Future-proof Antenna Systems

NAB Broadcast Engineering Conference 2016

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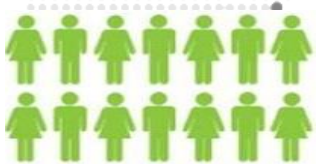
Agenda:

- Introduction.
- Repack observations.
- Advanced antenna systems to facilitate the repack: Scenario 1.
- Future proof antenna systems for the repack and beyond: Scenario 2.
- Advanced master antenna systems to facilitate the repack: Scenario 3.
- Real World case studies.

RFS at a Glance

Revenues: ≈ € **500 million**



2100
Employees

35 *
Sales and Technical Support Offices

6
R&D centres

7
Manufacturing centers

+250
Active patents

CERTIFIED ISO 9001:2008 COMPANY

ENVIRONMENTAL MANAGEMENT SYSTEM ISO 14001

OHSAS 18001

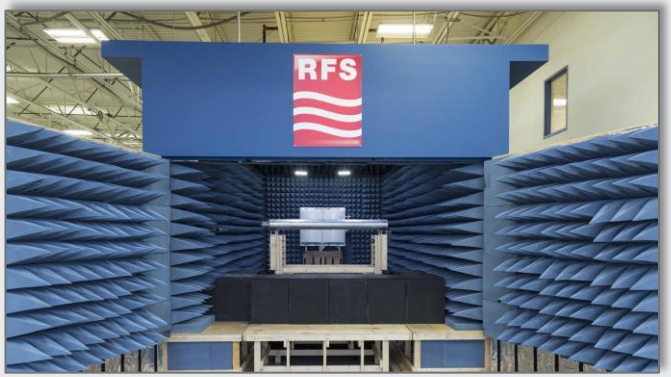
RFS Broadcast Production Sites

Broadcast Systems – Meriden Connecticut

- Located in Meriden, CT
- 20,000 ft^2 indoor production space allocated to broadcast.
- 76,000 ft^2 outdoor broadcast test area.
- Engineering teams located on site.
- Sales team located on site.
- Far and near field test ranges on site.

Activities: Broadcast, Meriden Connecticut

- Pylon antenna design and manufacturing.
- Broadband slot antenna design and manufacturing .
- Rigid line systems design and manufacturing.
- Semi flexible cable manufacturing.
- Panel antennas integration and test .
- RF systems, mask filters and channel combiners integration and test.



Repack challenges:

- 39 Month window.
- Coordinated effort or free-for-all?
- Number of qualified tower crews.
- Finite number of high power RF and Structural Engineers.
- Limited coverage during operation on interim antenna that can extend for a long period of time.

Observations from UK and Australian transitions:

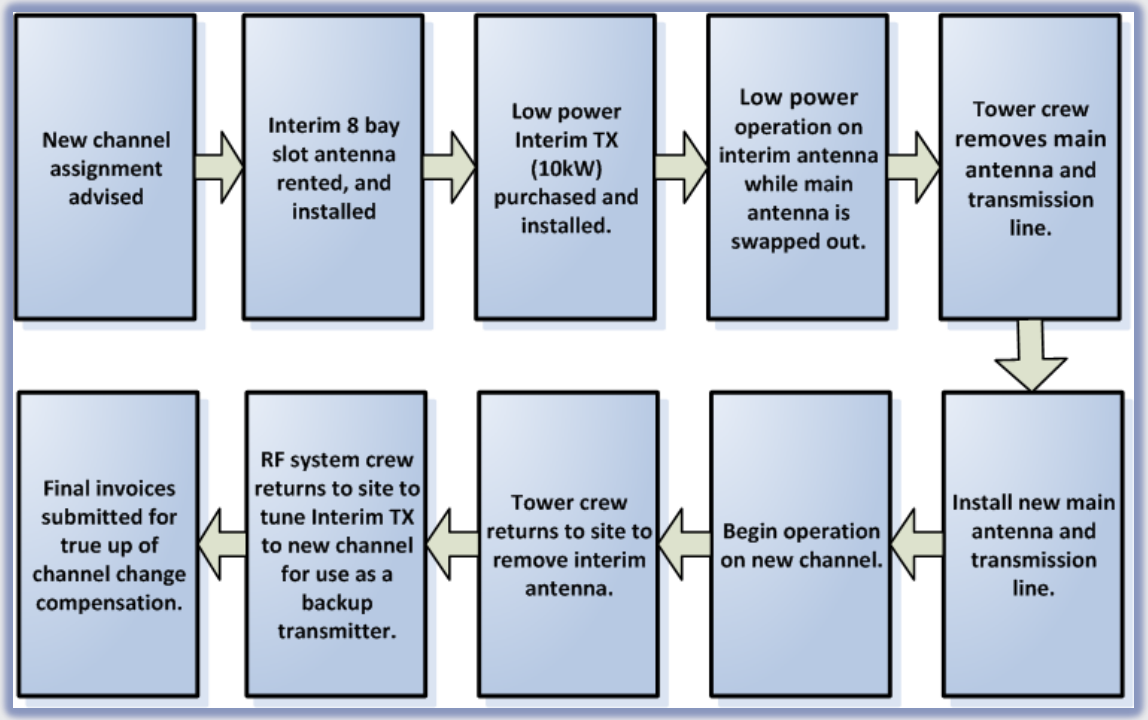
- **Delays to antenna work caused by weather are generally underestimated.**
- **Delay by one station can cause a domino effect, delaying multiple stations.**
- **The period of operation on an interim antenna was considerable in many instances. 6-18 months in some cases. For this reason high performance interim antenna solutions were adopted.**
- **The cost savings of re-using interim antenna systems was found to be questionable when the removal and refurbishment costs are considered.**
- **Shared, broadband transmission capabilities were shown to provide for a smooth transition, particularly when replicated at two sites.**

