

# OZ Optics Limited

## FIBER OPTICS DISTRIBUTED STRAIN AND TEMPERATURE SENSOR (DSTS)

June 2016

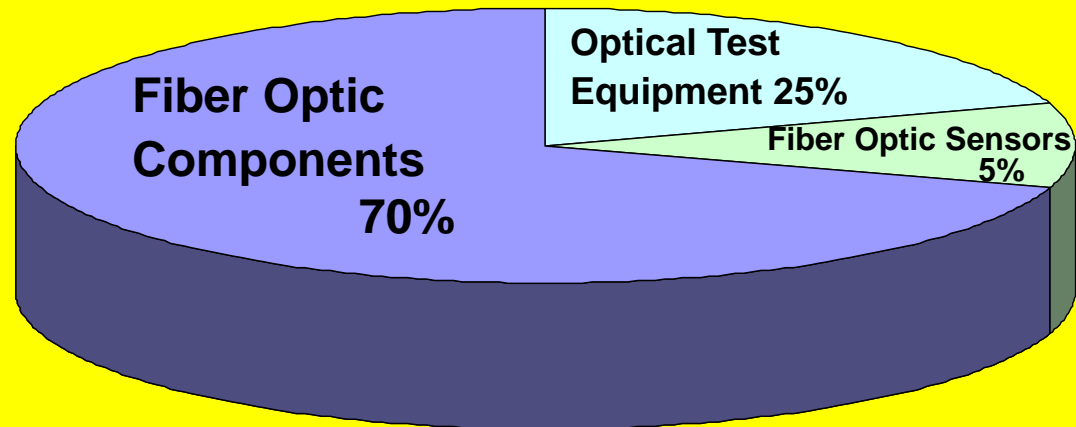
# Company Profile

- Company founded in 1985;
- Corporate headquarters located in Ottawa, Canada;
- Manufacturing facility in Ottawa/Canada, Izmir/Turkey, and Jiaxing/China
- Seven Product Groups: **Laser-to-Fiber Delivery Systems, High Power Fiber Optic Components, Polarization Maintaining Products, Attenuators, Opto-Electronic Packaging, Test Equipment, Fiber Optic Sensor Systems**
- Sales offices in Canada, USA, Turkey and China



# Company Profile

## ➤ Three Product Groups:



➤ Over 1,000 products

➤ Leading Edge R&D

# OZ Optics Products



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www.ozoptics.com

Global Leader in Fiber Optic Products since 1985

## Polarization Maintaining Fiber Optic Components

Patent Numbers: USA 7058275, 7095931, 7295731, China 1672073



**Polarization Maintaining Connectors / Patchcords**

**Polarization Maintaining and Polarizing Splitters / Combiners / Fused Couplers / Switches**

**All Fiber Manual and Electrically Driven Polarization Controllers / Scramblers**

**PM Fiber Directional Taps / Power Monitors**

**Manual / Electrically Controlled PM Fiber Pigtailed Variable Attenuators**

**PLC Splitters**

**Fiber Pigtailed Polarizers**

**PM Fiber Pigtailed Circulators**



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## High Power Fiber Optic Components

Patent Numbers: Canada 2494133, USA 7058275, 7095931, 7295731, China 1672073



**High Power/Temperature Connectors & Patchcords**

**High Power Isolators**

**High Power Laser to Fiber Couplers / Collimators / Focusers**

**High Power Mode Field Adapters**

**High Power Optical Taps / Power Monitors**

**CO<sub>2</sub> Cleaning for High Power Components**

**High Power Splitters / WDM's**

**Shutters / Receptacles / Sleeve Thru Adapters with Sensors**



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### Fiber Optic Attenuators for SM, PM, and MM Fibers

|  |   |  |
|--|---|--|
| <p><b>Digital Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• 0.008 Resolution, Fast Response</li> <li>• 0.008 to 1000 Extinction Range</li> <li>• 100 mW Max</li> </ul>   | <p><b>Electrically Controlled Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• 0.008 to 1000 Extinction Range</li> <li>• Up to 2 Watts Power Handling</li> <li>• PC Based, Analog and Digital Control</li> </ul>             | <p><b>MEMS Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• 0.008 to 1000 Extinction Range</li> <li>• Small Size, Low Cost, Low Power Consumption</li> <li>• Low Wavelength Response, Low Crosstalk</li> </ul>                                      |
| <p><b>SM / PM / MM Fiber Pigtailed Inline Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• 0.008 to 1000 Extinction Range</li> <li>• 500 to 2W Power, 200 Wavelength Response</li> <li>• 0.008 PCC, 0.008 Tolerance Specifications</li> </ul> | <p><b>Single/Multi Channel Miniature Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• Compact, Less Than 5mm Spacing Between Fibers</li> <li>• Designed for Multiple Fiber Arrays</li> <li>• PC Based, Monolithic</li> </ul> | <p><b>Reflective Style Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• 0.008 to 1000 Extinction Range</li> <li>• 0.1 to 100 W Power</li> <li>• 4000 - 10000 - 4000 Backreflection</li> </ul>   |
| <p><b>Air Gap Variable Attenuators</b></p>  <ul style="list-style-type: none"> <li>• 0.008 to 1000 Extinction Range</li> <li>• 1000 W Power, 200 Wavelength Response</li> <li>• 0.008 PCC, 0.008 Tolerance Specifications</li> </ul>                              | <p><b>Plug Type Fixed Attenuators</b></p>  <ul style="list-style-type: none"> <li>• Low Insertion Loss</li> <li>• High Reliability</li> <li>• Available in Various Fiber Types</li> <li>• Available in Various Power Levels</li> </ul>           | <p><b>Attenuating Fiber Patchcords</b></p>  <ul style="list-style-type: none"> <li>• Available in Various Fiber Types</li> <li>• Available in Various Power Levels</li> <li>• Available in Various Wavelengths</li> <li>• High Reliability and Long Lifetime</li> </ul> |

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### Laser & Laser Diode to Fiber Delivery Systems

|  |   |  |
|--|---|--|
| <p><b>Laser to Fiber Couplers</b></p>                                       | <p><b>Bare Fiber Adaptors with Magnetic Clips</b></p>  | <p><b>Bulkhead Receptacles</b></p>                  |
| <p><b>Pigtail/Receptacle Style High/Low Power Collimators/Focusers</b></p>  | <p><b>High/Low Power Patchcords</b></p>                | <p><b>WDM/RGB Combiners</b></p>                     |
| <p><b>OCT Modules and 2 micron Components</b></p>                          | <p><b>OEM Laser Diode to Fiber Couplers</b></p>       | <p><b>Turnkey, Ultra Stable Laser Modules</b></p>  |

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# OZ Optics Products



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### Fiber Optic Components for Optoelectronic Packaging


Hermetically Sealable Patchcords with Glass or Metal Solder



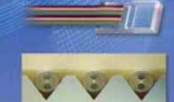
Single Channel



Multi Channel




Metalized Fibers



PM/SM/MM Fiber Pigtailed V-Groove Arrays



Polarization Measurement System for V-Grooves




Tapered / Lensed Fiber Polished / Laser Shaped




Glass Solder Preforms



Fiber Optic Ferrules



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### Fiber Optic Test Equipment



Polarization Extinction Ratio Measurement Systems



Power Meters with Smart Detector Heads



Broadband Digital Variable Attenuators



Optical Fiber Length Meters



High Power Visual Fault Locators Fiber Optic Stable Sources



Inline Optical Power Monitors/Meters



Laser Diode Sources Single/Multiwavelength



Fiber Optic Smart Patchcords



Fiber Optic Fault Finders



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# Product Innovation



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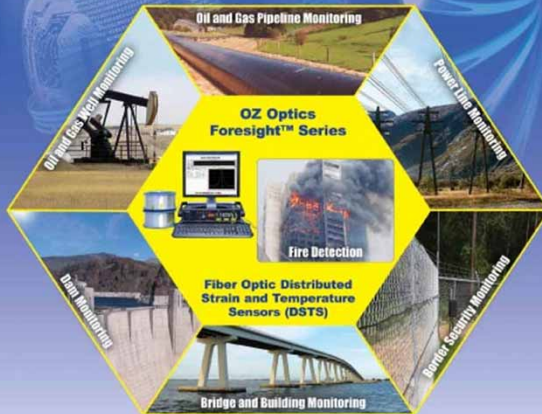


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## Fiber Optic Distributed Strain and Temperature Sensors

USA Patent Numbers: 7499151, 7599047

- BOTDA only, BOTDR only, or both BOTDA and BOTDR modules in one unit
- Simultaneous measurement of strain and temperature
- Fast, dynamic measurement of strain and/or temperature up to 100 km sensing range
- Uses standard telecommunication fiber to minimize costs



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## Fiber Optic Fault Finder for Optical Network Safeguard™

- Monitors and reports network health status in real time, 24 hours/day, 365 days/year
- Lowers network operating and maintenance expenses
- Reduces revenue loss due to fiber plant outages
- User friendly interface via various wireless interfaces (Wi-Fi, GPRS), USB, or RS-232
- Reports fault location, giving GPS coordinates with time stamp
- Early alert and outage reports via cellular phone, email, IM, SMS, or text messaging



OZ Guard Automated Test Solution



Remote Monitoring a WDM Network



Remotely Accessible/Wireless Fault Finders



GPS Locator



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# Product Innovation



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## 2 micron Fiber Optic Components for PM and SM Fibers



Fiber Optic Patchcords



Fused Couplers / Taps / Beam Splitters / Combiners



Fiber Pigtailed Laser Diode Sources



Pigtail / Receptacle Style Collimators / Focusers



Polarizers



Manual / Electrically Controlled Variable Attenuators



Isolators



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## Fiber Optic Products for OCT Applications



OCT Modules



Manual / Electrically Controlled Broadband Variable Attenuators



Manual / Electrically Controlled Fiber Optic Delay Lines



Manual / Electrically Controlled Polarization Controllers



Fiber Pigtailed Broadband SLED Sources



Fiber Collimators / Focusers



Broadband Fused Couplers



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# Company Profile

Over 470 employees worldwide:

- 260 in Ottawa and US
- 50 in Turkey
- 160 in China

OZ Canada



OZ China



OZ Turkey

# Company Profile

## *OZ Optics is lead by an experienced team:*

- **Ömür Sezerman, Chairman, President & CEO**
  - Founder and CEO since inception (31 years)
- **Zahide Sezerman, VP of Human Resources**
  - With OZ Optics since inception (31 years)
- **Garland Best, VP of Components Division**
  - 24 years at OZ Optics
- **Gordon Youle, VP of Test Equipment Division**
  - 17 years at OZ Optics
- **Martin Powell, Operation Manager**
  - 12 years at OZ Optics
- **Sarah Miller, Controller**
  - 3 years at OZ Optics
- **Metin Sezerman, General Manager of OZ Turkey**
  - 15 years at OZ Optics
- **Bing Li, General Manager of OZ Optics China**
  - 12 years at OZ Optics

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# Company Profile

- ISO9001:2008 certified
- Broad patent portfolio
- Advanced proprietary processing technology



# Company Profile

- *Using our strong direct sales and distributors, we address the following markets:*



# Company Profile

➤ *OZ Optics has resellers and distributors in over 30 Countries & Regions and over 10,000 customers globally:*



Australia



France



Japan



Spain



Austria



Germany



Netherlands



Switzerland



Belgium



Greece



Luxembourg



Sweden



Brazil



Hong Kong



Norway



Taiwan



Canada



India



Poland



Thailand



China



Ireland



Portugal



Turkey



Czech Rep.



Israel



Singapore



United Kingdom



Denmark



Italy



South Korea



United States

# In-House Production Capabilities

- Experienced and well-trained staff in following fields:
  - optical, mechanical, electronics & software

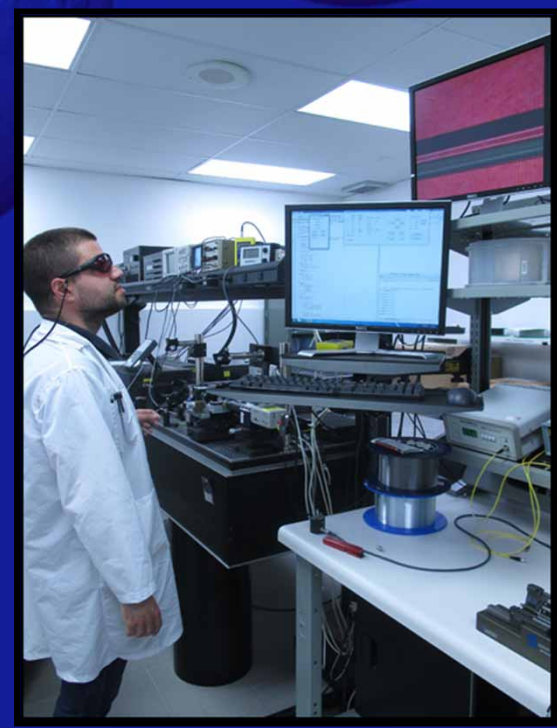
CNC Machine Shop



AR Coating



Femtosecond Laser Lab



Clean Room



Laser Conditioning/Cleaving



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# Branch Network



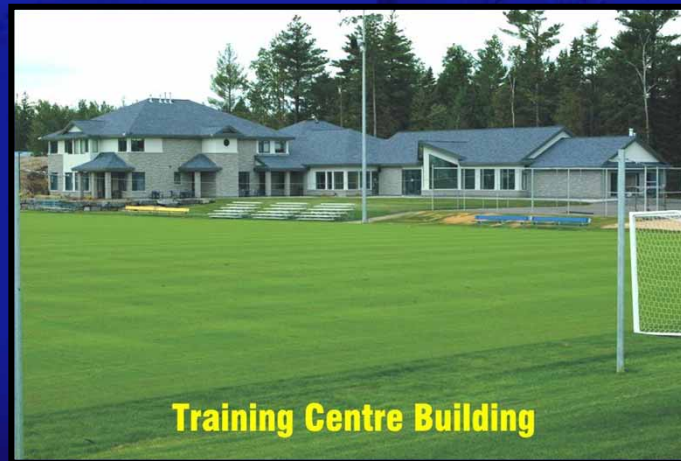
# Facility – Ottawa Headquarters

- 60,000 sq ft. – Manufacturing and R&D Facilities
- 15,000 sq ft. – Admin, Sales and Marketing
- 15,000 sq ft. – Training and Fitness Facility
- R&D, Product Design, Engineering, Final Assembly & QA





