what we can do. They are not any further ahead—in fact, I would suggest they are behind us—in terms of the technology, but if we want to make it happen then we need more investment.

**Lord Hunt of Chesterton:** In quite a few areas such as nuclear, nuclear waste and fusion, the UK is very strong. I am surprised you did not come up with that, as it were. The United States has been treading water.

**Dr Rob Buckingham:** Yes, absolutely, in that sector they have, and Fukushima will be the major driver for technologies which are developed for operating in those extreme environments. Within Sellafield, for instance, if we are going to get on top of those costs, we need the toolkit which does that cost-effectively and safely. We should be ensuring we use some of that money to push this technology forward. This is my point about needing a leadership council to make sure we invest in the right areas, because we will not have enough money to compete across the board. Therefore, we need hardnosed decisions on how we use this money for national interest, to meet our current liabilities and our own internal opportunities, and then the export markets, especially with Brexit. What are we going to be absolutely world class at?

**The Chairman:** Lastly from Lord Maxton.

**Lord Maxton:** Professor Blackmore, does this make a small-scale farmer less economic, or will it in the long term, and therefore put the advantage back to the big farmer?

**Professor Simon Blackmore:** No, I believe it is the exact opposite, and I will tell you why.

**Lord Maxton:** One would hope so, yes.

**Professor Simon Blackmore:** The big machines are very efficient but they require the big fields. That is why we used to take out the hedgerows, and so on; we modified the environment to suit the machines. Now we are making the machines clever enough to deal with the environment, and making them smaller. If we are looking at this from a global point of view and where we are going to get all this extra food from, I do not think it is necessarily going to come from increasing the efficiency of the big farms; they are already very efficient. The extra food production is going to come from the small to medium-sized farms that then do not have to invest £200,000 in a big tractor but invest £20,000 in a robot to do the same job but on a small scale rather than a big scale. I think it will have the opposite effect: it will support the family farms and we will get extra production from smaller farms and fields. I think that is where the extra food is going to come from.

**The Chairman:** I must bring this evidence session to a conclusion. You have made the very forceful and fair point that hard-nosed decisions on the national interest are going to have to be made. This is an area where, as we take evidence, we are going to have to decide for ourselves and others where we are indeed of world-class status. If you have any further thoughts on how you feel the decisions should be made and which areas to concentrate on, do please send us a note to develop that. I am particularly struck, also, by the implications on infrastructure and telecoms. You are talking about moving from a driver in a cab or in an autonomous vehicle of some kind to somebody controlling it from his or her desk; again, are there infrastructure implications we have not had time to cover on this? If, again, you would like to send a note on that, please feel free to do so.

Professor Blackmore and Dr Buckingham, thank you very much for a most interesting session. We will be sending a transcript of the session, and if there are any inaccuracies in that transcript you will have an opportunity to make corrections. On behalf of the Committee, very many thanks for your help.

## **University of Southampton Insurance Law Research Group<sup>308</sup> – Written evidence (AUV0031)**

### ***Executive Summary***

- *Public perception of these vehicles is crucial. When the motor car was originally introduced, poor safety and the absence of sufficient compensation adversely affected public perception.*
- *Insurance of vehicles is crucial for society as victims of accidents need to be compensated when accidents occur.*
- *The current system of regulation of conventional vehicles does not fit with driverless cars and therefore new regulation is needed. Regulation needs to be continuously reviewed to keep up with legislation.*
- *Motor Insurance Law should also be amended for conventional vehicles to ensure parity between victims although this is not an immediate concern.*
- *The priority is to ensure that the third party victim is properly compensated.*

### ***Options for Reform***

- *There are four options for reform of insurance/liability of driverless cars:*
  - 1) *Amendment of Road Traffic Act and Motor Insurance to include driverless cars*
  - 2) *Introduction of Product Liability System*
  - 3) *Introduction of First Party Insurance System*
  - 4) *State intervention and Central Fund*
- *Each system has significant benefits and detriments and each one should be studied in depth. There is no “right” answer and therefore the final choice is a political decision*
- *Significant amendments would need to be made to the Motor Insurers’ Bureau (MIB) agreements.*

### **Public Attitude to Autonomous Vehicles and Legislation**

[1] For people to consider the vehicles as safe they must also be trustworthy and reliable.<sup>309</sup> Another factor in helping with trust of an autonomous vehicle is the human qualities it possesses. Consequently, the more familiar and ‘human’ a car feels, the greater the trust of the public.<sup>310</sup>

[2] In general, it has been argued that factors that would discourage the introduction of new technology can outweigh factors in favour of the introduction.<sup>311</sup> It is thought that

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<sup>308</sup> Matthew Channon , Hannah Stones, Professor James Davey, Dr Johanna Hjalmarsson, Robert Veal

<sup>309</sup> Jae-Gil Lee, Ki Joon Kim, Sangwon Lee, and Dong-Hee Sin, ‘Can autonomous vehicles be safe and trustworthy? Effects of appearance and autonomy of unmanned driving systems’ [2015] 31 Intl. Journal of Human-Computer Interaction 682, 682.