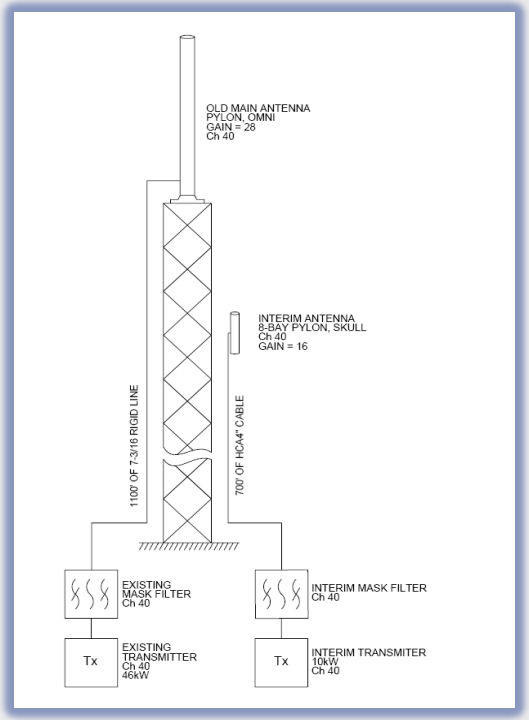
RADIO FREQUENCY SYSTEMS

Repack Scenario 1: Pylon Antenna Swap out

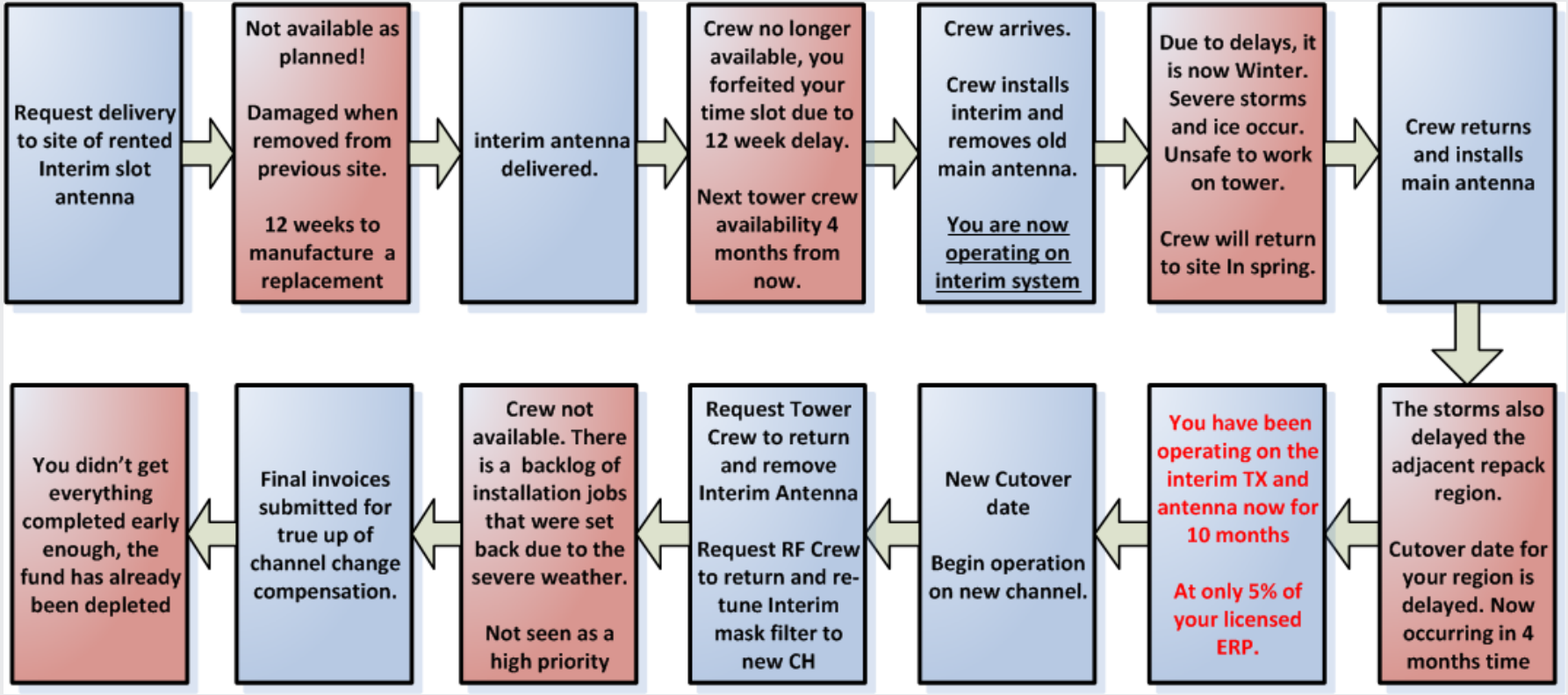
Repack Scenario 1

This scenario is similar to Case #1 in the Widelity and Digital Tech Consulting reports.





Scenario 1 Revisited. (Or - In the real world, stuff happens)



A better solution for repack scenario 1

Use a high performance interim antenna

- You could be on interim antenna for a long time. Try to maximize interim ERP
- Eligible for re-imbursement.

Use a fully broadband Interim antenna

- Availability (off the shelf).
- Permanent standby on new channel.
- Use on final channel at cut-over date if new main antenna install is delayed.

Purchase Interim antenna rather than rent.

- Availability (not waiting rental returns).
- Reliability (not worn / damaged).