# Facility – Ottawa Headquarters



# OZ Optics – Turkey Factory

- Operational since 2000
- 33,000 sq ft. Manufacturing Facility
- Located in Free Trade Zone
- Low Tax Rates
- Sub Component Parts Manufacturing
- Cost Effective Manufacturing
- High Quality Labor



# OZ Optics China

- Operational since 2009
- Wholly Foreign Owned Enterprise
- Subcomponent Parts Manufacturing
- Cost Effective Manufacturing
- High Quality Labor
- Extensive Training  
( 3-6 months in OZ Canada)



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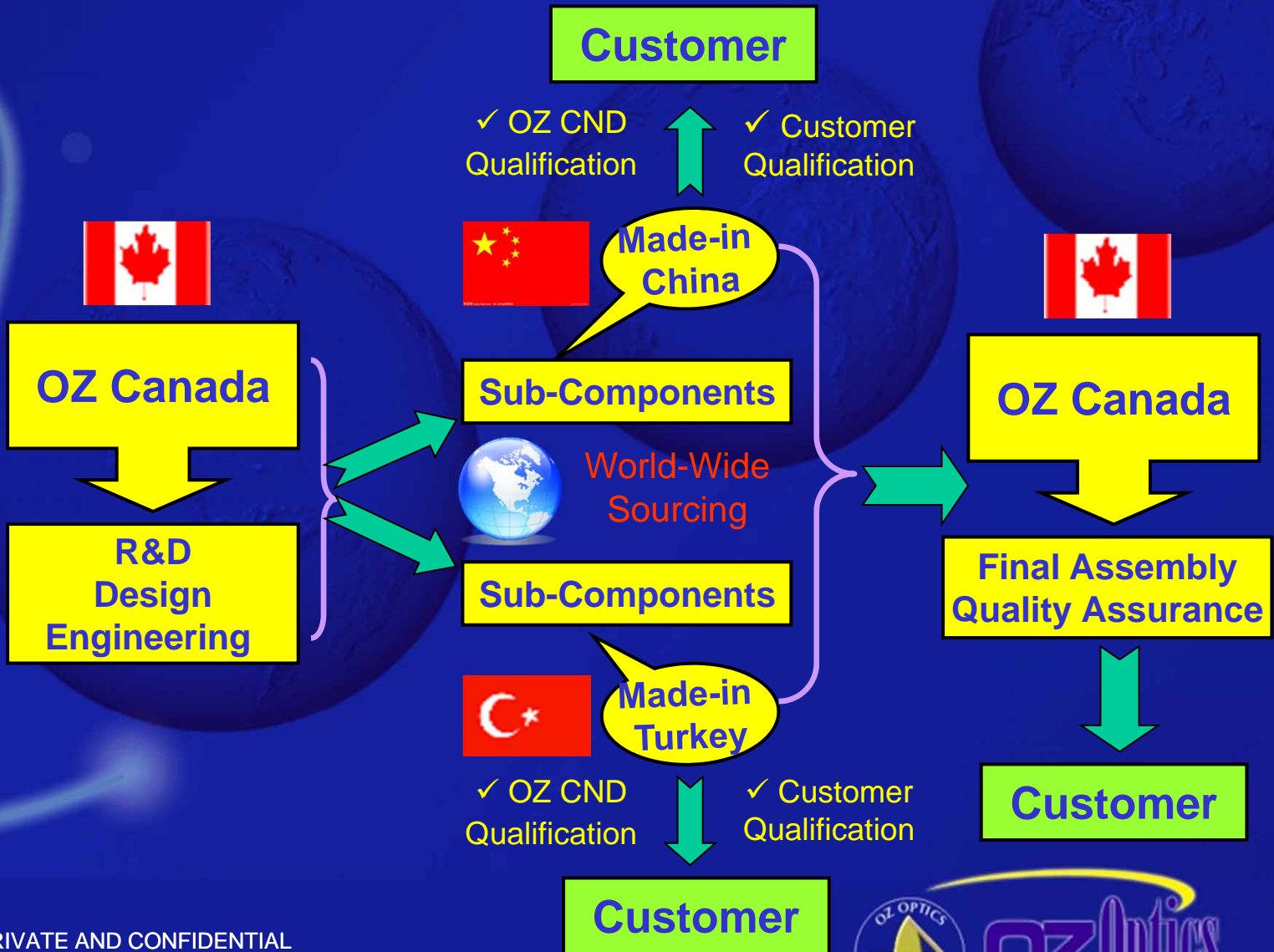
# OZ China Facility

## Jiaxing, China

- Located in Economic Development Zone
- 500 sq meters – Admin, Sales and Marketing
- 1500 sq meters – Manufacturing Area
  - 100 sq meters – Class 10,000 Clean Room
  - 100 sq meters – ESD Working Area



# Manufacturing Strategy



# Industry Standards

All products manufactured are in strict accordance with international industry standards:

➤ *Telecordia Compliance*



➤ *CE Compliance*



➤ *RoHS Compliance*



➤ *ISO 9001:2008 Certified (China, Turkey and Canada)*

➤ *Controlled Goods Directorate Registered*

# Core Competencies

- Pioneer in Polarization Maintaining (PM) Components
- Leader in Wavelength Flattened, High Power & Low PDL Components
- Leader in High Power Fiber Optic Delivery Systems
- Custom Test Equipment, Including Polarization Test Equipment and FTTH Equipment
- Widest Range in Attenuator Product Offering
- Fiber Optic Distributed Strain and Temperature Sensors
- Complete product line for OCT applications & 2 Micron

# Leading Technology

- **High Power Isolators**
  - power handling > 50W
  - low loss, low cost turnkey solution



High Power Free Space and Pigtailed Isolators

- **Pioneer in Polarization Maintaining (PM) Components**
  - wavelength flattened
  - high power & low PDL
  - PM test equipment



Polarization Maintaining Patchcords

Distributed Strain and Temperature Sensors



- **Fiber Optic Sensor**
  - fast and simultaneous measurement of strain & temp
  - large structure health monitoring

High Power Collimators/Focusers



- **Leader in High Power Fiber Optic Delivery Systems**
  - specializes in custom design





### OUR VISION

- Be the preferred Supplier of choice
- Capture and expand market share
- Maximize shareholder value

### OUR MISSION

- To become the leading provider of innovative optical products to telecom and non-telecom sectors

### OUR CORE VALUES

- Leadership
- Teamwork
- Boldness
- Commitment
- Innovation
- Rewards

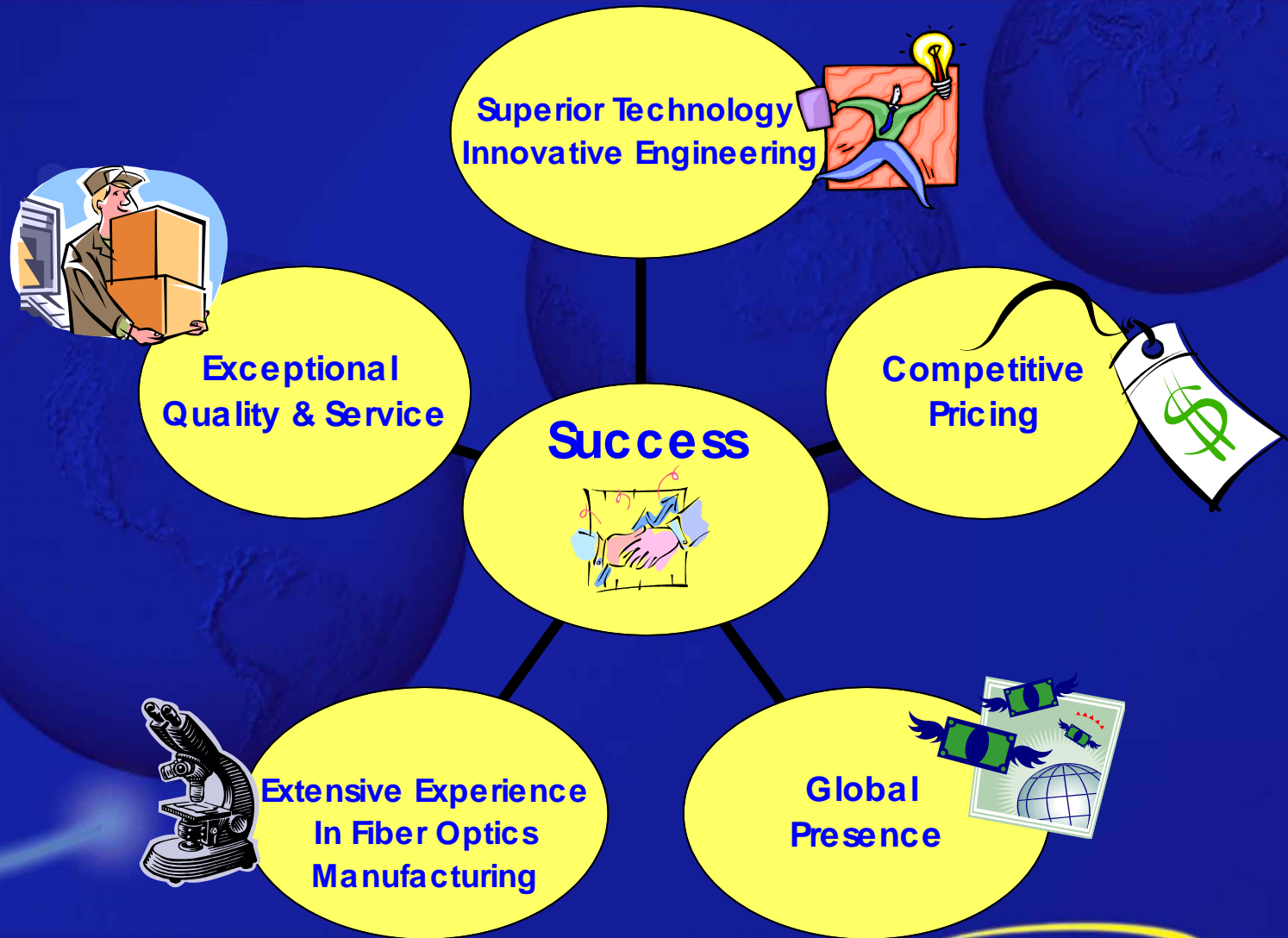
### OUR QUALITY POLICY

- Provide our Customers with a competitive advantage, leveraging performance, price and delivery, through a continuous process of Quality advancement in all areas of our Company
- Communicate effectively to our Customers, Suppliers and Shareholders our commitment to Quality and continuous improvement
- Promote opportunities of professional development for all members of our Company through education, training and personal challenge

Ömür Sezerman  
President

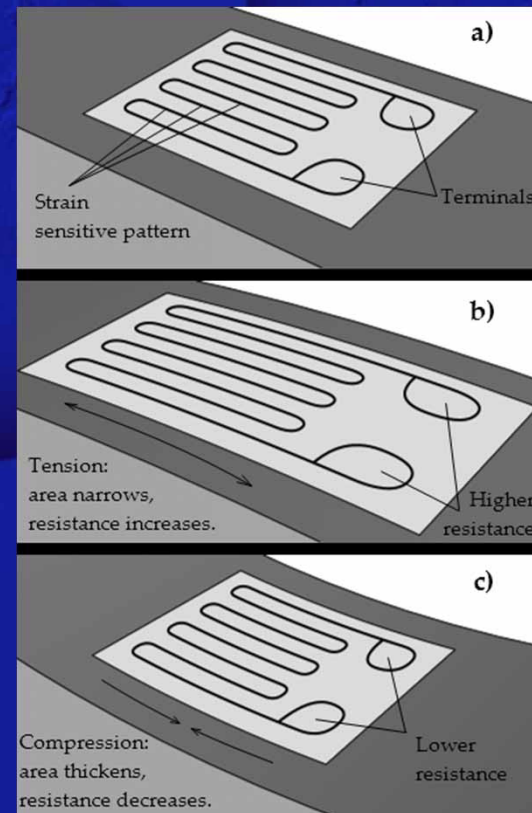


# Competitive Advantage



# Conventional Temperature & Strain Sensors

- **Temperature sensor: thermocouple**
- **Strain sensor: electrical strain gauge**
  - Temperature influence
  - Electromagnetic interference (EMI)
  - Humidity influence
  - Point sensor