<sup>310</sup> Ibid , 688

<sup>311</sup> J. Li, M. J. Cho, X. Zhao, W. Ju, and B. F. Malle, ‘From trolley to autonomous vehicle: perceptions of responsibility and moral norms in traffic accidents with self-driving cars’ presented at Society of Automotive Engineers World Congress, 12-14 April 2016, Detroit, USA, p1.

uncertainty over liability for accidents involving self-driving cars could discourage motorists from adopting the new technology. When cars were first introduced there were very few accidents, but the unfamiliarity of cars and absence of compensation meant that when there was an accident, it caused a far greater reaction than it might have done.<sup>312</sup> This then led to calls to ban cars.<sup>313</sup> Of course, it is likely that the use of driverless vehicles will be used in a commercial way by business at the beginning, however, trust is crucial for the vehicles to become more widespread.

[3] Incidents have been rare so far, but those that have occurred have created national headlines and raised significant concern over the safety of these vehicles (even though it is a development in motoring rather than a completely new form of transportation). For instance, when the first death occurred it caused a lot of concern, yet other deaths in conventional cars do not.<sup>314</sup>

[4] To reduce these concerns, as well as ensuring that driverless cars are thoroughly tested with significant checks in place, it is important that compensation is available to those with the misfortune of being in an accident. For conventional motor vehicles, people injured before 1934 were too often left with little or no compensation, causing substantial hardship and often leading to negative press coverage

### **Amendment to Insurance Legislation**

[5] Technology is accelerating at a rapid pace and driverless cars are already being trialled on the road. The protection and compensation of the third party victim in cases of accidents from both conventional and driverless cars is essential. The current system for conventional motor vehicles provides some protection for the third party victim and the insurer will most likely be required to pay compensation. There are currently only limited defences available to the insurer<sup>315</sup> and the insurer holds a duty to satisfy claims<sup>316</sup>. The Motor Insurers' Bureau will pay compensation to the victims of uninsured and untraced drivers and extra assistance is provided by the state through public bodies such as the NHS.

[6] This system of insurance would not work with driverless cars as it currently stands, currently it is the driver or anyone who 'uses' the vehicle who is required to be covered by insurance and not the vehicle itself<sup>317</sup>. Some alteration to the law will ensure that there is an insurance system which fits with driverless cars and provides the third party with the compensation needed.

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<sup>312</sup> J. R. Spencer, 'Motor-cars and the rule in *Rylands v. Fletcher*: a chapter of accidents in the history of law and motoring' [1983] 42(1) Cambridge Law Journal 65, 73.

<sup>313</sup> Ibid

<sup>314</sup> Sam Levin and Nicky Woolf, 'Tesla driver killed while using autopilot was watching Harry Potter, witness says' (The Guardian, 1 July 2016) <https://www.theguardian.com/technology/2016/jul/01/tesla-driver-killed-autopilot-self-driving-car-harry-potter> accessed 13 October 2016.

<sup>315</sup> For example the Insurer is limited as to exclusion clauses they can use (Section 148 Road Traffic Act 1988) and their use of utmost good faith (Section 152).

<sup>316</sup> Section 151, Road Traffic Act 1988.

<sup>317</sup> See cases such as *Charlton v Fisher* [2001] EWCA Civ 112 and the judgment of Laws LJ.

[7] There are lessons to be learned from past mistakes. Compulsory third party motor insurance was introduced in 1930, and it contained significant loopholes allowing insurers to repudiate liability, causing significant hardship to third party victims. Not enough attention was paid to ensuring the victim was compensated for their injuries. As a result, the legislation required significant amendments within a few short years. Thorough consultation is needed for driverless vehicles and all knowledge bases questioned to ensure balanced legislation.

[8] It is crucial that there is parity in the laws of motor Insurance and driverless cars insurance so that the victim of an accident would get the same treatment and access to compensation across both forms of transportation. Of course there is nothing to prevent different systems of insurance existing in parallel, as long as the end result is that the victim receives the same amount of compensation for their injuries or damage caused to their property.

[9] Therefore, there undoubtedly needs to be significant reform to the current motor insurance regime, which does not provide adequate protection to the third party victim. Significant differences exist between the UK legislation in the **Road Traffic Act 1988** and EU regulation in the **Sixth Consolidated Motor Insurance Directive**, including where the vehicle should be insured, with the Directive providing much greater protection than UK law. Limiting the protection available for accidents involving automated vehicles to that currently applicable to conventional vehicles would significantly undermine public confidence and therefore to ensure parity, the protection given to accident victims of conventional vehicles needs to be significantly increased.

## **Four Options for Reform**

### **Extending Motor Insurance**

[10] This was not mentioned in the DfT consultation which is the ‘single policy’ approach favoured in particular by the ABI.<sup>318</sup> This would involve having one policy which covers automated driving and conventional driving without the need for product liability (PL) insurance for manufacturers. This is certainly the most simplistic approach and one which would need the least adaptation by the insurance industry and therefore it could be cheaper than PL with less liability disputes.

[11] This system seems to fall in with the Motor Insurance Directives which require the policy to cover for ‘any use’ consistent with the ‘normal function of that vehicle’,<sup>319</sup> and in fact it is clear from the recent European Commission Impact Assessment<sup>320</sup> that automated vehicles fall within this definition.