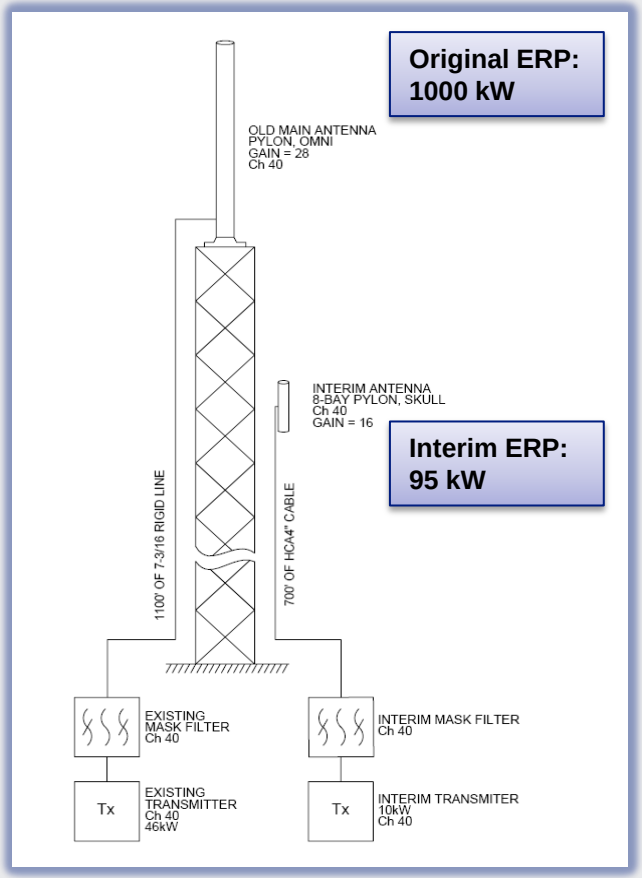
Do not remove the interim antenna.

- Tall tower crews scarce, better utilized getting others on air by the deadline.

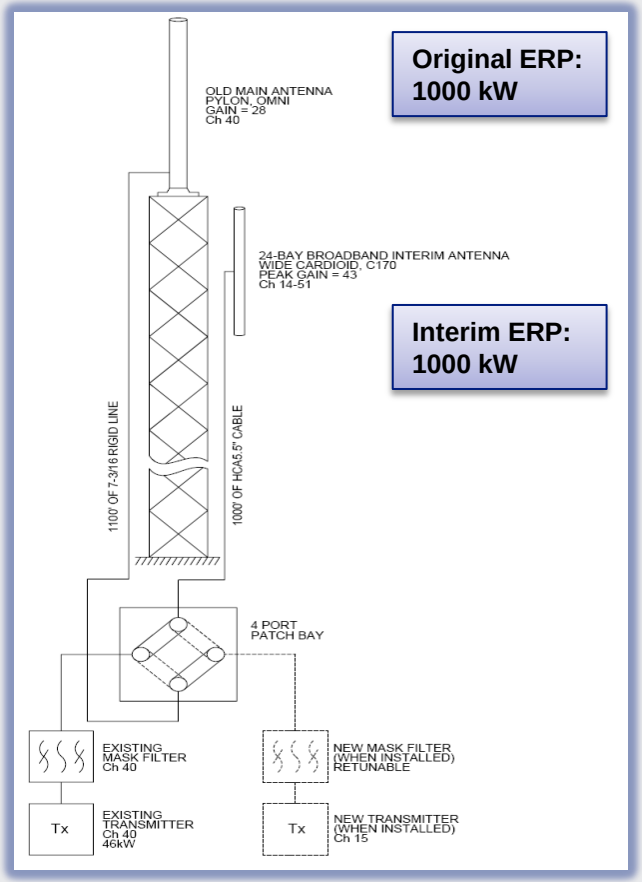
Use a re-tunable mask filter.

- Wasteful of taxpayers money to throw filter away after the channel change.

Original scenario 1

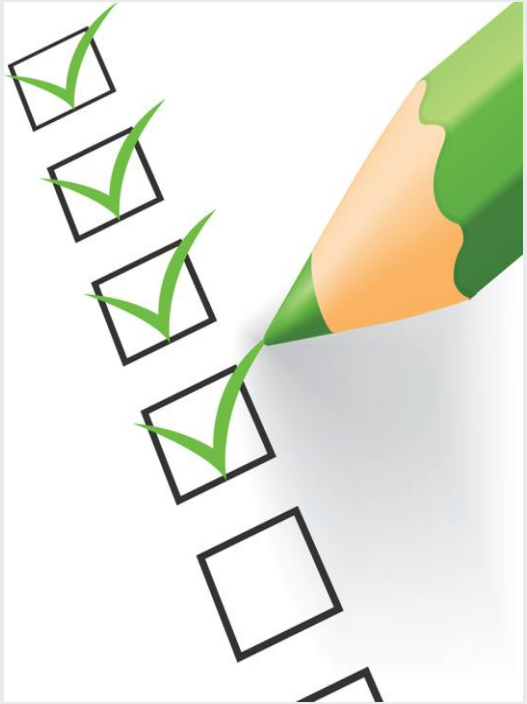


Improved interim solution



Equipment requirements for improved interim solution….

- Antennas that provide full band operation: 470-698 MHz.
- Low wind load: same or less than side mount pylon.
- Power handling to allow up to 2 x 1MW ERP's.
- Elevation gain to allow full ERP with existing transmitters.
- Standard azimuth patterns to simplify FCC filing:
  C-170, S-180, Ominoid.
- Re-tuneable high power mask filters, to allow re-use on post repack channel.
- Mask filters that don't require a specialist crew to re-tune.