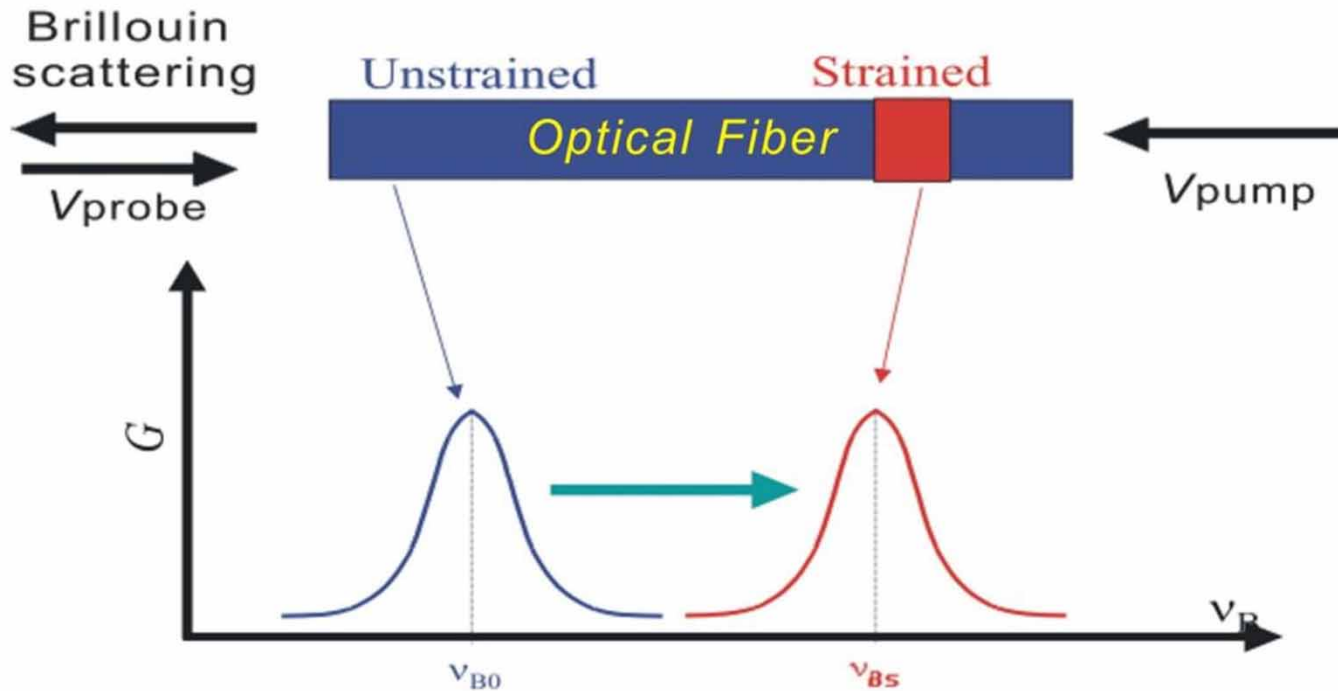
# Fiber Optic Sensors

- **Advantages of Fiber Optic Sensors**
  - Electrically insulating materials (no electrical cables are required)
    - high voltage environments
  - Chemically passive, not subject e.g. to corrosion
  - Immune to electromagnetic interference (EMI)
  - Wide operating temperature range
- **Fiber Bragg Grating Sensor**
  - Strain resolution and accuracy:  $< 2 \mu\epsilon$
  - Cannot distinguish strain and temperature
  - Point sensor
- **Distributed Fiber Optic Sensors**
  - Raman scattering based — only temperature
  - Brillouin scattering based — both temperature and strain

# Fiber Optic Sensors

- **Fiber Bragg Grating Sensor**
  - Sensor medium: Fiber Bragg grating
  - Laser source and data acquisition system: Spectrum analyzer
- **Distributed Fiber Optic Sensors (Brillouin Sensors)**
  - Sensor medium: Conventional communication fiber (such as SMF, LEAF, etc..)
  - Laser source and data acquisition system: Brillouin sensor system
    - **OZ Optics [Foresight™ DSTS (Distributed Strain and Temperature Sensors)]**
    - Omnisens (STA)
    - Yokogawa (AQ8603) (Discontinued)
    - Sensornet (DTSS)
    - Neubrex (Neubrescope)
    - fibrisTerre (fTB 2505)

# Working Principle — BOTDA

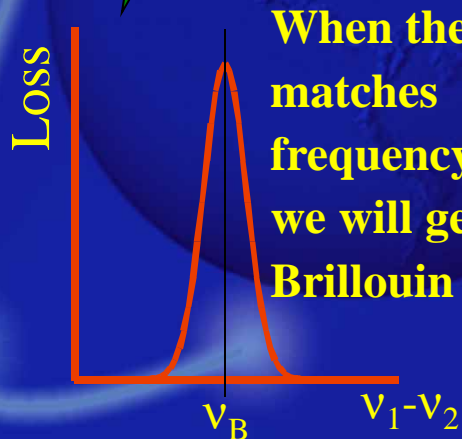
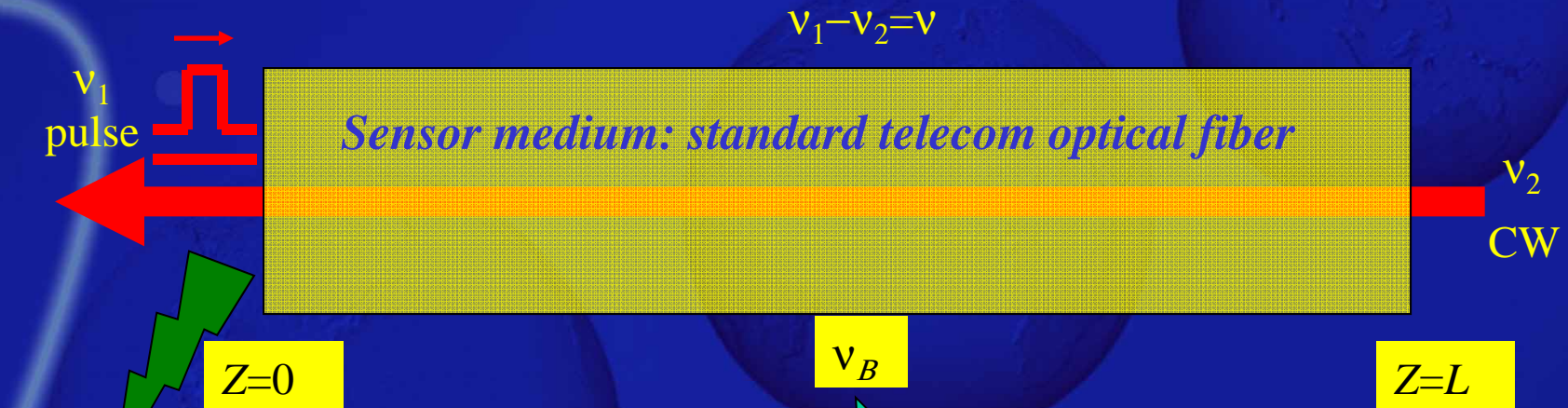


$$\nu_B = \nu_{B0} + C_T (T - T_0) + C_\epsilon (\epsilon - \epsilon_0)$$

**$T$  and  $\epsilon$  are variables**

**In order to differentiate these two variables, Brillouin peak in the spectrum is required.**

# Working Principle — BOTDA



When the beat frequency  $\nu$  matches intrinsic Brillouin frequency of the fiber  $\nu_B$ , we will get maximum of Brillouin spectrum.

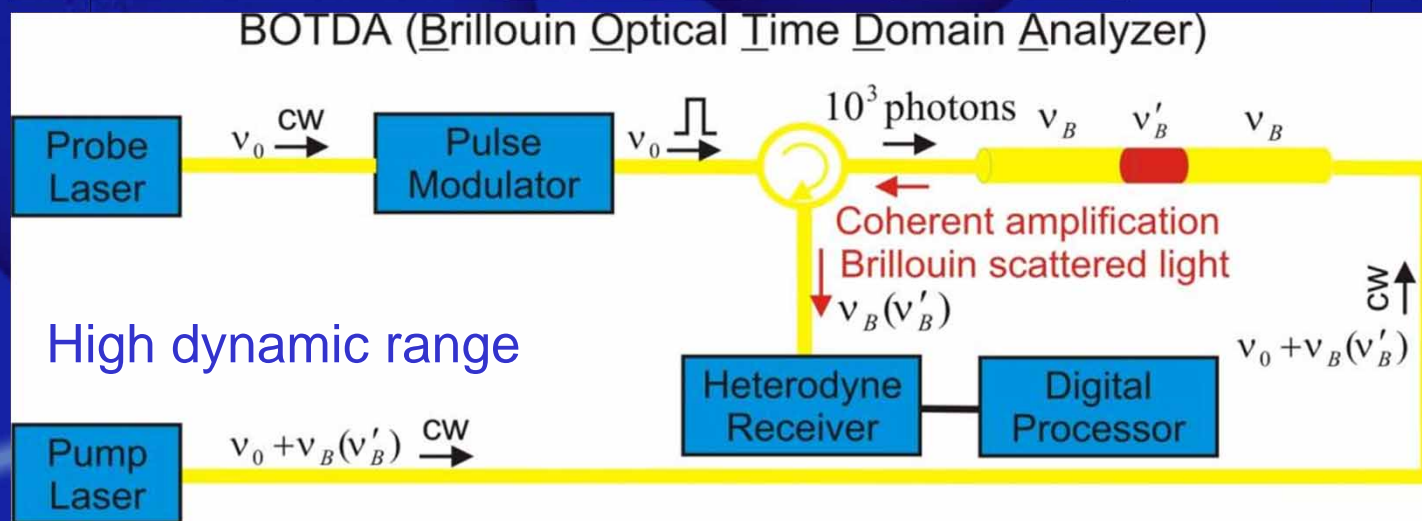
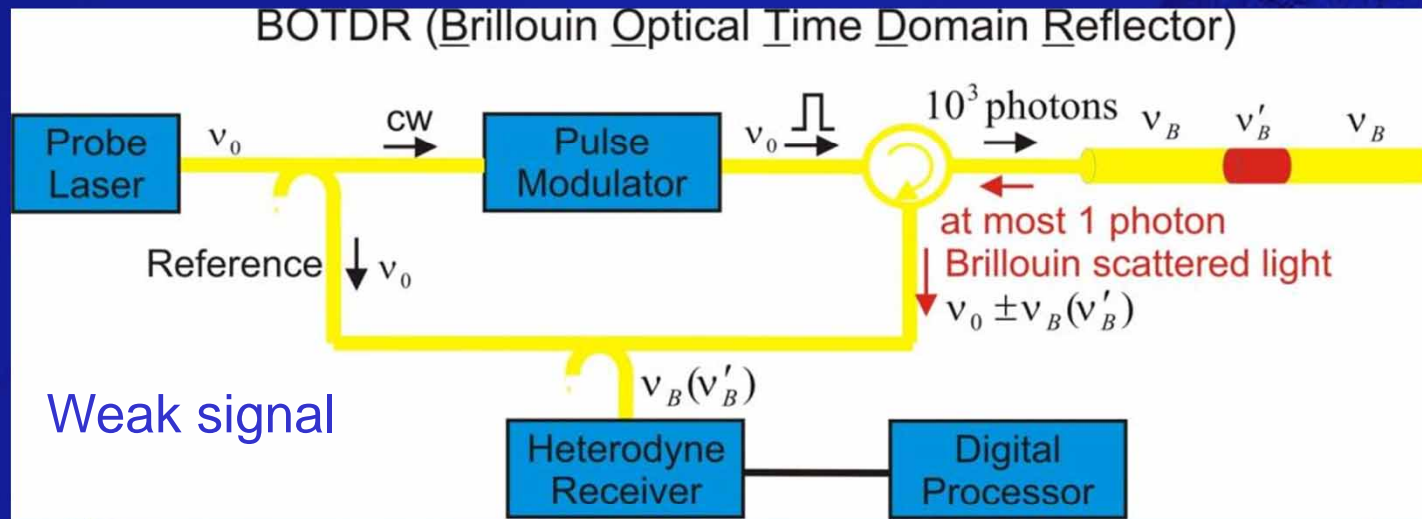
$\nu_B$  changes linearly with the strain and temperature exerted.

$$\nu_B = \nu_{B0} + C_T (T - T_0) + C_\epsilon (\epsilon - \epsilon_0)$$

**Brillouin Spectrum**

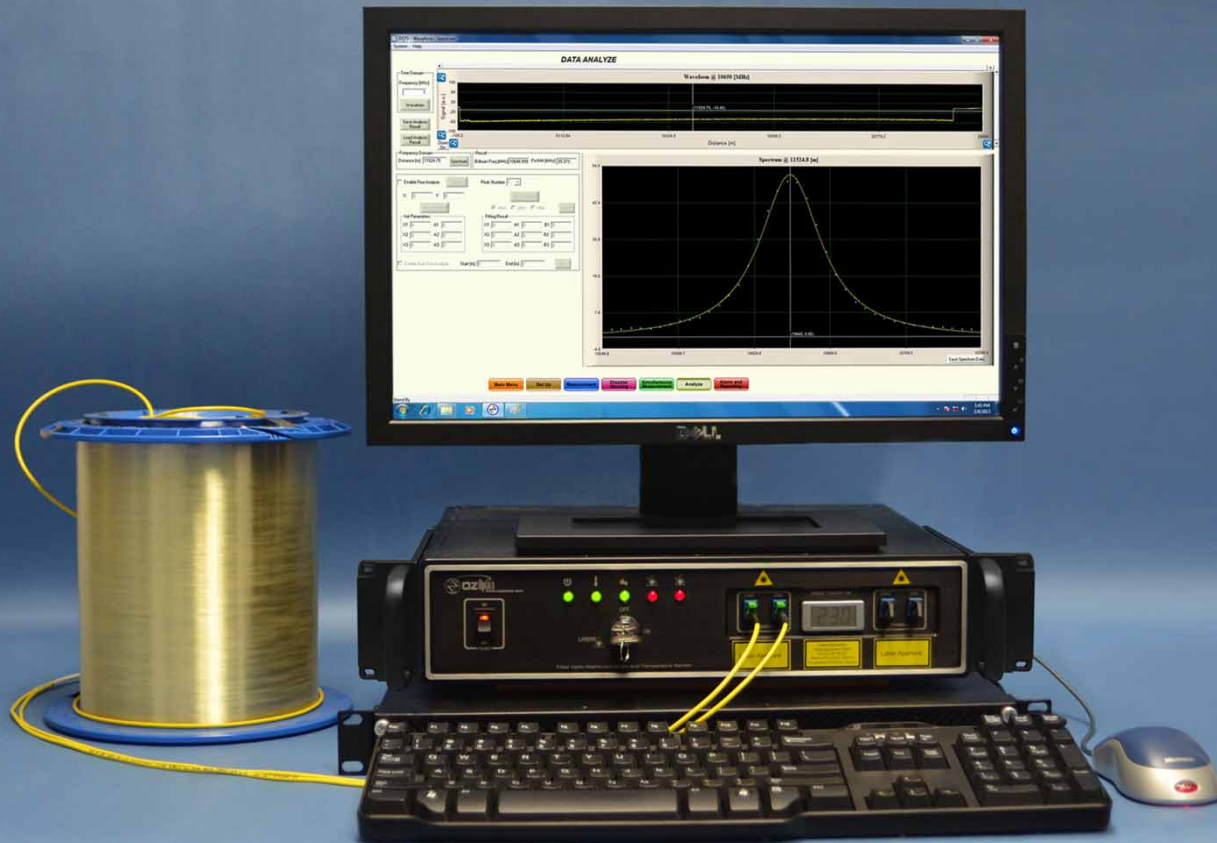
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# Comparison of BOTDR and BOTDA