[12] Difficulties exist with this, however, especially as the current motor insurance regime is significantly outdated having been only slightly amended in 80 years. For an extension of

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<sup>318</sup>[https://www.abi.org.uk/~media/Files/Documents/Consultation%20papers/2016/09/090916\\_ABI\\_Thatcham\\_response\\_CCAV\\_Automated\\_Driving\\_Consultation.pdf](https://www.abi.org.uk/~media/Files/Documents/Consultation%20papers/2016/09/090916_ABI_Thatcham_response_CCAV_Automated_Driving_Consultation.pdf)

<sup>319</sup> Expounded in recent case of Damijan Vnuk v Zavarovalnica Triglav (C-162/13) [2016] R.T.R. 10

<sup>320</sup> European Commission , “Adaptation of the scope of Directive 2009/103/EC on motor insurance” [http://ec.europa.eu/smart-regulation/roadmaps/docs/2016\\_fisma\\_030\\_motor\\_insurance\\_en.pdf](http://ec.europa.eu/smart-regulation/roadmaps/docs/2016_fisma_030_motor_insurance_en.pdf)

motor insurance to work, motor insurance for conventional vehicles would need to be significantly reformed as a priority. Furthermore, liability disputes could still arise even under a single policy.

### **Product Liability**

[13] Extension of motor insurance to include product liability seems to be the most popular solution. Making manufacturers strictly liable for a defect in their vehicle ensures a high standard of production (giving the manufacturer greater incentive to prevent themselves from being sued) and further ensures that the third party is compensated for an accident attributable to the technology.

[14] As Lanoue notes it is important to have consistency in the system:

“Increasingly, computers are being used in devices like automobiles. It would be undesirable to permit an injured consumer to collect under strict products liability for a defective steering mechanism, but not for a defective computer program in the car which may have caused the same injuries.”<sup>321</sup>

[15] PL will equalise the availability of compensation between autonomous vehicles and those that are not. In shipping, where strict liability applies (e.g. a shipping incident on passenger ferry) it would also be inequitable for people on autonomous ships to not get the benefit of strict liability when they would otherwise – it is important that the types of liability and availability of compensation are equal.

[16] However product liability is also extremely complex and will not prove an easy fit. The greatest challenge is in the interaction between drivers' and manufacturers' insurers in the early stages of limited automation, especially when it is not clear as to who or what is at fault for a particular accident. There is the potential that the courts become clogged up with liability disputes between manufacturers' and drivers' insurers.

[17] Furthermore, product liability, as it currently stands, does not confer as much protection as is required for vehicle accidents. Defences available to the manufacturer such as the ‘state of the art’ defence, where the manufacturer could prove that they could not have known about a potential defect, should not be used against an innocent third party or first party.

[18] Finally there are other issues such as limits of damages, control of policy terms, and lifespans, which would need to be resolved and adjusted for a product liability system to fit. Moreover, complex issues surround the interaction between the Motor Insurance Directives and the Product Liability Directives which would cause further complexity.

### **Central Fund**

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<sup>321</sup> Susan Lanoue, ‘Computer software and strict products liability’ [1982-3] 20 San Diego L. Rev. 439, 449.

[19] A central fund<sup>322</sup> is a possible alternative and one which has not been properly examined. The fund would work through levies paid on fuel/cost of the vehicle and would then compensate victims of accidents on a no-fault basis. This would remove any liability issues which would consequently lower litigation costs. Therefore, it is envisaged that the cost of this system would be cheaper.

[20] There are a number of negative implications also, as it would not be popular amongst the insurance industry due to loss of profits. It would also provide little incentive to manufacturers to ensure the safety of their vehicles as they would not be liable for any defaults. Moreover, the management of such a fund would bring complexities and costs to ensure proper management. Finally, it would introduce an unintended benefit for those vehicles which enter the UK without paying into the central fund, even if these drivers were required to purchase insurance, managing this system would be complex.

[21] It is unlikely that this system will be introduced especially as it was not mentioned in recent DfT Consultation. However, it is worth examining whether a scheme such as this could be used in the long run. A comparison could be made with the New Zealand system for conventional vehicles managed by the Accident Compensation Corporation which provides “comprehensive, no-fault personal injury cover for all New Zealand.”<sup>323</sup>. Central funds are often used in shipping law such as in relation to oil pollution so further comparison could be made there.

### **First Party Insurance**

[22] A first party insurance model would bypass some of the liability issues in relation to the product liability system by allowing a claim to the insurers of vehicle which caused the accident with liability issues determined later. This would speed up the claims process although would not remove liability disputes.

[23] A first party model would be a major diversion from the current system for conventional vehicles and would require the insurance industry to make a significant adjustment. This would most likely cost more than the other proposed systems which would be disproportionate to the number of automated vehicles on the road currently.

[24] Another significant disadvantage of this system is the imposition of a substantial burden on pedestrians and cyclists who would not normally be insured, but would be potential victims.

[24] This is a system which could be introduced at a later stage if other systems are deemed inadequate, however, for the short to medium term, it is submitted that this system would be too complex and costly without providing enough benefits.