Outcome: SBB Broadband Pylon Antenna

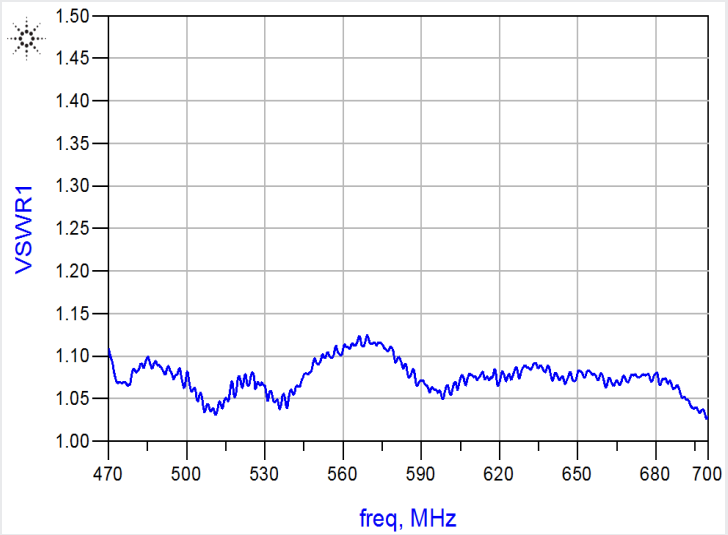
- **Fully broadband, 470-698 MHz - operate on any UHF channel.**
- **Simple and reliable construction - No cables inside.**
- **Low wind load. (radome dia 15”)**
- **Standard azimuth patterns, stable across the band.**
- **Can transmit multiple services with CH combiner.**

Model	SBB-8	SBB-16	SBB-24	SBB-32
Gain (C-170)	17	30	43	59
Max input power (kW)*	18	36	54	72
Typical ERP’s	340 kW	1 x 1MW	2 x 1MW	3 x 1MW

* Higher power option available

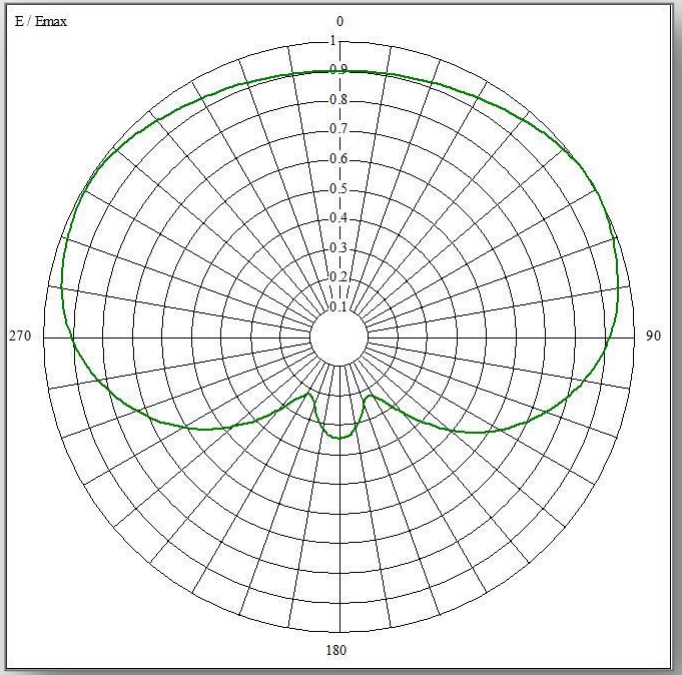
SBB-8 Broad-Band Slot Antenna

Production testing of SBB broadband pylons



SBB-8 measured VSWR

Production testing of SBB broadband pylons



SBB-8 measured radiation pattern C-170

Outcome: 50 kW Re-tunable UHF Mask Filter

- **Tunable from CH14 – CH41.**
- **Less than 0.2 dB insertion loss. (>95.5% efficiency)**
- **Small footprint.**
- **Allows high power filters to be stocked at RFS and at TX manufacturer factories.**
- **Easy to retune using RFS software.**
- **Units operating in the field since 2014.**

6PPXX325E – 50 kW re-tunable UHF TV filter [1)]

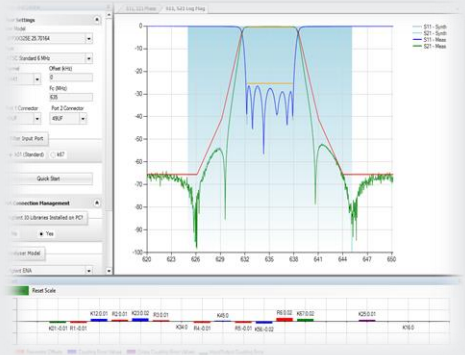
[1)] RFS tunable TE-101 mode resonator high-power filters first patented in 2014

Mask filter tuning software simplifies retune

S-parameters

BCAT

Filter Library



Visualization of tuning errors

Tuning Actions

RADIO FREQUENCY SYSTEMS

Repack Scenario 2: Future proof equipment

Scenario 2: Single station, future upgrade path desired

Scenario and assumptions:

- **Broadcaster is unlikely to participate in auction and will likely be repacked.**
- **Desire to be ready well ahead of, or early in the repack window.**
- **May want to share ongoing OPEX with a second station, however would like the ability to make that decision in the future.**
- **Wishes to add a vertical polarization component to improve coverage.**
- **Will use existing TX now with some Vpol and will increase the amount of Vpol when the transmitter is replaced/upgraded.**
- **Desires a future proof solution, ATSC3.0 is just around the corner.**

Product requirements were determined…

- **Broadband antenna. Full UHF band operation: 470-698 MHz.**
- **Low wind load antenna: similar to top mount pylon and less than stacked pylons.**
- **Power handling capability to allow at least to 2 full power stations with elliptical or circular polarization.**
- **Ability to change polarization ratio in the future (VPT).**
- **Ability to add a second channel with independent polarization ratio.**
- **Re-tuneable / Broadband RF systems (mask, switch) - up to 100 kW.**
- **Re-tuneable channel combiners when a second channel is added.**

Broadband Cylinder Antenna

Outcomes:

- PEP-L Broadband Cylinder antennas.
- 6PPXX271 re-tuneable 30kW Mask Filter
- 6PPXX325 re-tuneable 50kW Mask Filter
- CA6PPXX325 re-tuneable 100kW CIF
- Tuneable channel combiners that allow polarization ratio change (VPT).