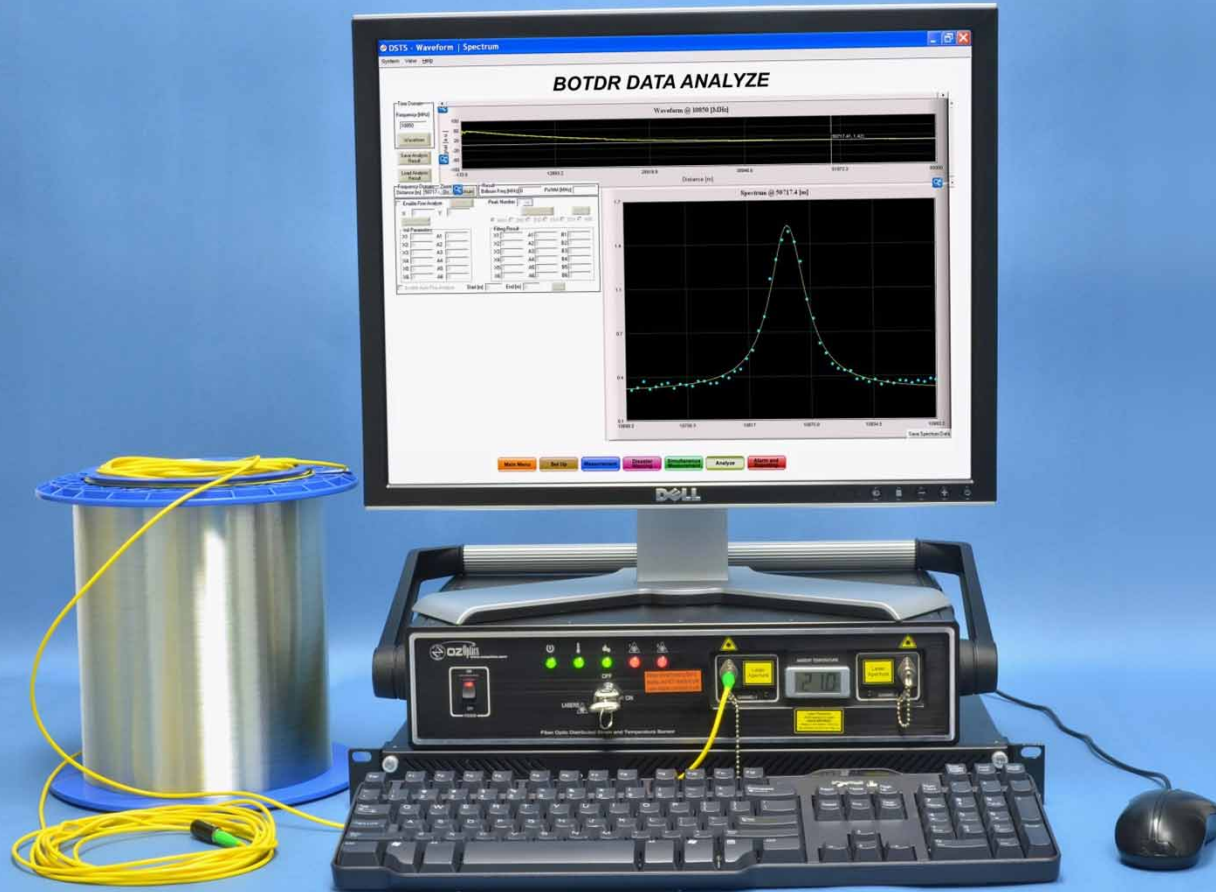




# DSTS BOTDA



# DSTS BOTDR



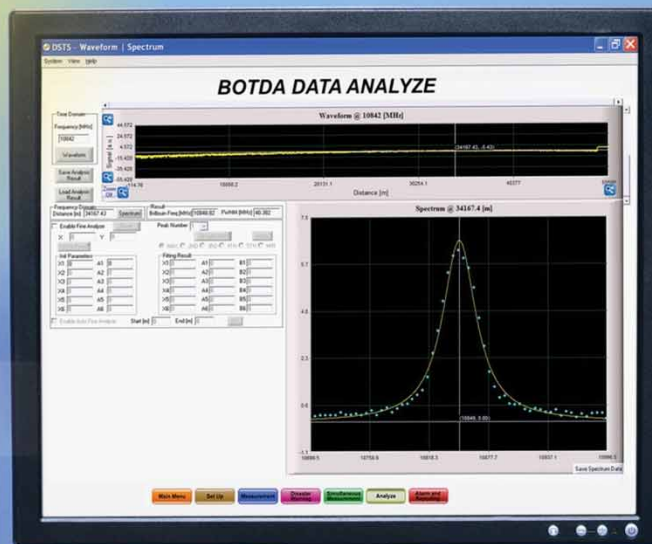
# DSTS BOTDA/R Combo

BOTDA Module



Combines 2 modules into 1

BOTDR Module



# Foresight™ DSTS

## Silver Level Winner



**US Patents #: 7499151 and 7599047**

# Merits of DSTS BOTDA

- Coherent amplification of Brillouin scattering signal  
⇒ longest measured range (100 km sensing range, 160 km fiber length)
- Narrowest Brillouin spectrum (~ 45 MHz )  
⇒ highest resolution of strain and temperature
- Special low loss fiber components and electronic processing  
⇒ high stability of system
- With proprietary techniques, Brillouin frequency is extracted accurately  
⇒ highest accuracy in measuring strain and temperature separately or simultaneously
- New technology  
⇒ quick measurement of strain and temperature (as low as 1 second: 1 Hz)

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# Merits of DSTS BOTDR

- Low noise detection for weak spontaneous Brillouin scattering signal
  - ⇒ longest measured range (70 km in one direction)
- Special low loss fiber components and electronic processing
  - ⇒ high stability of system
- Sophisticated design
  - ⇒ Small size and light weight

# Competitive Analysis

| Company   | OZ Optics                  |                                  | OmniSens               | Neubrex                   | SensorNet             | fibrisTerre            |
|---|----------------------------|----------------------------------|------------------------|---------------------------|-----------------------|------------------------|
| Technology  | BOTDR                      | BOTDA                            | BOTDA                  | BOTDA                     | BOTDR                 | BOFDA                  |
| Maximum Sensing Range                               | 70km                       | 100km (fiber length up to 160km) | 50km                   | 27km                      | 24km                  | 25km                   |
| Highest Spatial Resolution <sup>1)</sup> / Accuracy | 1m <sup>2)</sup> /5cm      | 10cm <sup>2)</sup> /5cm          | 50cm/10cm              | 2cm/1cm                   | 1m/50cm               | 50cm/5cm               |
| Dynamic Range at highest spatial resolution         | 10dB                       | 7dB                              | NA                     | 0.5dB                     | NA                    | NA                     |
| Strain / Temperature Precision ( $\sigma$ )         | 16 $\mu\epsilon$ /0.8°C    | 2 $\mu\epsilon$ /0.1°C           | NA/0.1°C               | 7.5 $\mu\epsilon$ /0.35°C | NA                    | 2 $\mu\epsilon$ /0.1°C |
| Strain / Temperature Resolution                     | 0.1 $\mu\epsilon$ /0.005°C | 0.1 $\mu\epsilon$ /0.005°C       | 2 $\mu\epsilon$ /0.1°C | NA                        | 10 $\mu\epsilon$ /1°C | NA                     |

- 1) Specifications of other vendor's products are based on their public datasheets.
- 2) Based on scientific definition, the spatial resolution is defined by pulse width. 10ns pulse width is equivalent to 1m spatial resolution while 1ns pulse width is equivalent to 0.1m spatial resolution.

# Comparison: DSTS BOTDA and Raman based DTS

|  | Raman based DTS   | OZ Foresight™ DSTS   |
|--|---|--|
| <b>Max Fiber Length</b>                    | 20km (MM)   | 150 km round-trip (physical distance 75 km)  |
| <b>Fiber Type</b>                          | Multimode   | Standard telecom singlemode  |
| <b>Response time @ 20km, 2C Resolution</b> | More than 10 minutes  | 30 seconds to 3 minutes  |
| <b>Configuration</b>                       | Single ended or double ended  | Single ended or double ended   |
| <b>Measurement Base and Precision</b>      | Intensity based<br>Require calibrations<br>Sensitive to attenuation changes | Frequency based<br>No calibration required after setup<br>Not sensitive to attenuation changes                 |
| <b>Dynamic Range</b>                       | 3-4 dB<br>May fail when attenuation increases                               | 25-30 dB<br>Allows better immunity to attenuation<br>Wider measurement range and longer use of installed fiber |
| <b>Measurand</b>                           | Temperature   | Temperature and Strain   |
| <b>Measurement Resolutions</b>             | Comparable @ over 1 minute  | Comparable @ several seconds   |



