Repack and BBA Design Choices

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AMERICAN TOWER®

TV's Gettysburg!

- It is rather for us, **the survivors of the incentive auction**, we here be dedicated to the great **repack** remaining before us — that, from these honored **auction winners** we take increased devotion to that cause for which they here, gave the last full measure of devotion — that we here highly resolve these **stations** shall not have died in vain ; that the **industry**, shall have a new birth of freedom, and that **television** of the people by the people for the people, shall not perish from the earth.

Here is what we will cover:

- Incentive Auction Update
- Repack Effects
- System Considerations
- Defining BBA's
  - Antennas
  - Transmission Lines
  - Combiners

Incentive Auction

Reverse Auction

TV stations voluntarily participate to sell spectrum

Auction progressively reduces prices until demand is met or stations drop out

- Winners Sell spectrum and:
  - End Operations
  - Channel share with losing station
  - Move to Hi-VHF
  - Move to Lo-VHF
- Losers Keep spectrum and:
  - Remain on current channel
  - Participate in non-voluntary repack below spectrum clearing target
    - May or may not be safe on channels below target

Incentive Auction

Forward Auction

Wireless carriers purchase licenses for 5MHz blocks of uplink and downlink

- **Auction progressively raises prices until bidding stops**
- **Intent is to have demand of forward auction buyers exceed supply of reverse auction spectrum and generate surplus revenue for the FCC**

Through 2 stages and on 3rd stage of reverse auction

- ✓ Reverse Auction:
  - › Stage 1 $86 B
  - › Stage 2 $56 B
  - › Stage 3 ?? Ongoing
- ✓ Forward Auction:
  - › Stage 1 $23 B
  - › Stage 2 $21 B
  - › Stage 3 ??

When will the numbers start to meet?

Incentive Auction

Spectrum Clearing Scenarios

Repack Statistics

Clearing Target (MHz)	Cleared above channel	Full Power Stations Cleared	Class A Stations Cleared	Total Stations Cleared
126	29	922	211	1133
114	31	695	164	859
108	32	656	162	818
84	36	593	144	737

* Figures are for the maximum number of stations. Final values will be lower dependent on results of reverse auction and who "winners" are.

- Recent FCC estimates are:
  - 114 MHz Cleared — 1393 Stations to Repack
  - 84 MHz Cleared — 1274 Stations to Repack
  - Both include a minimum of 540 stations below cleared band