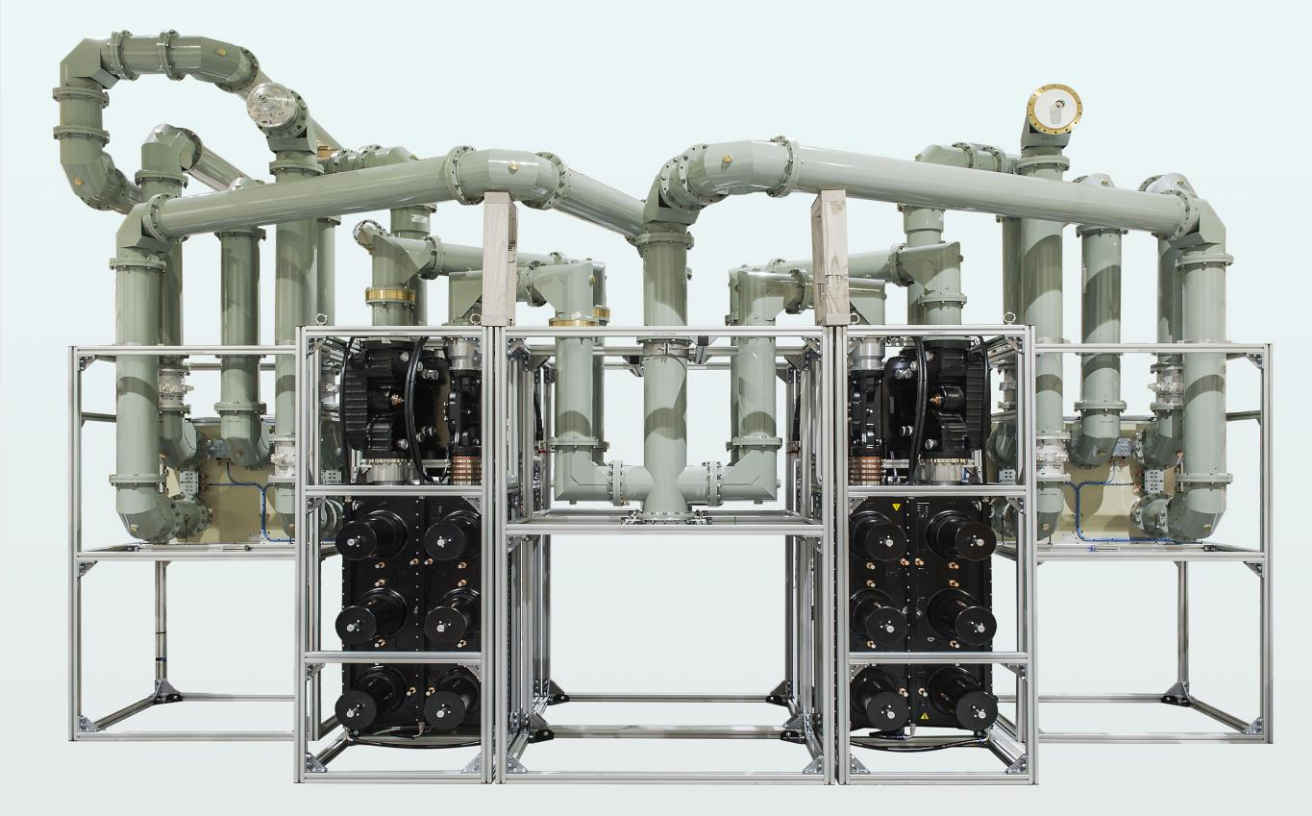
Range test of PEPL-28 antenna for Dallas TX (half antenna under test)

Real World Example, Dallas TX:

- 28 bay PEP-L antenna replaces two stacked pylons.
- Two stations will share the infrastructure.
- Elliptical polarization. Different ratios for each station.
- 80kW + 80kW re-tuneable adjacent channel combiner.
- All components are broadband. Simple channel change when repack cut-over occurs.

Preparing PEPL-28 antenna for installation at Dallas site.

Dallas TX: Tunable 80kW + 80kW VPT Combiner



[1)]Patents granted

RADIO FREQUENCY SYSTEMS

Repack Scenario 3: Master Antenna System

Repack Scenario # 3: Shared antenna system

Scenario:

- **Broadcast infrastructure provider wants to provide solutions to existing clients and potential new clients who find themselves repacked.**
- **Could be a tall building or a tall tower, placed for superior coverage.**
- **Wants to be ready in the early stages of the transition.**
- **The clients are requesting some vertical polarization component to improve coverage, however not all at the same ratio or at the same time.**
- **Reserve systems are required (possibly at a second site).**
- **The system must be future proof, frequency agile and ready for ATSC3.0**

Product requirements were determined…

ANTENNAS:

- **Full UHF band operation: 470-698 MHz.**
- **Power handling to allow multiple full power stations with elliptical or circular polarization.**
- **Low wind load: less than existing panel antennas.**
- **Independent polarization ratio setting.**
- **Maintainable without removing antenna from the tower.**
- **Superior radiation pattern performance.**

Product requirements were determined…

CHANNEL COMBINERS:

- **Must be re-tuneable for repack and future channel changes.**
- **Must be adjacent channel capable.**
- **Must allow independent polarization control for each tenant.**
- **Power handling up to 100kW per input and up to 320kW total combined power.**
- **Compact and modular to minimize footprint and installation time.**