# Competitive Analysis



Neubrex



fibrisTerre



SensorNet



Foresight\_C



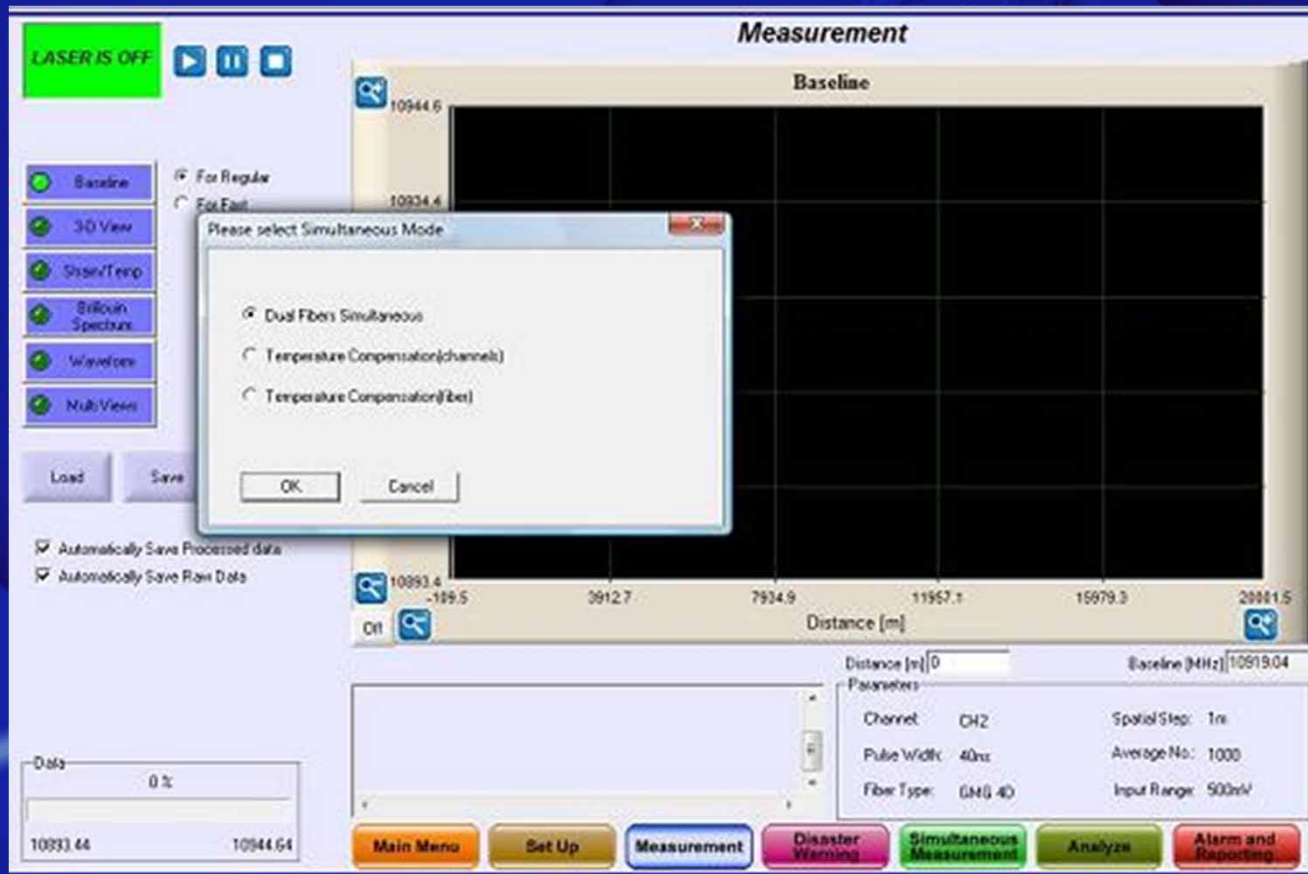
Omnisens

# New Features

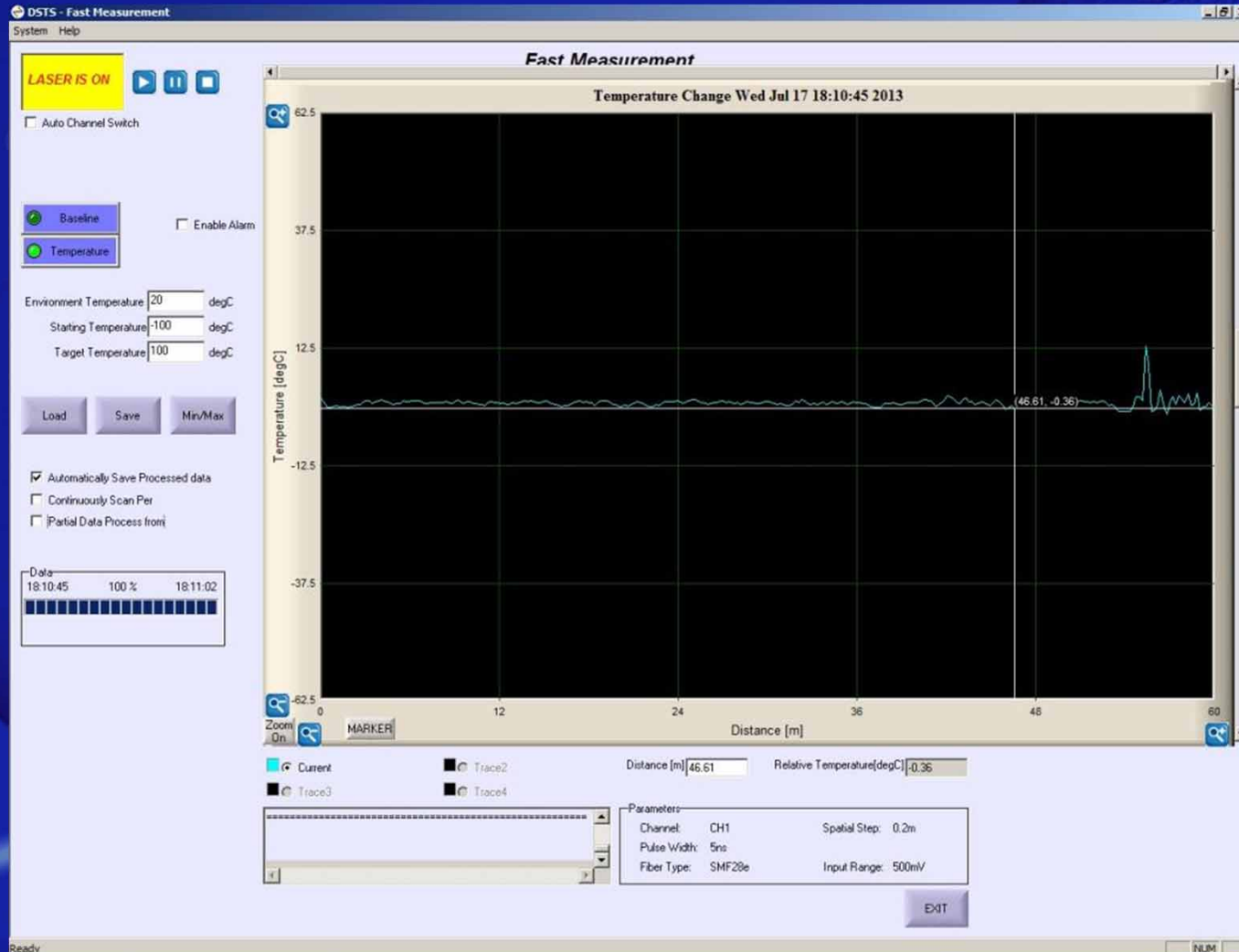
- **Unit will auto configure almost everything**
- **Auto Channel Switch allows continuous scans between channels.**
- **Frequency data added to output file to compare against previous DSTS measurements from competitors equipment.**
- **Real-time fault point detection**
- **Fast measurement**
- **Simultaneous measurement**

# Merits of OZ Optics Foresight™ DSTS

- Dynamic Measurement
- Fast Measurement



# Fast measurement (temperature only)



# Simultaneous modes

DSTS - Simultaneous Measurement  
System View Help

**LASER IS OFF** [Play] [Pause] [Stop]

Auto Channel Switch

**Strain Distribution**

Baseline  Enable Strain Alarm  
 Strain & Temp  Enable Temperature Alarm

Simultaneous Measurement Configuration  
Connection Point [m] 4048.34  
Fiber 1 [Core2] Fiber 2 [Core1]

Load Save Min/Max  
 Automatically Save Processed Data  
 Automatically Save Raw Data  
 Continuously Scan Per  
 Partial Data Process from

Data  
15:33:43 100% 15:37:24  
10599.68 10997.12 10997.12

**DUAL FIBERS SIMULTANEOUS**

**Strain Change Wed Nov 27 10:48:33 2013**

Temperature Change Wed Nov 27 10:48:33 2013

Data processing... finished

Parameters:  
Channel: CH1  
Pulse Width: 10ns  
Spatial Step: 0.1m  
Average No.: 10000

Distance [m] 4042.03  
Strain [ue] 590.07  
Temperature [degC] 21.303

Main Menu Set Up Measurement Disaster Warning Simultaneous Measurement Analyze Alarm and Reporting

**Temperature Distribution**

# OZ Optics Foresight™ DSTS Benefits

- **Reducing risk and influence of failure**
  - Fast response
  - Status trend in long term
  - Full range of coverage
- **Reducing operating expenses**
  - No future re-calibration of unit
  - Expected cable life over 20 years

# Applications



**Oil and Gas Pipeline  
Monitoring**



**Dyke and Levee  
Monitoring**



**Power Line  
Monitoring**



**Oil and Gas Well  
Monitoring**



**Bridge and Building  
Monitoring**



**Border Security  
Monitoring**

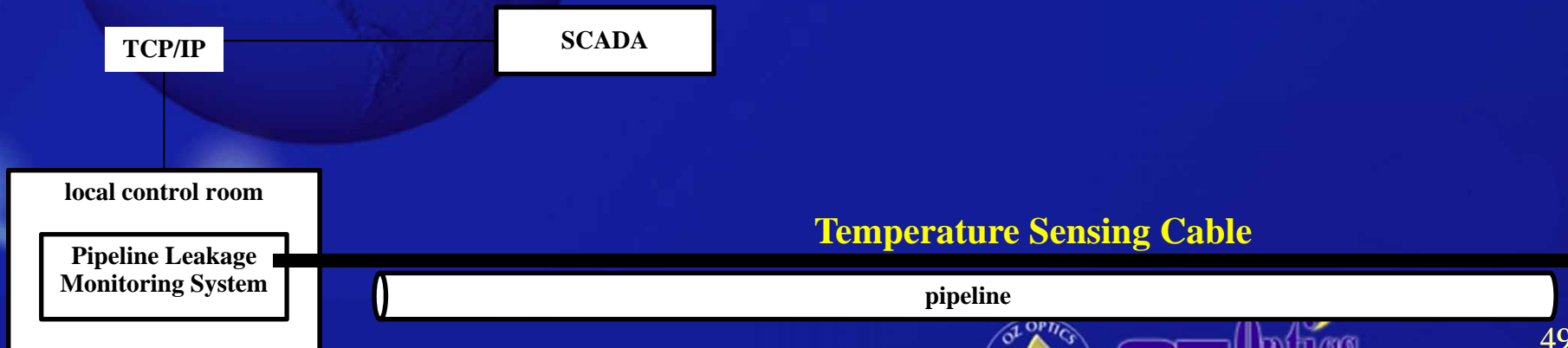
# Oil and Gas

- **Pipeline Leakage Monitoring**
- **Well Integrity Management**
- **Refinery Temperature Monitoring**



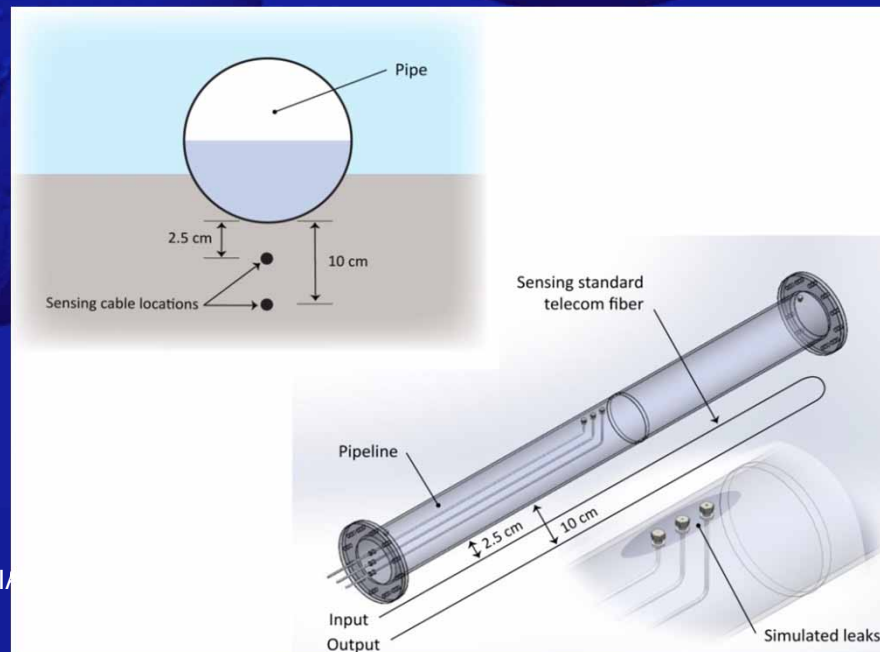
# Pipeline Leakage Monitoring System

- Policy Requirement
- Economic Requirement

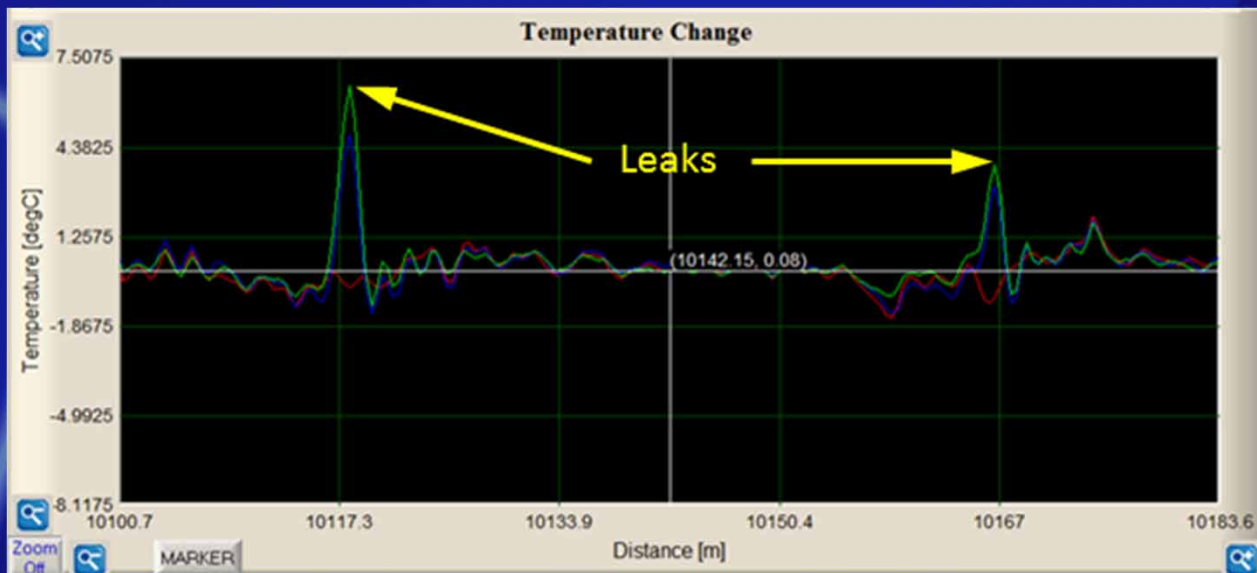


# Third Party Evaluation

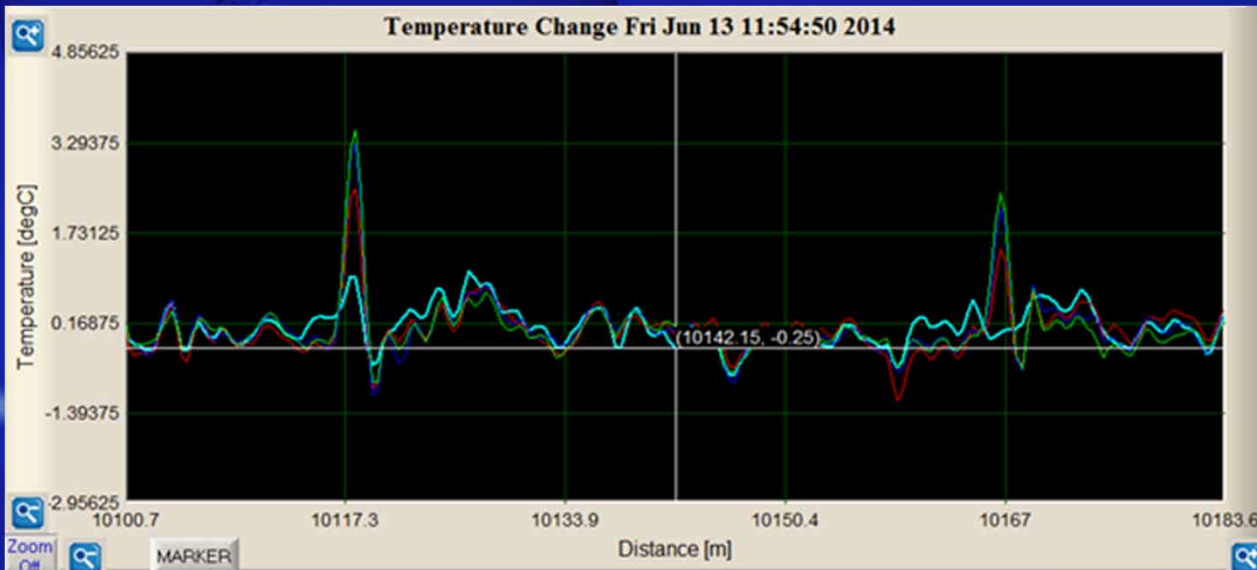
- Leakages from a 1/8" orifice with an injection pressure as low as 22 psi, and a temperature difference of 20°F between the soil and line temperatures, have been easily detected and accurately located.
- An impressive leakage detection response time of less than 2 minutes has been achieved.
- Evaluation was done under laboratory conditions over a period of one month, by Southwest Research Institute (SwRI) and funded by major oil companies through a joint industry program.