### **Amending MIB Agreements**

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<sup>322</sup> Central fund idea was examined in Matthew Channon and Lucy McCormick , “Look, no Hands!” New Law Journal 2016, 166(7708), 12-13 also in Matthew Channon , “How will self-driving cars affect your insurance?” The Conversation, August 22nd 2016 <https://theconversation.com/how-will-self-driving-cars-affect-your-insurance-64253>

<sup>323</sup> <http://www.acc.co.nz/>

[25] For three of the above systems<sup>324</sup> there would need to be measures in place to ensure victims of uninsured/untraced vehicles would be compensated. It is envisaged that the MIB in the UK would undertake this role by extending its Agreements to involve uninsured and untraced drivers.

[26] The Uninsured Drivers Agreement was recently significantly reformed in 2015.<sup>325</sup> The new Agreement has increased third party protection by removing a number of procedural restrictions and unlawful exclusions of liability. However, the Agreement would need further reform to be effective for automated vehicles.

[27] For example Clause 9 which excludes MIB liability for acts of terrorism is of particular concern. There is greater potential for automated vehicles to be used for these purposes especially as it would not involve the potential death of the person responsible. Therefore, excluding liability for acts of terrorism would significantly undermine trust in these vehicles.

### **Conclusion**

Public trust is crucial for the widespread adoption of automated vehicles and the absence of a suitable means of compensation could severely damage this. It is clear that there is not one perfect solution, with the four mooted systems having significant advantages and disadvantages. It is also clear that the rights of victims for conventional vehicles need to be substantially improved to ensure that there is parity.

*25 October 2016*

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<sup>324</sup> Product Liability, Extension of Motor Insurance and First Party System

<sup>325</sup> For an examination of reforms see Matthew Channon, "The new Uninsured Drivers Agreement: An analysis" British Insurance Law Association Journal, Issue 128.

## **Weightmans – Written evidence (AUV0080)**

### **About Weightmans**

Weightmans LLP is an ABS and a top 45 national law firm employing 1,500 people across 11 offices, with one of the largest national defendant litigation solicitor practices and an annual turnover in civil litigation work approaching £60 million. Weightmans deals with motor, liability and other classes of claims for clients from the general insurance industry, other compensators including the NHSLA, local authorities, and self-insured commercial organisations such as national distribution and logistics companies.

Weightmans is actively involved in the insurance sector and has a number of major insurers as clients. Weightmans also specialises in the London Insurance Market, cyber liability, and automotive technology including autonomous systems and telematics, robotics and artificial intelligence, business crime, regulatory compliance, legal and commercial risk as well as offering in-house advisory services to insurers, non-insurer compensators and self-insureds.

Weightmans specialist Motor Technology Group regularly advises on the legal and commercial implications in respect of advancing autonomous technologies, represents insurer and automotive manufacturer clients in technology related claims, and is actively involved in the industry to facilitate the scoping of the legal and insurance framework necessary to make such technologies a success.

### **The consultation**

We are pleased to be able to respond to questions 1, 12, 13, and 15 of your Call for Evidence as follows:

### **Question 1**

#### **What are the potential applications for autonomous vehicles?**

#### **Comments**

The development of advanced driver assistance systems (“ADAS”) and autonomous driving technologies (“ADT”) has the potential to deliver demonstrable benefits to the citizens of the UK. Such benefits include the reduction of accidents, reductions in insurance premiums, reductions in the number of fatal and life changing injuries, reductions in congestion and delays, a smoother flow of traffic and social inclusion for those with disabilities preventing them from driving motor vehicles and thereby restricting their mobility. There can be no doubt that these advances have the potential to improve the quality of life for all, as well as bringing savings for industry and ultimately reducing our impact on our environment.

### **Question 12**

#### **Does the Government have an effective approach on data and cybersecurity in this sector?**

## Comments

The Department for Transport recently consulted on the issue of the regulatory and insurance frameworks required for the development of autonomous vehicles. We were extremely surprised that the issue of data and cyber security was not a specific section of that consultation. Our response to that consultation indicated that data and security must be addressed as part of the review. We would therefore like to take this opportunity to reinforce our views on the issues of cyber security and data.

## Cyber Security

Our cars are increasingly morphing into mobile computers with wheels and an engine. The advancements in the technology installed into our vehicles makes them almost unrecognisable from those cars we drove only a decade ago. The analogy of a car being a mobile computer requires careful consideration by government and the issue of cyber security in the context of a car has never been more important than it is now.

In the last few weeks there have been a number reports in the press of a team of hackers from a Chinese security company taking control of a Tesla Model S remotely from a distance of 12 miles away. They were able to access the cars controller area network (also known as the Can bus), which connects a modern vehicle's systems. The hackers were initially able to take control of the indicators, windscreen wipers, dashboard display units, they could open doors and the boot whilst the car was in motion, and move seats backwards and forwards. Alarmingly, they were also even able to overcome Tesla's "gateway" system and gain control of the cars safety critical driving systems, enabling them to control the brakes adding a more sinister dimension to the hack.