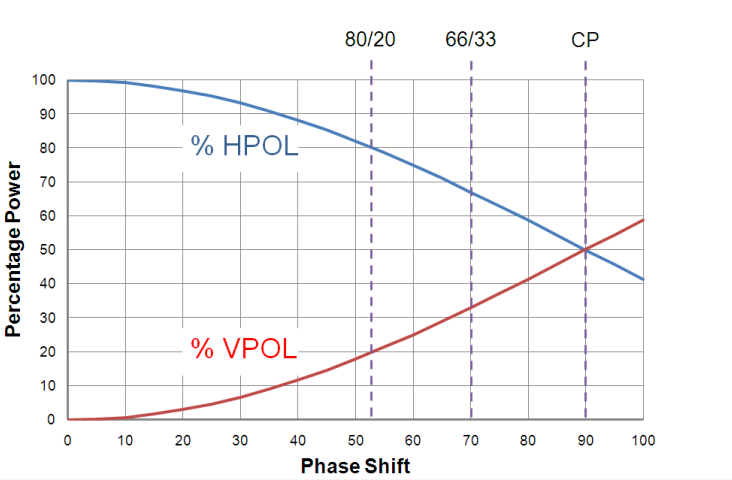
Resulting products:

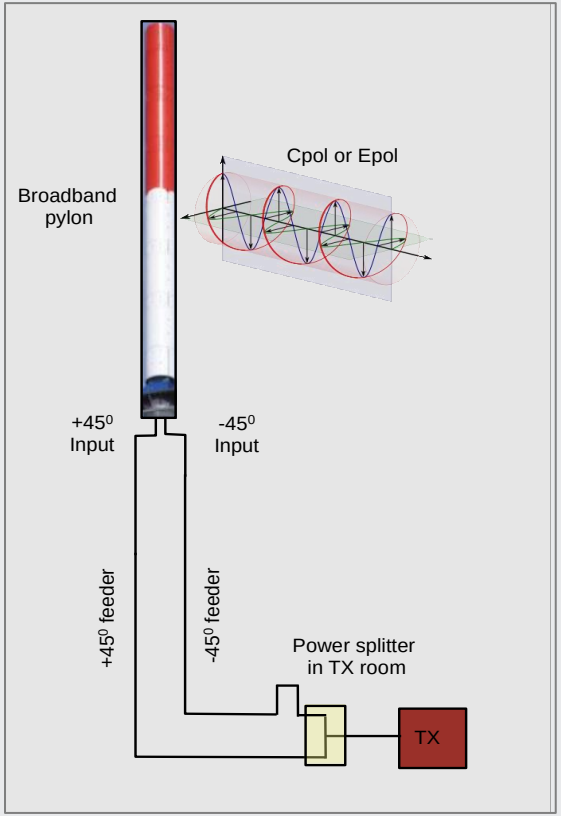
- **PEP elliptically polarized master antennas.**
- **PEP elliptically polarized wrap-around antennas.**
- **CA6PPXX325 re-tuneable combiner module.**
- **CA6PPXX325WG Waveguide re-tuneable combiner module.**
- **Variable polarization technology (VPT).**

Example of a high power wrap around antenna

VPT: How do we vary the polarization ratio ?

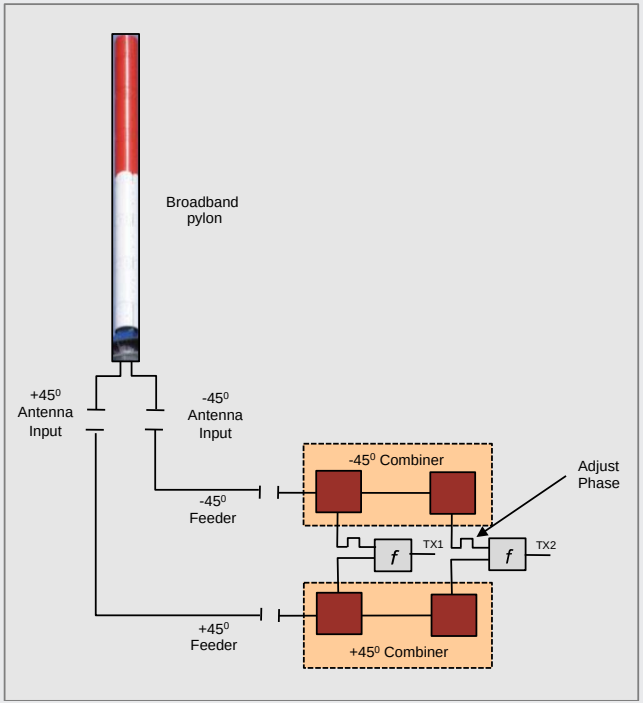
- VPT utilizes dual input antennas.
- By changing the phase between inputs, the desired polarization ratio can be achieved.



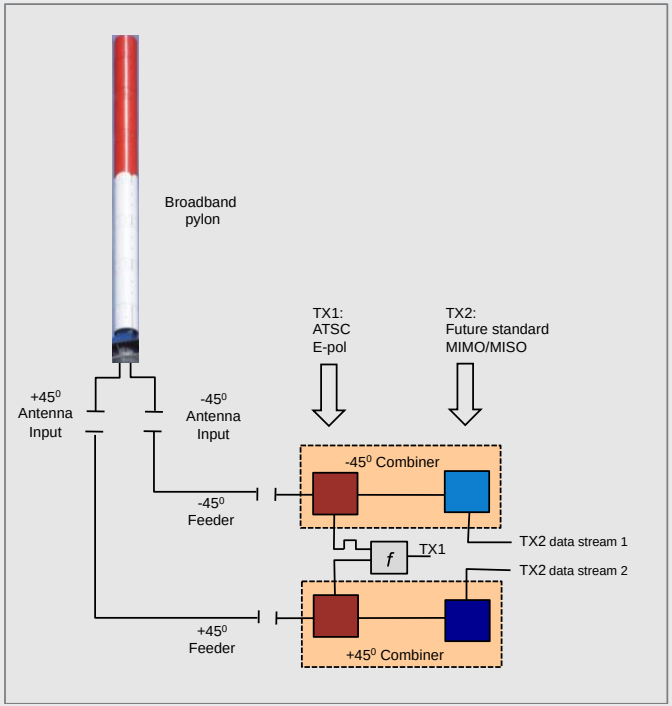


A single channel VPT system.