Repack Implementation Timeline Example

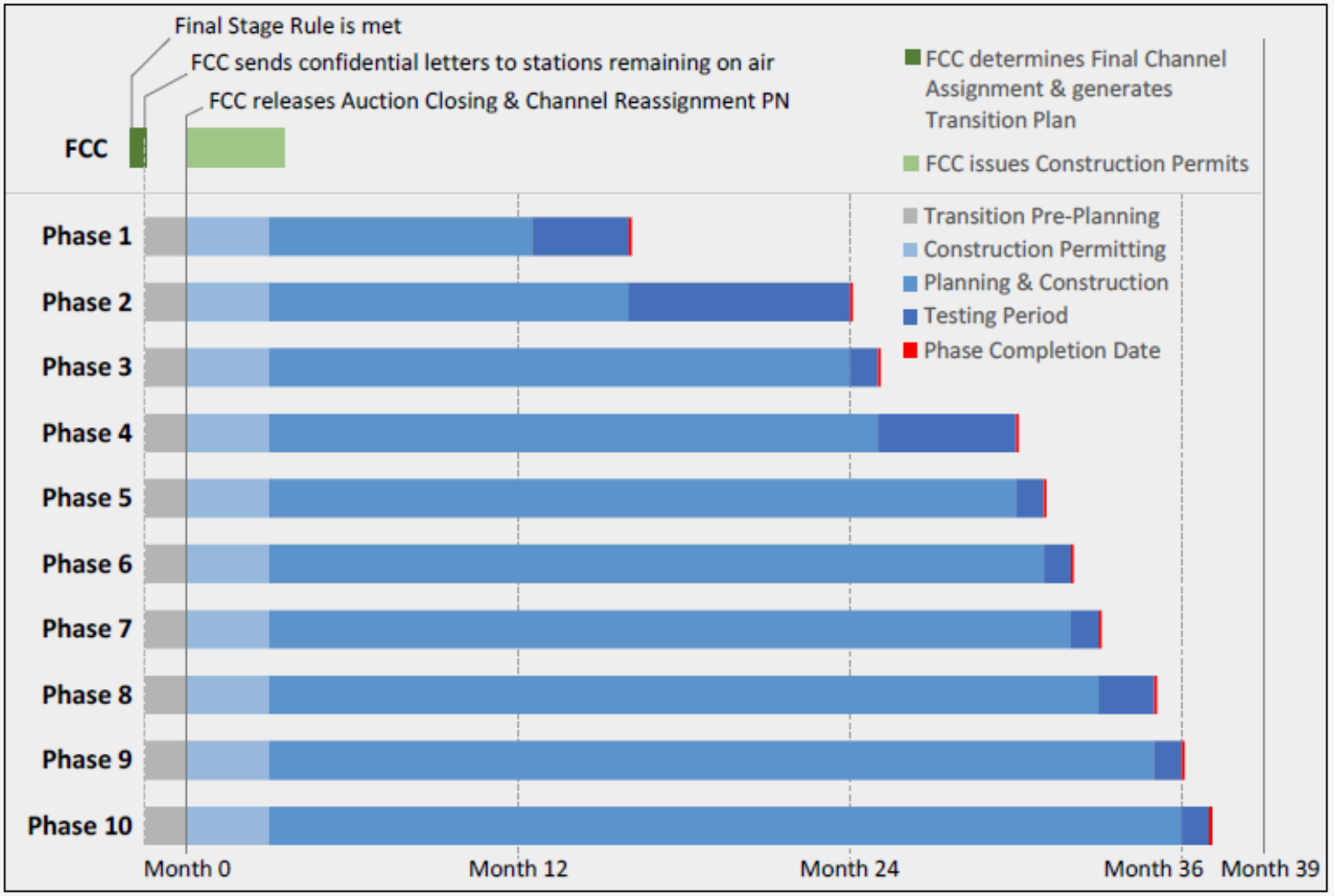


Figure 13: Phase timelines at 84 MHz

Repack Implementation Timeline Example

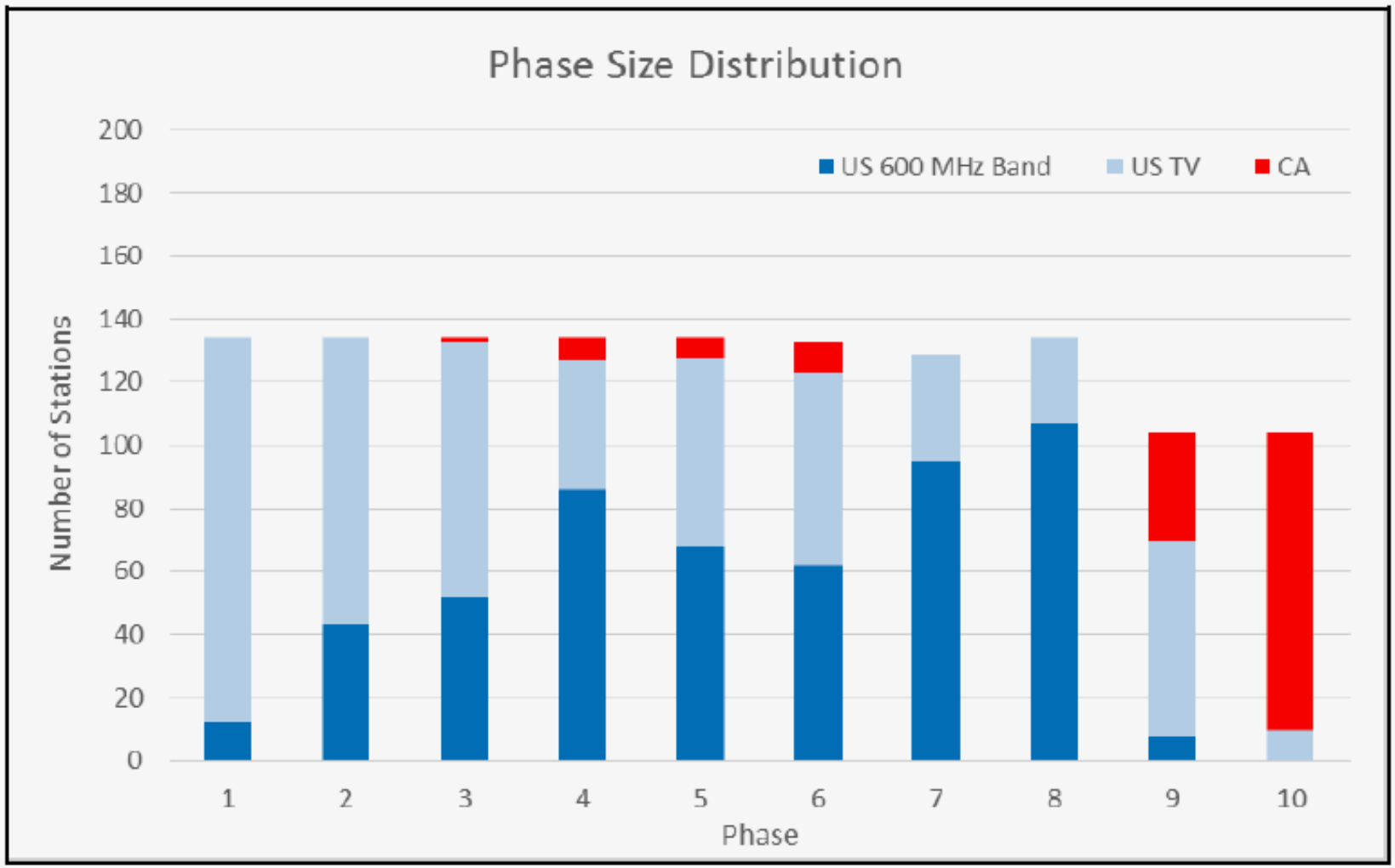


Figure 5: *84 MHz Clearing Scenario*

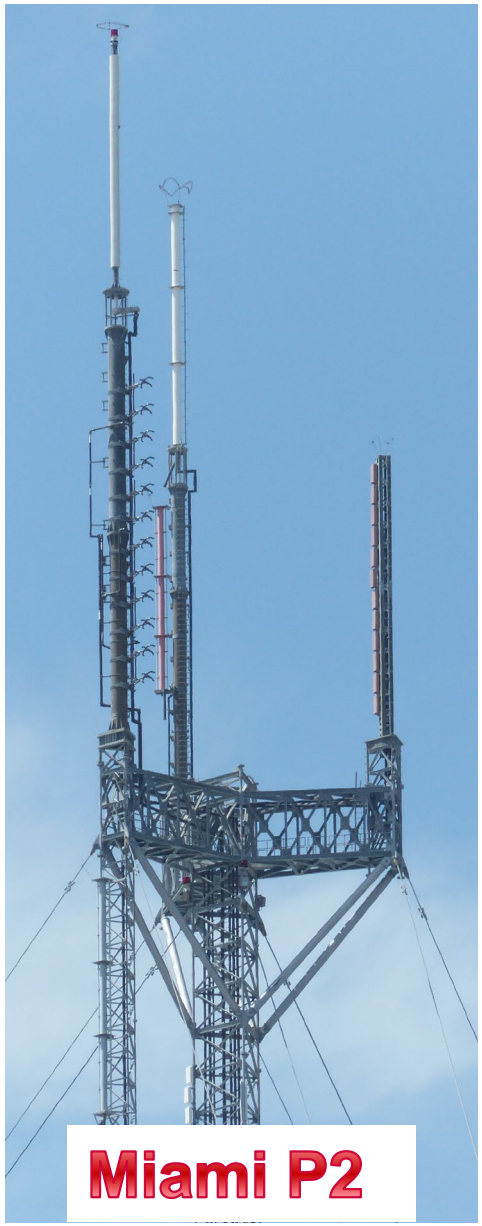
Repack Effects

- Repack stations need to switch out antennas for new channel antennas