In this particular case, Tesla were fortunate, as this was a so called 'ethical hack' where the hackers were looking for holes in the IT security system of the car and immediately reported their findings to Tesla. To Tesla's credit, they acted immediately and issued a software update over the air to their vehicles to address the issue whilst taking immediate steps to inform their customers of the security breach.

It's not just Tesla that has fallen foul of cyber security. There are anecdotal reports of a mainstream manufacturer neglecting to take sufficient security precautions with their over the air software update system. It is reported that this manufacturer used http protocol as opposed to the more secure https protocol leaving their vehicles computer systems unsecured and ripe for attack.

In February last year, BMW responded to reports of a security flaw, which potentially allowed hackers to unlock some of its vehicles, with an over the air security patch, in much the same way Tesla did. These incidents have served to highlight weaknesses which if exploited by an individual or group with malevolent intent, are particularly chilling. As cars are connecting over the air with manufacturers and other third parties, they are vulnerable to the same cyber attacks as our home computers. These vehicular computer systems control almost every safety critical function and those cars with increasingly autonomous features are handing more and more control to their computers. It is not difficult to envisage hackers causing a multi vehicle accident by hijacking the connected cars.

It is well known that viruses are capable of migrating from one computer. This multiplies the risk when you consider that fully autonomous vehicles and those with more advanced driver assistance systems will need to communicate with smart roadside furniture to optimise journey times and establish safe operation of an autonomous road network.

There is no doubt that manufacturers are taking their security obligations seriously, evidenced by the speed with which both Tesla and BMW issued software updates to patch the holes in their systems. Indeed, consumer confidence in fledgling autonomous technologies would be seriously eroded if such prompt action was not taken.

The Tesla incident, in particular, raises a number of interesting legal questions that need to be considered; firstly is the manufacturer responsible for keeping its vehicle systems secure and is the manufacturer liable if they don't. Alternatively, is the consumer responsible for ensuring their security systems are up to date much as they are with their own computers and smart phones? Secondly, who is liable in the event of a hack; and how do we access sufficient information to establish what actually happened?

It is therefore our view that cyber security is an issue of paramount importance for the manufacturing industry and must continue to be a fundamental component of autonomous vehicle research and development. We believe that this should form an integral part of the government's review of the regulatory framework for autonomous vehicles.

### **Data**

The sharing of data collected by autonomous systems is extremely important to the determination of liability. Whilst the DFT consultation does not expressly deal with the issue of collected data, we believe that it is essential that this issue is included within any review of the regulatory and insurance framework. This is important from both insurance and regulatory perspectives especially where a situation could arise in a partially autonomous world where the driver, the manufacturer, the software programmer or a combination thereof could well be ultimately liable for an incident.

Manufacturers already receive data through connected devices installed into their cars and it is this data which is increasingly essential in understanding the cause of an accident and in determining liability. Whilst data sharing will inevitably see concerns raised surrounding privacy, confidentiality, data protection and intellectual property, these challenges are not insurmountable. What is clear to see is that, without access to the data collected by automotive systems, insurers have little hope of being able to understand the cause of an accident, and the determination of liability could be almost impossible. It is therefore essential that manufacturers and insurers work together to facilitate cost effective access to the data to allow insurers to accurately and quickly determine liability.

We believe that an acceptable data solution would be for manufacturers to send a pre-agreed "package" of data to a central repository, much in the same way that insurers share information with the CUEPI, MIAFTR, the Insurance Fraud Register, and others. This central repository can provide the appropriate data when necessary to insurers and the authorities in the event of an accident to determine the cause and to assist in the determination of any apportionment between insurers and/or manufacturers. Such a repository would mean that

manufacturers are not receiving regular requests for information from numerous sources adding to their operational costs.

### **Question 13**

**Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

#### **Comments**

The Government's proposal contained within the recent DFT consultation to review the regulatory framework as such advanced technologies come to market is logical and we agree with this proposal. The fluid nature of advances in automotive technologies is such that it would be almost impossible to identify the risks and issues associated with future technologies until they have been developed and adequately tested. It is arguably an inappropriate and unacceptable risk to attempt to pre-empt legislation required for future technologies not yet in the development pipeline. It therefore seems appropriate for the regulatory framework to adapt as these technologies are developed and tested so that regulation is not a barrier to innovation and further, that those seeking to impose regulation can do so with the full knowledge of the technologies, their capabilities, and their limitations.

### **Question 15**

**What does the proposed Modern Transport Bill need to deliver?**

#### **Comments**

A clear and understandable framework which ensures access to justice for victims of road traffic accidents including the “drivers” of ADAS vehicles whilst ensuring the integrity of the autonomous network.

*26 October 2016*

## **White Willow Consulting (Andy Graham) – Supplementary written evidence (AUV0094)**

*This supplementary evidence addresses two questions not asked in the House, to add some facts and thinking based on discussions with colleagues at ITS-UK.*

**HAVs will generate a wealth of data of potential benefit to many audiences. However, this raises potential concerns around privacy and data protection.**

- Who will own this data?

Firstly, the answer depends on what we actually mean by “data”. There already is a wealth of data collected from vehicles and it is growing, although we in the roads sector could do far more to quickly exploit what we have now and reduce costs of roads operations and improve services.