Multi-channel VPT systems



A channel combiner is used on each input.
TX's have independent power splitters with phase control => Independent polarization for each TX.



Future configuration: TX2 upgrades to a future transmission standard that incorporates MIMO/MISO. TX1 remains on the current standard.

Real World Case Study, One World Trade, NYC

Solution:

- Two UHF VPT antennas.
- VPT capable VHF antenna.
- Tuneable waveguide UHF combiners.
- Fully redundant systems
- Design in anticipation of ATSC3.0.

Case Study, One World Trade Center, NYC

UHF Upper Antenna
40 VPT panels.

VHF Antenna
16 VPT panels.

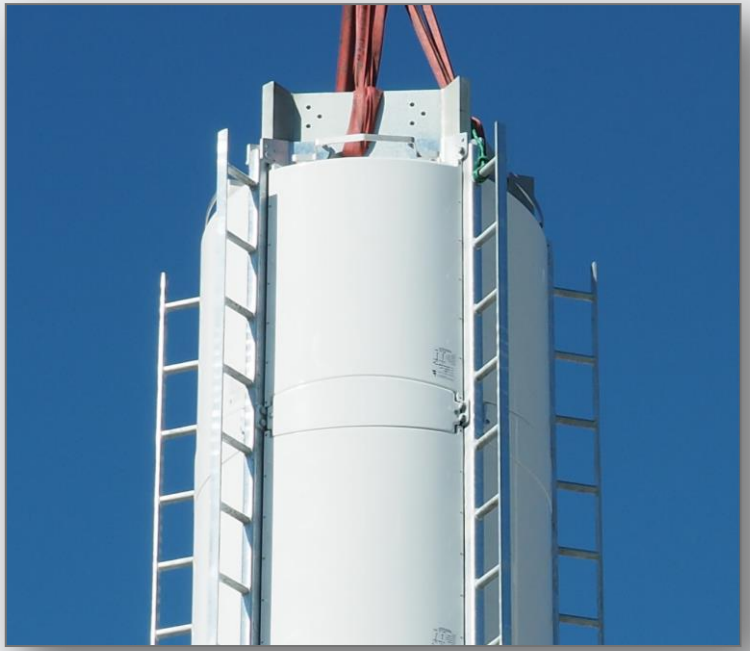
UHF Lower Antenna
96 VPT panels.

One World Trade Center, Trial antennas

- **Coverage studies were performed and the elevation patterns optimized.***
- **Trial antennas were manufactured and installed (one full face of panels).**
- **Extensive field strength measurements confirmed the expected performance.**

* We wish to acknowledge the valuable assistance of Dr Oded Bendov, Doug Lung and S. Merrill Weiss during the antenna elevation pattern optimization process.

Range Testing – One World Trade UHF Antenna 1



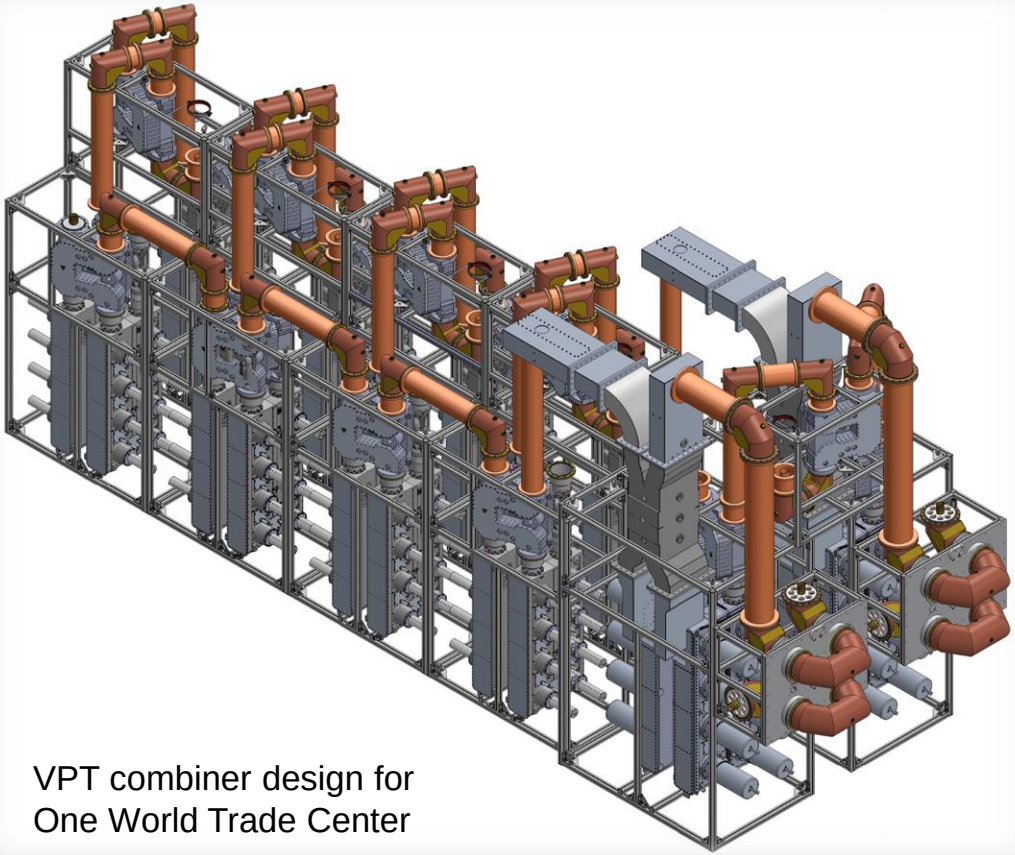
A section of the upper One World Trade UHF antenna about to be lifted onto RFS far field test range A.