# Performance



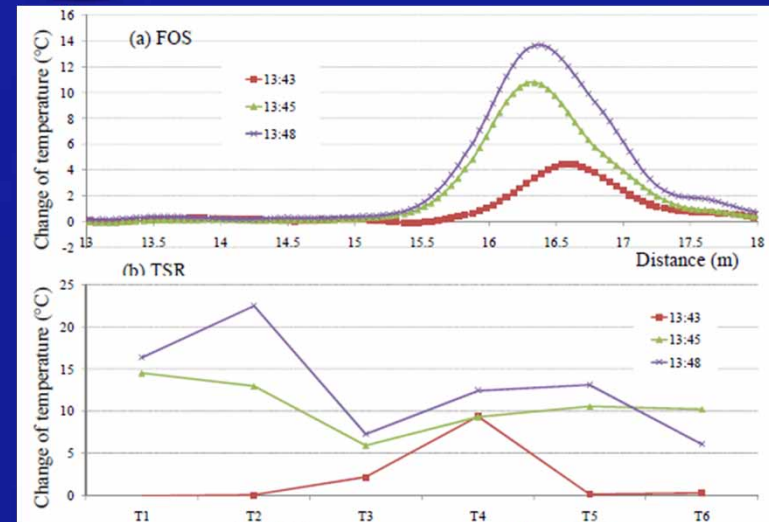
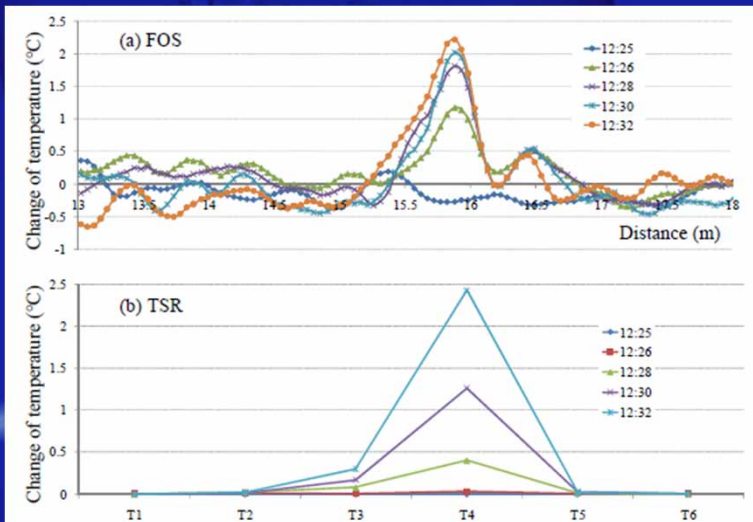
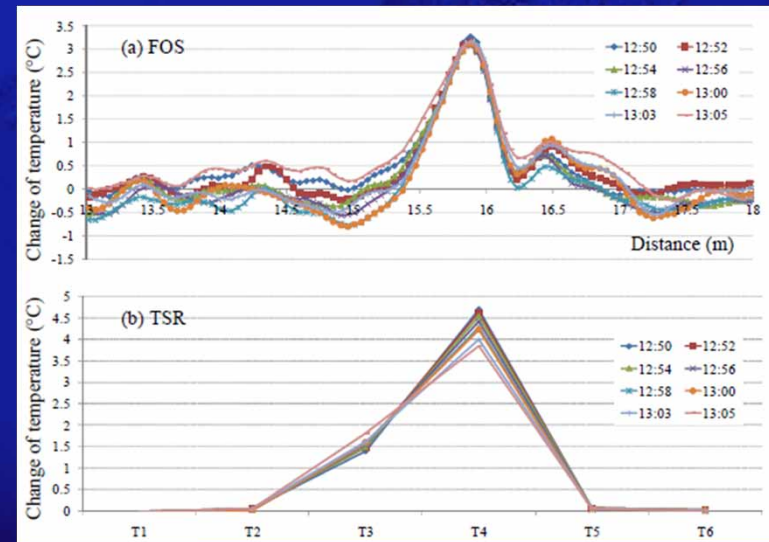
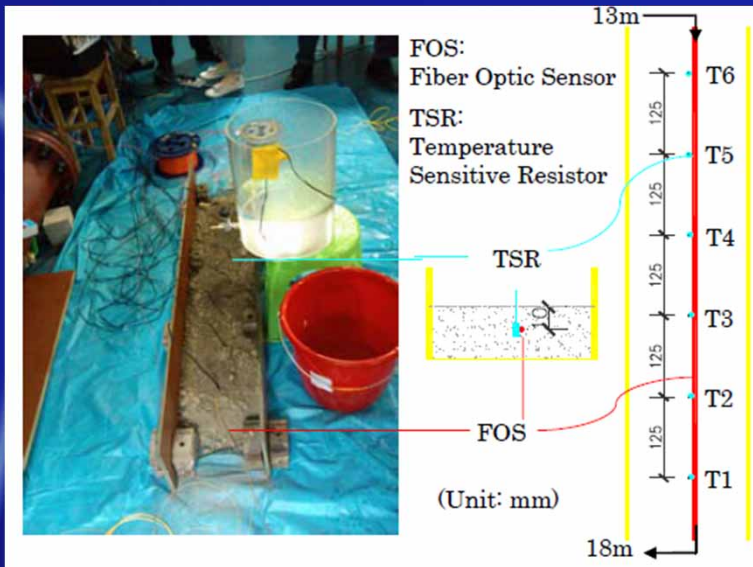
Large leakage detection from 1/8" orifice with 400 psi injection pressure, soil temperature before test: 85°F, line temperature: 115°F.



Small leakage detection from 1/8" orifice with 50 psi injection pressure, soil temperature before test: 73°F, line temperature: 90°F.

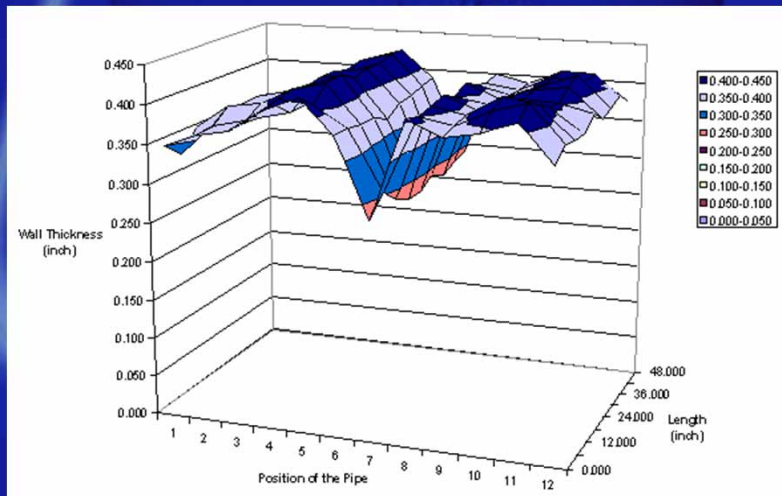
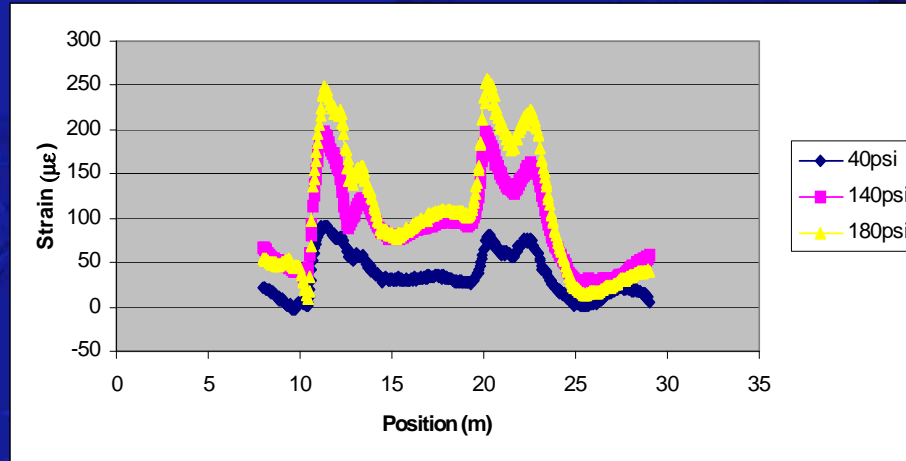


# Soil Temperature Monitoring



# Pipeline Corrosion Monitoring

Pipeline corrosion monitoring in Canmet Materials Technology Laboratory, NRCan, Ottawa, NACE International — Corrosion 2008 Conference and Expo, New Orleans (Louisiana, USA 16-20 March, 2008).



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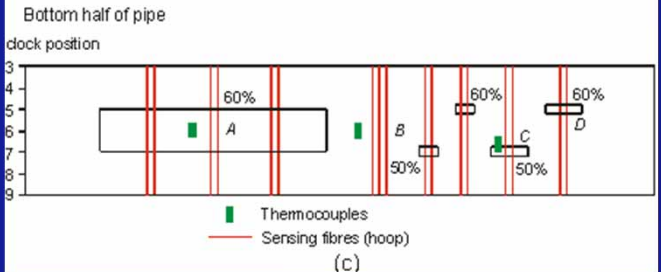
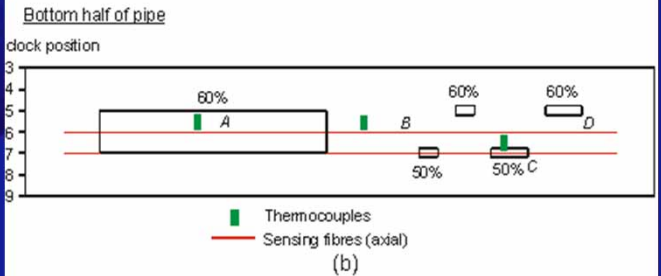
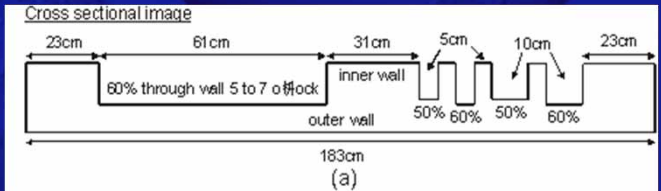


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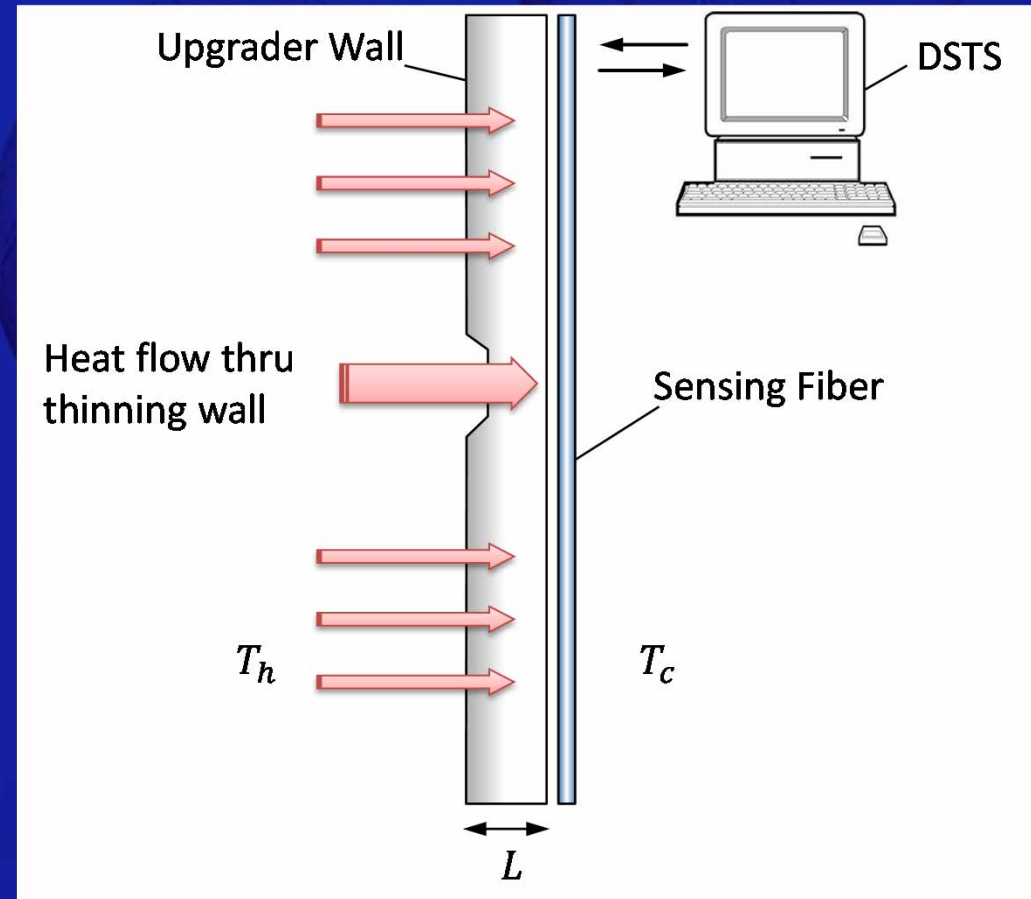
# Pipeline Corrosion Monitoring