If we regard “data” as raw sensor and vehicle outputs like “a vehicle is here” or “the road temperature is 1C” it is a different issue from *“Andy Graham drove this vehicle ABC123 from his house to work at an illegal speed of 75mph”*. It is what is done with the data to derive intelligence that is the issue, not the data per se

The data that is already collected is by many organisations (INRIX, TomTom, Here, Google and many UK based fleet management companies, as well as mobile phone operators) is about vehicle or mobile phone movements – eg GPS points used to derive location and speed.

It is already collected from at least 2.5 million vehicles in the UK (sources INRIX and TomTom). These vehicles are typically those doing most miles (commercial fleets or high mileage private cars), so we calculate perhaps 20% of all vehicle miles are currently in the dataset)

The industry is increasingly adding data about the infrastructure condition (potholes, loss of traction, acceleration etc) that can help roads operators manage and plan assets better.

This location data is already collected and used anonymously with safeguards to protect the identity of users (eg random user references that change daily and by having the start and ends of a trip deleted). It is collected with the full permission of the data owner. Often the data owner – eg a satnav user – benefits directly from sharing their data as it improves route choice for their journeys.

This data – once processed - is also now being used to plan better new roads through surveys of where people travel using mobile phone data that is far more representative than traditional roadside interviews. It is used to monitor journey times instead of using roadside number plate cameras, inform on car park space availability and monitor weather. In projects funded by DfT, I am exploring with City Of York Council its use to improve existing traffic signal performance to reduce delays and reduce costs.

Many companies have already built businesses taking these millions of data points and providing services for both sat nav and roads operators using this. The market has seen an opportunity to add value and the UK leads in this area both technically in data science and with innovations in fleet management services. Hence, keeping data anonymous and used only for the purposes it is collected for is a strong theme in current services – these businesses cannot afford to lose data or have any privacy issues for their customers.

However, in the future, more and more detailed data will become available from vehicles. For example, a “CAM” message is a way of saying “I am here” many times per second both to other vehicles and roads infrastructure like signals. It has to be shared openly to work in this way, so is broadcast to anyone who will receive it. Using this approach, there are benefits to other road users and the driver, yet no “ownership” as such. Other vehicle to vehicle and road to vehicle messages can also be open to all.

But some other data, such as the road assets’ images, (for example an image of a new road sign implying a new speed limit) will not be made open by design but perhaps should be for the public good, although there are existing businesses that collect and process this. This is the area to focus on – data not required for safety that is not already open.

However, the use of data that shows I did 75 mph on the road and who I am is mine and should not be open.

Therefore, discussions around fully “open” data and drivers being able to turn off data from their vehicles have a risk. If for example safety messages are not freely shared as the user has turned them off, then the data the system needs is incomplete and potentially dangerous – that missing element turned off could be the data you need to know or send out to avoid a crash.

Hence, I see the data landscape as a mix of:

- Services using data with data owners’ permission to add value by turning masses of raw data into smaller volumes of intelligence (as now)
- Open data shared for the safety and good of road users and the public, as well as the driver. This could mirror the EU directive which requires service providers to share safety data collected for free but not the higher value journey time data
- Data owned by the vehicle maker to make their vehicles better that is of little use to anyone else.
- Data owned by the driver they can choose to others to use. Note that the value per user of the vehicle is unlikely to be high, so users “selling” individual data as some business models suggest is likely to be unsustainable. The content of this group needs more work as suggested below.

Hence if any “platform” for open data is developed or mandated, it needs to focus on newer data that is open by design and not try to challenge existing business models. Also allowing users to “turn off” their data must have sufficient safeguards – similar for example to those before turning off traction control.

- **Has there been any research into public attitudes to the use and or retention of this data by Government agencies, automotive manufacturers or others?**

There are various studies but many have suffered from the question being asked without the respondents having exposure to the benefits from the data being used to give something back (as affects many CAV surveys, the question is simple but the background complex).

One survey suggests 91% of people want to be able to switch connectivity off, but as shown above, users may not understand what this means in terms of risk. We must ask if they will have the same views when they cannot access services they want or there are extra costs? The answer "*Sorry, we can't fix your car remotely, as you turned it off.*" from a dealer or recovery club may change behaviour. However, we do not know as this is a new area and we need to test real people with real opinions and behaviour.

It is also important to note that these same people may be more than happy to give their precise location and status on social media without it being any issue at all. However, this is a key area of automotive user trust and acceptance, so we need pilots and surveys to inform us via real UK users exposed to the services and benefits from them.

DfT did this with introducing sat nav in 1990s – it funded real user tests and feedback and then gave the private sector the evidence of what it needed in terms of policy and scoped the opportunity, but then left it to two UK companies to deliver. The cost was a few pence for every sat nav now in UK use.

Without this real user feedback collected by DfT with the help of the AA, RAC, Volvo, Bosch and Halfords, industry would not have been able to understand what customers wanted and DfT see where the policy issues were.