Disconnecting the lifting equipment.

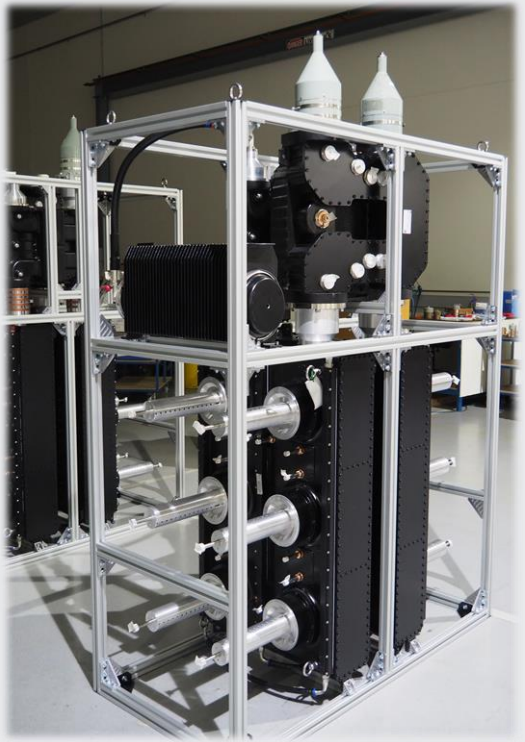
RFS far field test range A, one of four broadcast outdoor antenna ranges.

Range Testing – One World Trade VHF Antenna

5-channel tunable TE-101 mode WG combiner



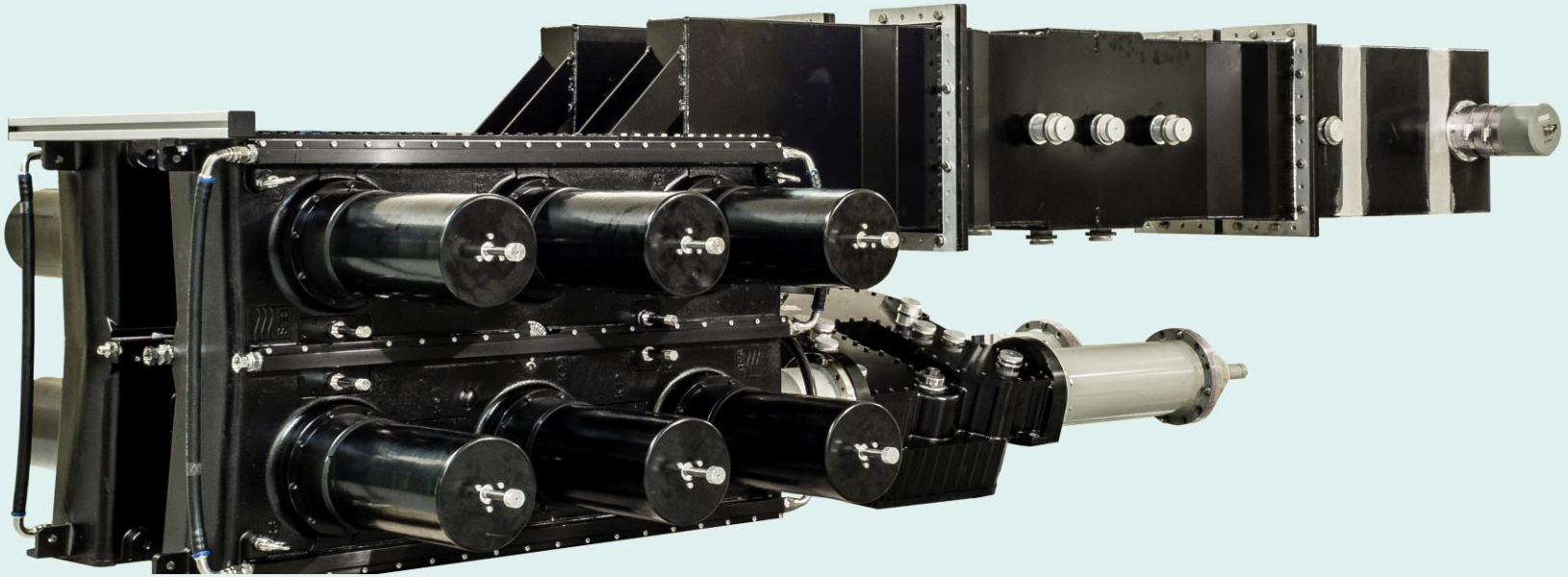
VPT combiner design for
One World Trade Center



VPT combiner module ready for test

[1)]Patents granted

Tuneable Combiner Module with Waveguide Output



[1)]Patents granted and pending

OWT design in anticipation of ATSC3.0

- Antennas and combiners were designed with consideration of the increased peak power requirement.
- Ability to increase vertical polarization component in the future to enhance reception on hand held devices.
- Mask filters designed with upgrade to ATSC3 in mind.
- Antennas ready for MIMO.

Conclusions

- **Based on our experience with the UK and Australian repacks, RFS believe that broadband frequency agile equipment provides the easiest path to a successful outcome.**
- **Weather and tower crew availability could delay installation of the main antenna. A high performance broadband interim/reserve antenna that operates on pre and post restack channels provides some insurance against operating at reduced ERP for a significant period of time, or missing the switch-over date.**
- **Consider a re-tuneable interim mask filter that can be reused on the new channel allocation.**
- **Consider frequency agile and polarization agile solutions that provide a future upgrade path.**
- **Ensure that ATSC 3.0 operation has been considered during the design of any new equipment.**
- **Operation from a shared master site may prove to be the easiest way forward for many.**

Thank You

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