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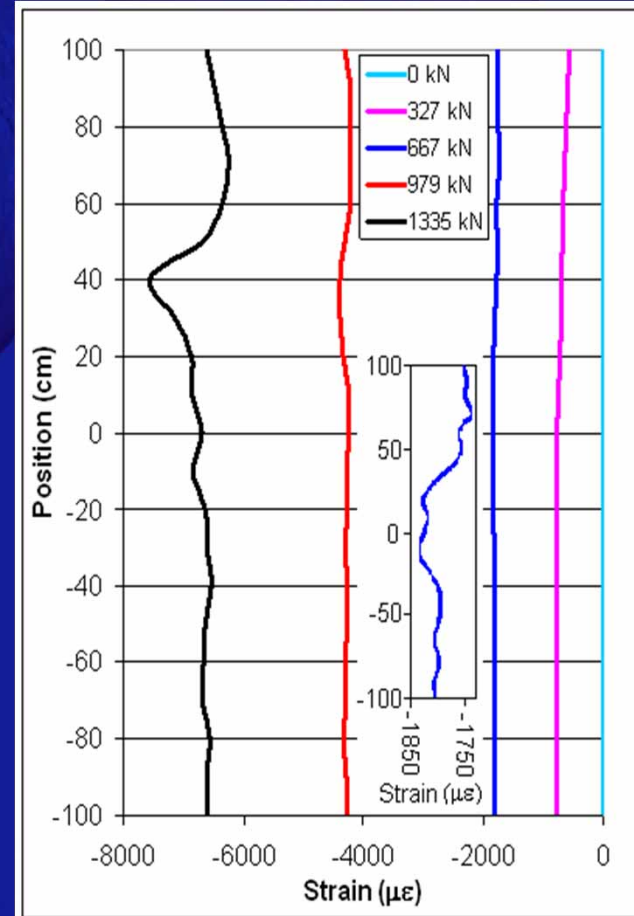
# Refinery Temperature Monitoring

- Refineries use reactors and pressure vessels to transform heavy oil into synthetic crude oil.
- The upgrader reactors are operated at very high temperatures, exceeding 500 °C.
- Due to the thermal stress exerted on the structure of the reactor, a wall-thinning problem might occur, resulting in conductive heat dissipation.
- Without the proper sensing technology, the refinery operator might prematurely shut down operations to perform untimely maintenance, or worse yet, the problem might go unnoticed, resulting in a catastrophic accident.



# Pipeline Buckling Detection

- Pipeline buckling detection in TransCanada Pipeline Ltd, Calgary, and C-FER Technology, Edmonton

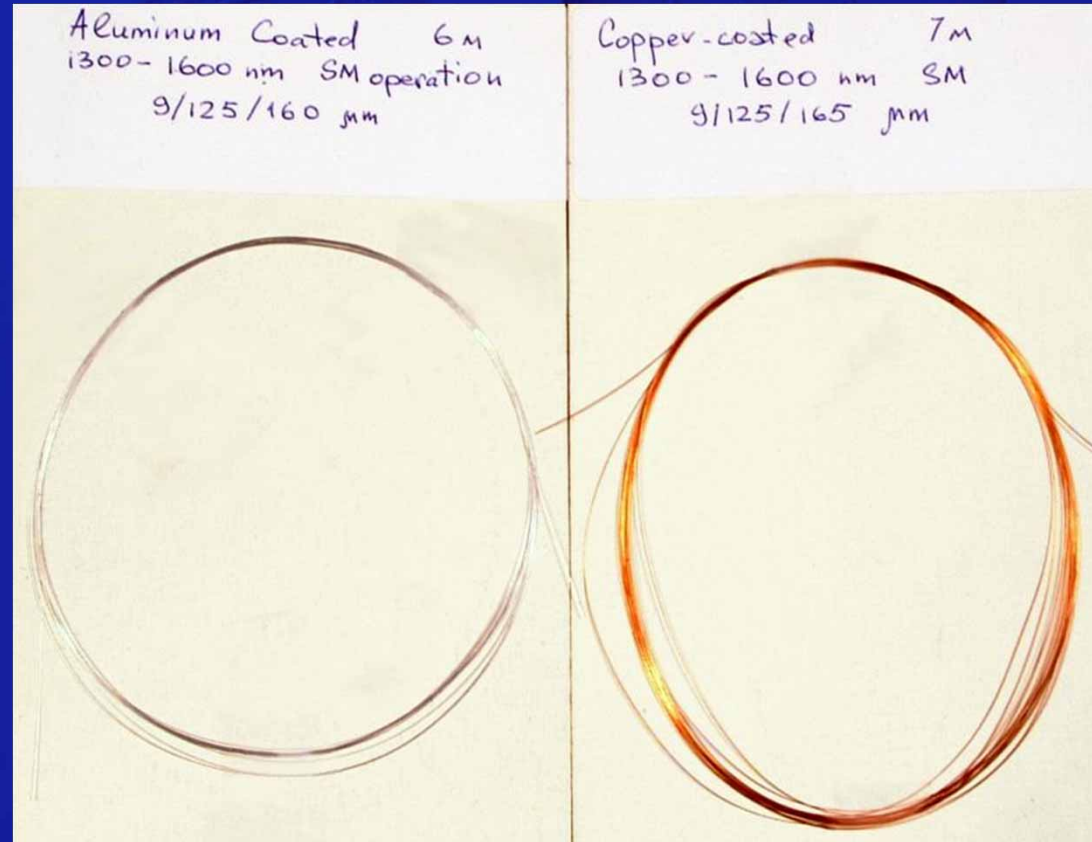




# Metal/Polyimide Coated Hermetic Fibers

## Coating materials and maximum sustainable temperatures

|                        |        |
|------------------------|--------|
| UV-cured acrylate      | 100°C  |
| UV-cured dual acrylate | 150°C  |
| Polyimide              | 400°C  |
| Copper+polyimide       | 400°C  |
| Aluminum               | 450°C  |
| Copper alloy           | 600°C  |
| Gold                   | 700+°C |



# Power Utility

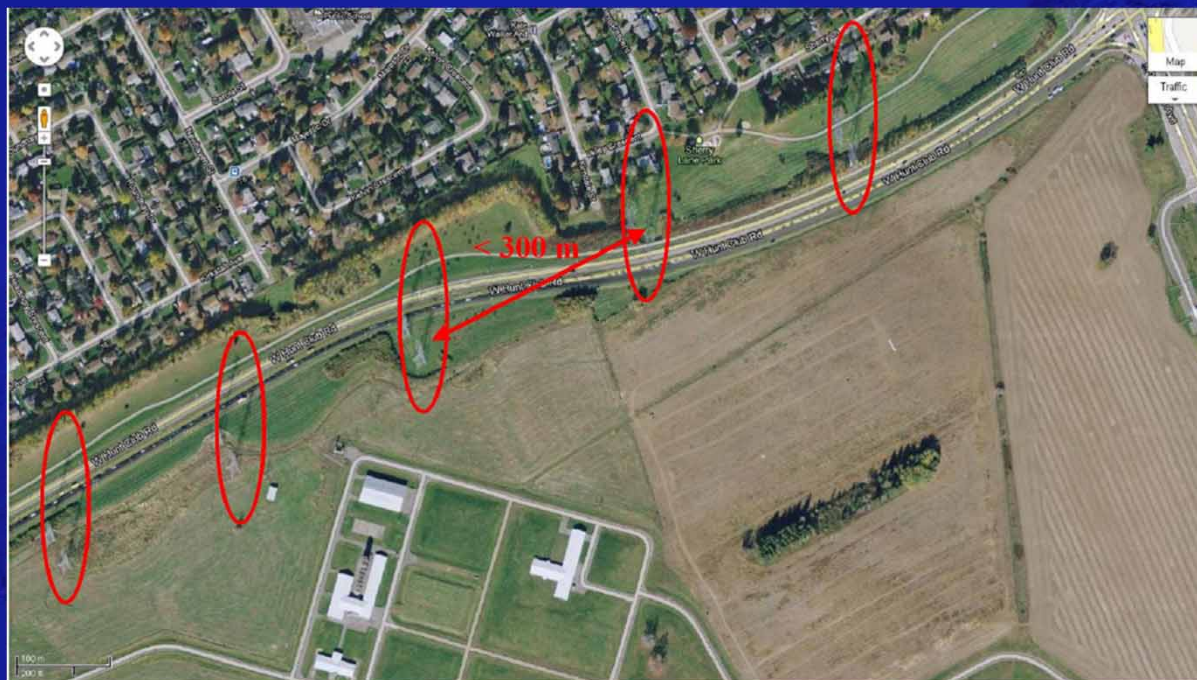
- **OPGW Monitoring**
- **Power Cable (Submarine Cable) Monitoring**



# OPGW Monitoring

- **Monitoring the working status of OPGW**
- **Abnormal event found and located**
- **Event caused by broken strand, lightning, frost covering, change of strain, etc..**

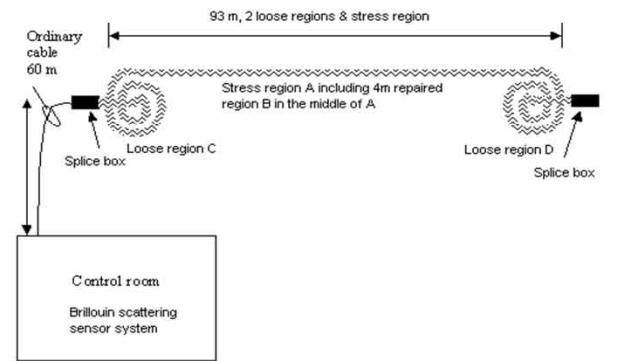
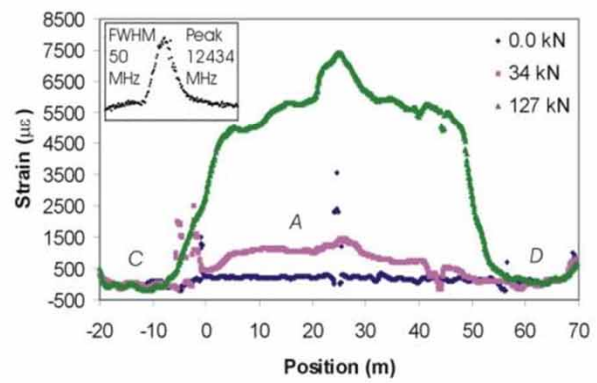
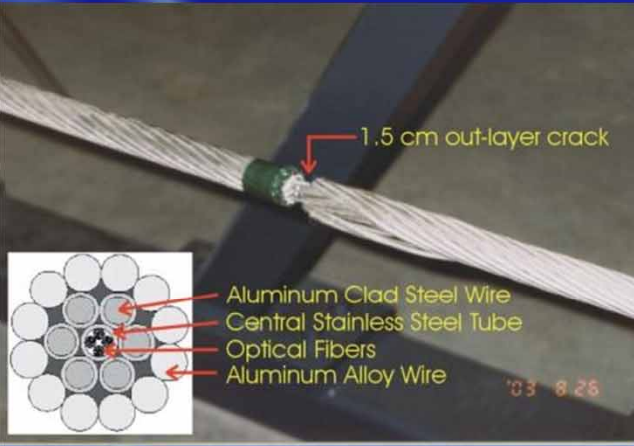
# OPGW Status Monitoring



- The OPGW is located from Smith Falls to Merivale-Ottawa, Ontario, Canada.
- The total fiber length was close to 140 km.
- The BOTDA located in Merivale-Ottawa made measurements as often as once every 60 minutes starting in June 2012 and continuing till July 2013.

# OPGW Strain Monitoring

- Power line/OPGW monitoring in Hydro-Quebec, Montreal



# High Voltage Underground Cable with Fiber

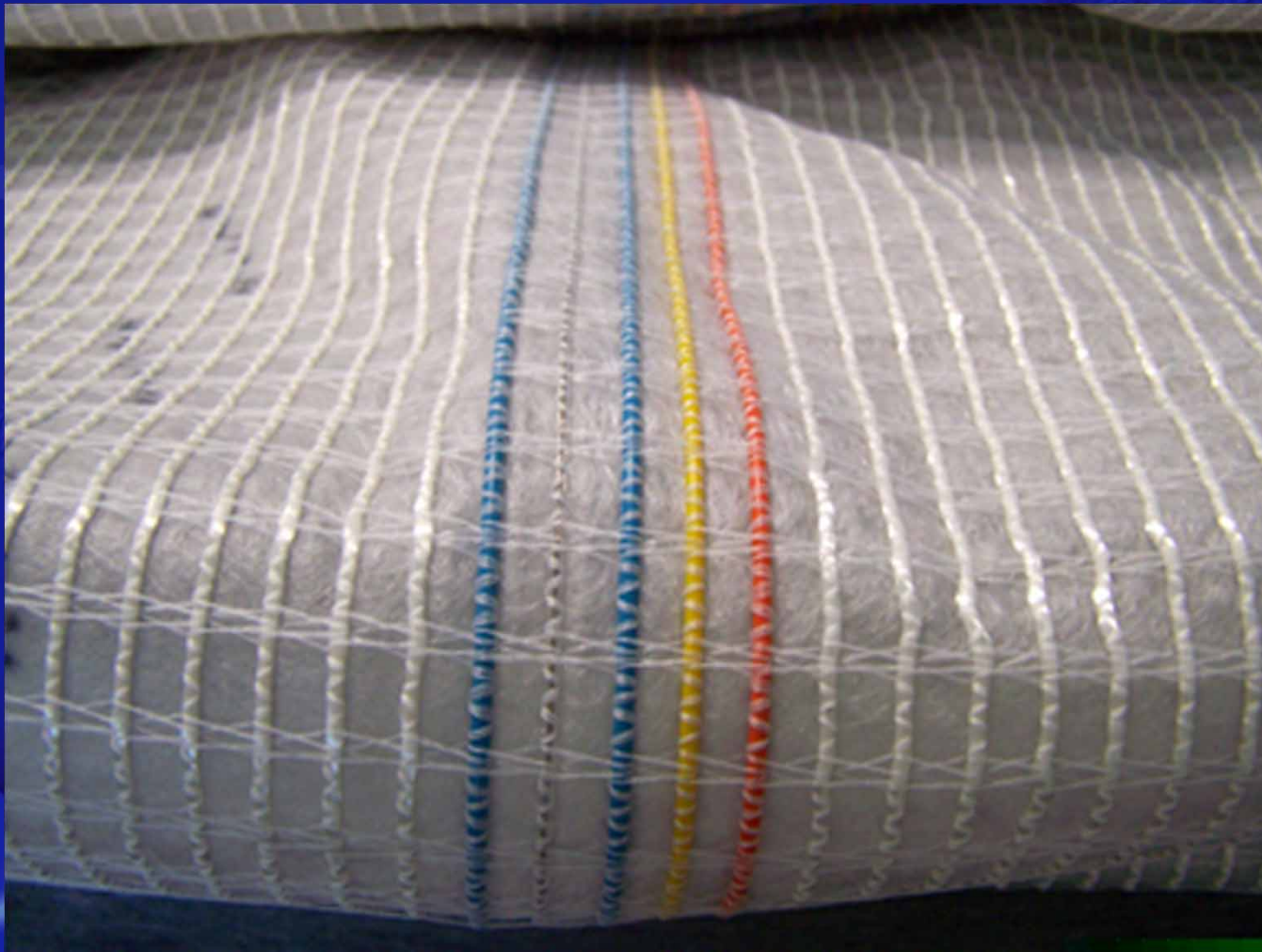


# Concrete Beam/Highway Monitoring

- Concrete beam/Highway monitoring on HW40/University of Sherbrooke, Dr. Brahim Benmokrane