**Therefore, the key to moving on from questions to delivery of benefits is to expose real UK users to the services, technology and benefits and understand their behaviour. We must aim to use data for as wide a range of services to users and roads operators as possible within this behaviour, to capture evidence of benefits for UK plc. Government has a key role in funding the risks and in collecting evidence of how drivers and users react to services, and sharing knowledge to support for example smaller local authorities.**

**The biggest challenge to autonomous vehicles remains the people using it, no the technology. By learning and sharing lessons with connected but human driven vehicles in the short term, we will inform the pathway to much more complex systems later with evidence of real UK benefits.**

*Author: Andy Graham, Director of White Willow Consulting and Founding Chair of ITS (UK) Connected Vehicles Interest Group*

29 November 2016

## **Zurich Insurance plc – Written evidence (AUV0068)**

### **INTRODUCTION**

#### About Zurich Insurance Group

Zurich Insurance Group is a leading global insurer, providing life insurance and general insurance products and services to retail and corporate customers in more than 170 countries. Zurich's UK Life business is a leading provider of pensions, investment policies and protection products, available through financial intermediaries. UK Life also provides pensions and protection policies for the corporate market available through employee benefit consultants. The UK General Insurance division supplies personal, commercial and local authority insurance through a number of distribution channels.

Based at around 20 locations across the UK - with large sites in Birmingham, Cheltenham, Farnborough, Glasgow, London, Swindon and Whiteley - Zurich employs approximately 7,000 people in the UK.

Zurich welcomes the opportunity to respond to The House of Lords Science and Technology Select Committee Inquiry on Autonomous Vehicles but also appreciates that other stakeholders may be in a better position to respond to some of the specific questions raised.

### **IMPACTS AND BENEFITS**

#### **1. What are the potential applications for autonomous vehicles?**

1.1 Autonomous vehicle technology has the potential to transform use of the road network depending on infrastructure investment and development which could lead to more efficient use of the road network with associated easing of congestion. There is also an opportunity for widespread development in off-road scenarios which might include warehouse and storage facility movement of goods as well as agricultural uses.

1.2 From an insurance perspective, we anticipate two significant benefits –

- Safety mechanisms which will reduce the frequency of accidents estimated to have been caused by human error.
- Increased information which can be analysed to assess risk and manage claims more efficiently

#### **2. What are the potential user benefits and disadvantages from the deployment of autonomous vehicles?**

2.1 Some of the benefits anticipated are:

- Lack of human error resulting in far less accidents and injuries. Research published by Thatcham Research found that vehicles fitted with AEB technology were involved in fewer insurance claims for third-party injury than equivalent vehicle models that did not have this technology and it is anticipated that continual developments will lead to further improvements.
- Improvement in traffic conditions and congestion – for example with sensors allowing cars to travel closer together and more on the road, and platooning
- Increase in fuel economy
- Increase in mobility for all – meaning disabilities would no longer be a factor in driving
- Less space needed for parking as well as a vehicle could drop the driver off and park further away
- Many hours are wasted commuting for workers – this would free up this time to be used productively
- No need to pass a driving test
- From an insurance perspective, increased information which can be analysed to assess risk and manage claims more efficiently

2.2 Some of the disadvantages anticipated are:

- With the need for drivers reduced/eliminated there would be a substantial impact on the work force with many workers losing their employment (lorry drivers, taxi drivers etc)
- In the early days of development these vehicles are likely to be extremely expensive
- A concern that software hacking or computer malfunction could result in a catastrophic accident

**3. How much is known about the potential impact of deploying autonomous vehicles in different sectors?**

3.1 We are not in a position to differentiate between sectors however, our view is that if the safety performance of automated driving technology continues to develop as expected, this will reduce the overall frequency of road accidents. As such, this should reduce claims costs overall, although the incorporation of more complex components with in-built technology is likely to increase vehicle repair costs in any given case.

3.2 There will be a number of factors which could affect the potential for additional costs related to insurance for automated driving, including:

- Frequency of incidents where the driver of a ‘manual’ car is the at-fault party in an incident involving an automated car as a result of the automated vehicle reacting more quickly to any given situation during the period of transition to automated vehicles.

- The speed of transition towards ADT technology and the ease with which drivers adapt to how this technology works.
- Any change in the cost/availability of parts.
- The requirement to ensure that there is an adequate number of engineers and repair technicians with the necessary skills to repair and maintain both manual and ADT vehicles.

**4. How much is known about public attitudes to autonomous vehicles?**

4.1 We are not in a position to answer this question at this stage.

**5. What is the scale of the market opportunity for autonomous vehicles?**

5.1 We support the development of this technology, which has the potential to have a significant beneficial impact on road use and safety. We also anticipate benefits to society and the economy as previously outlined although we are not in a position to calculate the scale of this.

## **CREATING AN ENABLING ENVIRONMENT**

### **Research and development**

**6 Is the scale of current and planned demonstration facilities for autonomous vehicles sufficiently broad and ambitious?**

6.1 We are aware that there are a number of controlled test and research projects currently under way which at this stage appear largely to involve low speed environments. It appears that there will ultimately need to be a framework available which will afford the opportunity to test this technology in higher speed scenarios including motorway and extra-urban conditions.

**7 Is the Government doing enough to fund research and development on autonomous vehicles, and to stimulate others to do so? Should it be doing more to coordinate UK actions?**

7.1 We refer to our answer to question 6 above regarding a structured approach to testing outside of city centre/urban conditions.