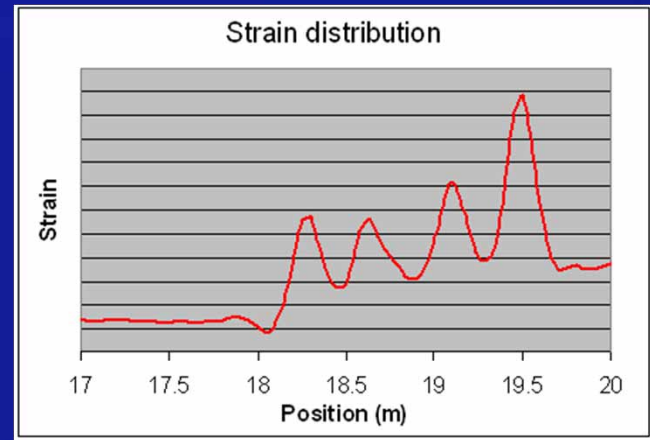
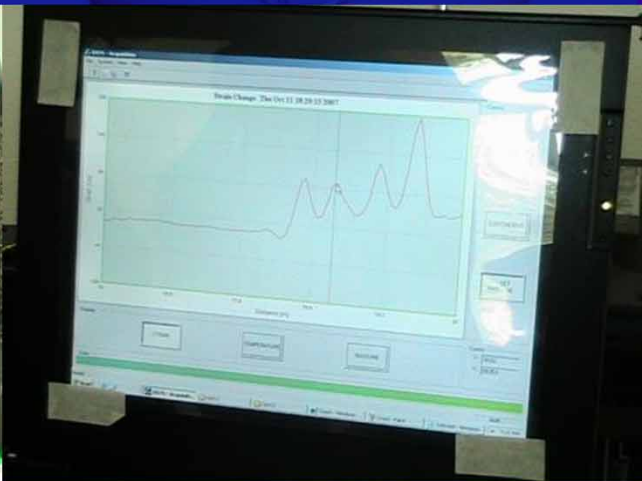
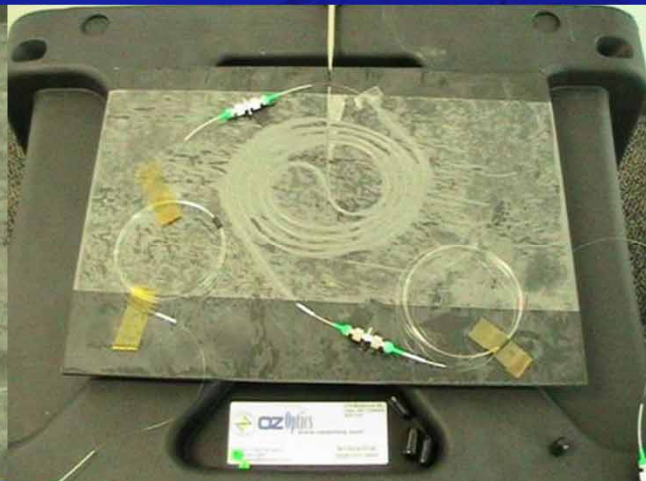
# GeoDetect With Embedded Fibers





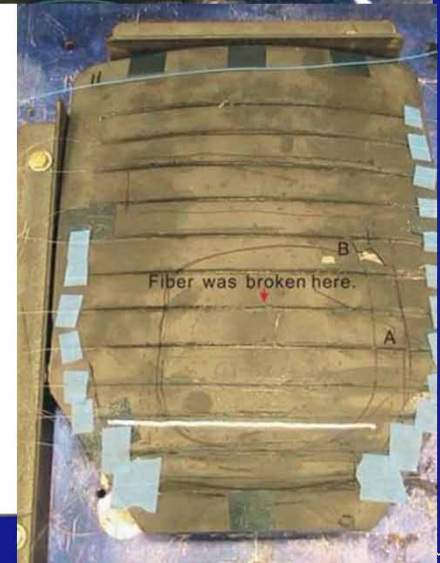
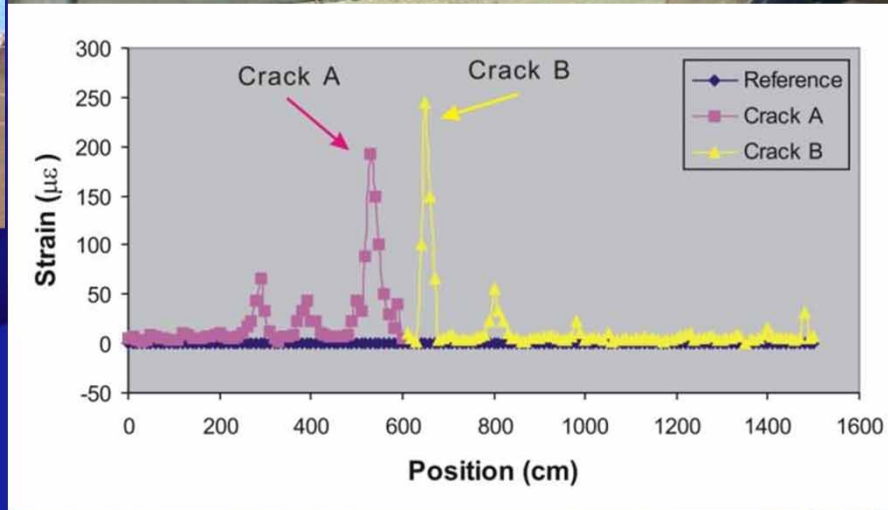
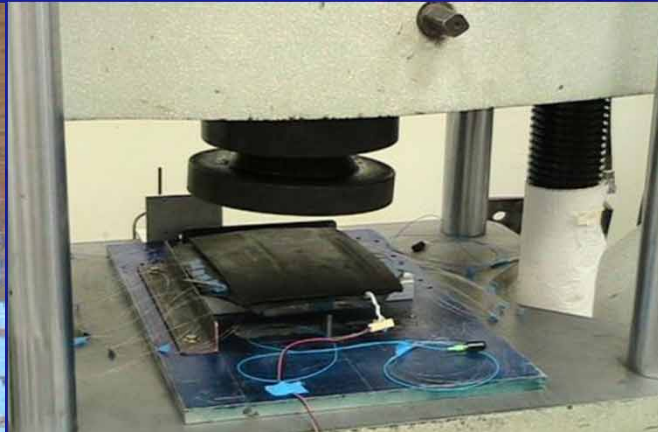
# Crack Detection

Crack detection in University of California, Irvine, Dr. Maria Feng, 19<sup>th</sup> International Conference on Optical Fiber Sensors, Perth (Australia, 14-18 April 2008).



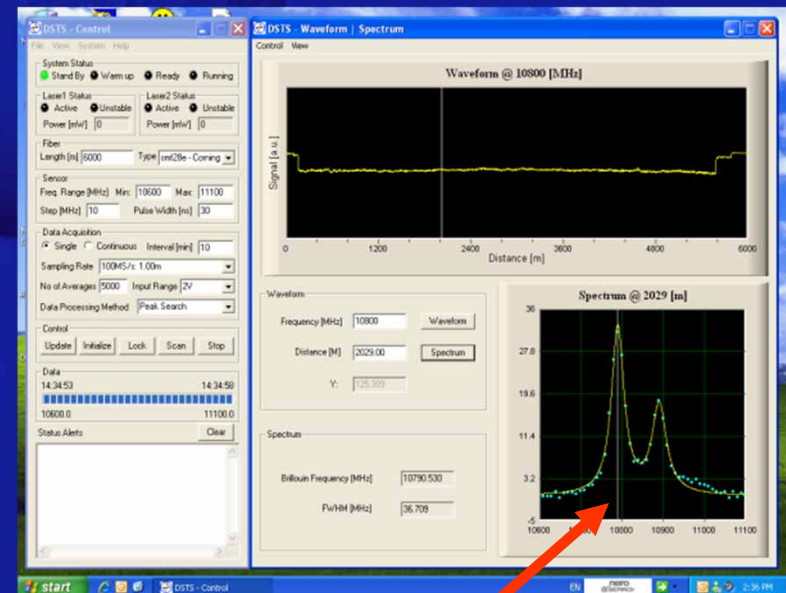
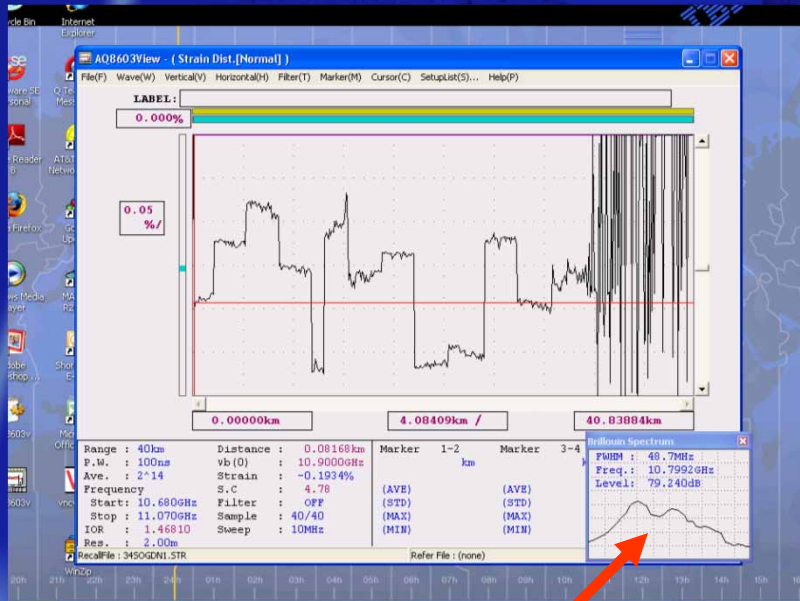
# Crack Detection

Crack detection in University of California, Irvine, Dr. Maria Feng, 19<sup>th</sup> International Conference on Optical Fiber Sensors, Perth (Australia, 14-18 April 2008).



# Brillouin Sensor Monitoring of Telecom Fibers

- Detects minor events that are too small to be seen by OTDRs.
- Can replace OTDRs for monitoring fibers.
- Can be used to monitor new or existing fiber installations.
- Permits performance monitoring of fibers above or below ground.
- Avoids unnecessary replacement of old fibers, saving millions of dollars in installation costs.



Yogokawa's results from AT&T's old telecom fiber, very broad Brillouin spectrum, which results in poor resolution and accuracy.

OZ's results from AT&T's old telecom fiber, very narrow Brillouin spectrum, which results in high resolution and accuracy.

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# The Cost of Catastrophic Failure

- **Example: Druzhba Pipeline July 2006**
- **Small 50 cubic meter leak results in:**
  - Interruption of \$100M/day pipeline
  - Global spike in oil prices
  - Report of environmental catastrophe
  - Months of investigation and ecological monitoring
- **Single point of failure in 3,000 km pipeline**

# The Cost of Catastrophic Failure

- Example 2: Nigerian Pipeline July 2006
- Accidental leak
- 180,000 barrels / day shutdown
- $180,000 * \$74 = \$13\text{M}$  per day
- 10-day shutdown = \$130M
- Brillouin operation  $\ll$  \$1/m/year
- Single production shutdown far exceeds lifetime sensor operating costs.

# Acknowledgements

- University of California, Irvine, Dr. Maria Feng
- University of Ottawa, Dr. Xiaoyi Bao
- University of Sherbrooke, Dr. Brahim Benmokrane
- TransCanada Pipelines Limited (TCPL)
- C-FER Technologies
- Canmet Materials Technology Laboratory, NRCan
- Hydro-Quebec
- Southwest Research Institute®

# The OZ Optics Commitment

*OZ Optics is committed to providing a complete solution, lab evaluation, and field trial to meet your structural health monitoring requirements.*

# OZ Optics

*Your solution provider for existing and next generation fiber optic components and test equipment*

*Please Contact Our Sales Dept:*

Tel: 613-831-0981 ext 3370

Toll Free: 1-800-361-5415

Email: [sales@ozoptics.com](mailto:sales@ozoptics.com).



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*Thank You for Choosing OZ!*