7.2 We believe there is a need to ensure that adequate type approval controls are developed which will require to be consistent from an international perspective.

**8 How effective are Innovate UK and the CCAV in this area?**

8.1 We are not in a position to answer this question.

**9 Is the environment for small and medium-sized enterprises (SMEs) working in this sector sufficiently enabling?**

9.1 We are not in a position to answer this question.

### **Real world operation**

#### **10 Will successful deployment of autonomous vehicles require changes to digital or physical infrastructure?**

10.1 We agree with the ABI response on this matter in relation the need for insurers to have access to data and information on vehicle specification/capability as well as post-accident information.

10.2 Many of the automated driving systems will require ongoing upgrades and maintenance (including, potentially, via over the air software updates). The insurance industry would expect there to be regulatory oversight ensuring that safety-critical upgrades are performed and clarifying where the responsibilities of manufacturers and registered keepers lie in relation to ongoing maintenance of the vehicle. It is likely that this will need to be supported by digital infrastructure that will be capable of verifying that necessary upgrades have been performed.

#### **11 How might a move from current levels of highly automated vehicles to their extensive deployment best be managed? What do you see as the key milestones?**

11.1 Zurich supports the proposal contained within the recent C-CAV ‘Pathway to Driverless Cars’ consultation that a “rolling programme” of regulatory reviews should be implemented. Such a rolling programme will permit regulatory change based on experience and enhanced understanding and will allow consideration of the complexity of interdependent national and international regulation that will be required.

11.2 In that respect, it is vital that, in addition to the issues being considered in the context of the Modern Transport Bill, the UK Government actively works with its worldwide counterparts to establish:

- Universally agreed, easily understood, consumer-friendly definitions of advanced driver assistance systems and automated driving systems; and
- Universally agreed minimum and maximum technical requirements for different levels of ADAS and for ADT, binding upon all involved parties.

#### **12 Does the Government have an effective approach on data and cybersecurity in this sector?**

12.1 We are not in a position to answer this question although we understand the critical nature of this in ensuring safe development and maintenance of an effective automated vehicle environment.

**13 Are further revisions needed to insurance, regulation and legislation in the UK to create an enabling environment for autonomous vehicles?**

- 13.1 Yes. Zurich submitted a response to the recent C-CAV consultation in relation to its ‘Pathway to Driverless Cars’ work and we would be happy to furnish a copy of the response if that would be of assistance.
- 13.2 It is essential that the existing compulsory motor insurance framework is developed to accommodate automated driving scenarios however we do not believe that the appropriate mechanism to achieve this is through extending the application of ‘product liability’ insurance.
- 13.3 Consideration also needs to be given to the creation of an associated right of recovery (allowing insurers to claim costs from manufacturers, developers or other stakeholders where they are ultimately responsible for a road accident) which would ensure that automated driving is covered and provide cover for the ‘not at fault’ driver as well as passengers and (external) third parties.
- 13.4 There will need to be a consistent approach to this from manufacturers regarding software design and development as well as “allocation” of responsibility in the event of a technology failure which results in an accident. We believe a manufacturing industry wide alignment would be of considerable benefit. We expect that the UK Government’s work on the Modern Transport Bill will prompt vehicle manufacturers to engage constructively on these questions on an industry-wide basis. It is clear that regulation cannot be ‘brand specific’, and that all vehicles on the road will ultimately need to be bound to the same standards and regulatory framework.

**14 What, if any, ethical issues need to be addressed in the substitution of human judgement in the control of vehicles by algorithms and Artificial Intelligence?**

- 14.1 We recognise that this is a matter which requires very careful consideration as safety standards for automated driving are developed however we do not have access to any detailed information on this issue.

**Wider governance**

**15 What does the proposed Modern Transport Bill need to deliver?**

- 15.1 The Modern Transport Bill needs to afford a common sense and workable framework which will provide clarity for both consumers and insurers in relation to insurance arrangements for the initial introduction of automated vehicles onto UK roads and flexibility to accommodate ongoing technological development in this area. We see the Government’s commitment to setting a clear direction in advance of the technology being commercially available as very welcome.

15.2 It is hoped that the Modern Transport Bill will also set out a framework to manage the needs and expectations of all stakeholders including drivers and consumers as this technology develops.

**16 How effective is the UK's education system in delivering people with the right skills to support the autonomous vehicles sector?**

16.1 We have no specific information to provide but recognise that this is a matter which requires active consideration to ensure that suitably skilled and qualified people are available to support the development of infrastructure and vehicles in an autonomous landscape.

**17 Is the Government's strategy and work in this area sufficiently wide-reaching? Does it take into account the opportunities that autonomous vehicles offer in a wide range of areas, not just on the road?**

We are not in a position to answer this question.

**18 What are the implications of exit from the European Union for research and development and the autonomous vehicle industry in the UK? Are specific actions from the Government needed to support or protect the autonomous vehicles sector in the short term or after the terms of Brexit have been negotiated?**

18.1 We are not aware of any reason why the terms of Brexit should directly affect the ongoing research and development into how automated vehicles will be used although it is important that the UK works collaboratively on an international basis in this field.

*26 October 2016*