  - May need transmission line changes as well
- Towers need to be modified to support new antennas
  - Same gain antennas larger due to lower frequencies
  - Tower structural standards have changed
- Temporary antennas and feedlines needed to sustain operation during change-out
- Old abandoned antennas and feedlines need to be removed to increase capacity
- Significant time required on “complex” sites for multiple antenna moves

Repack Effect Examples

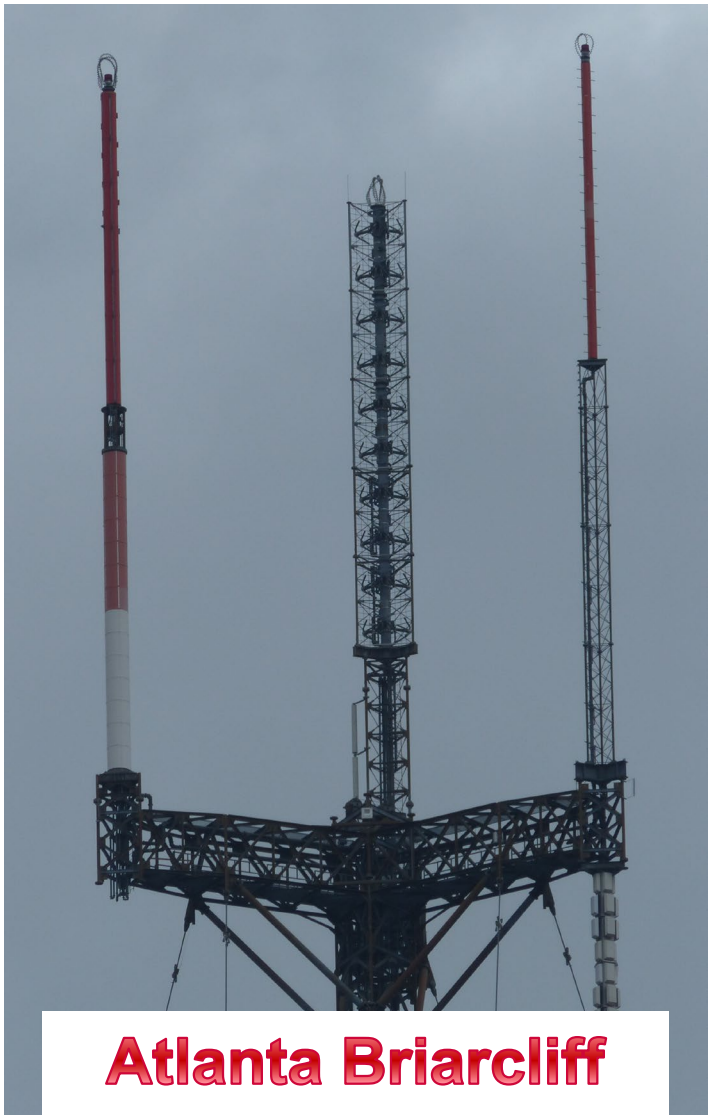
Miami RT

- 9 full power tv's
- 4 "likely" repack tv's
- Numerous FM operations



Miami P2

Repack Effect Examples



Atlanta Briarcliff

- 9 full power tv's
- 3 "likely" repack tv's
- 2 UHF Broadband Antennas
- Numerous FM operations

Repack Effect Examples

Dallas Cedar Hill West

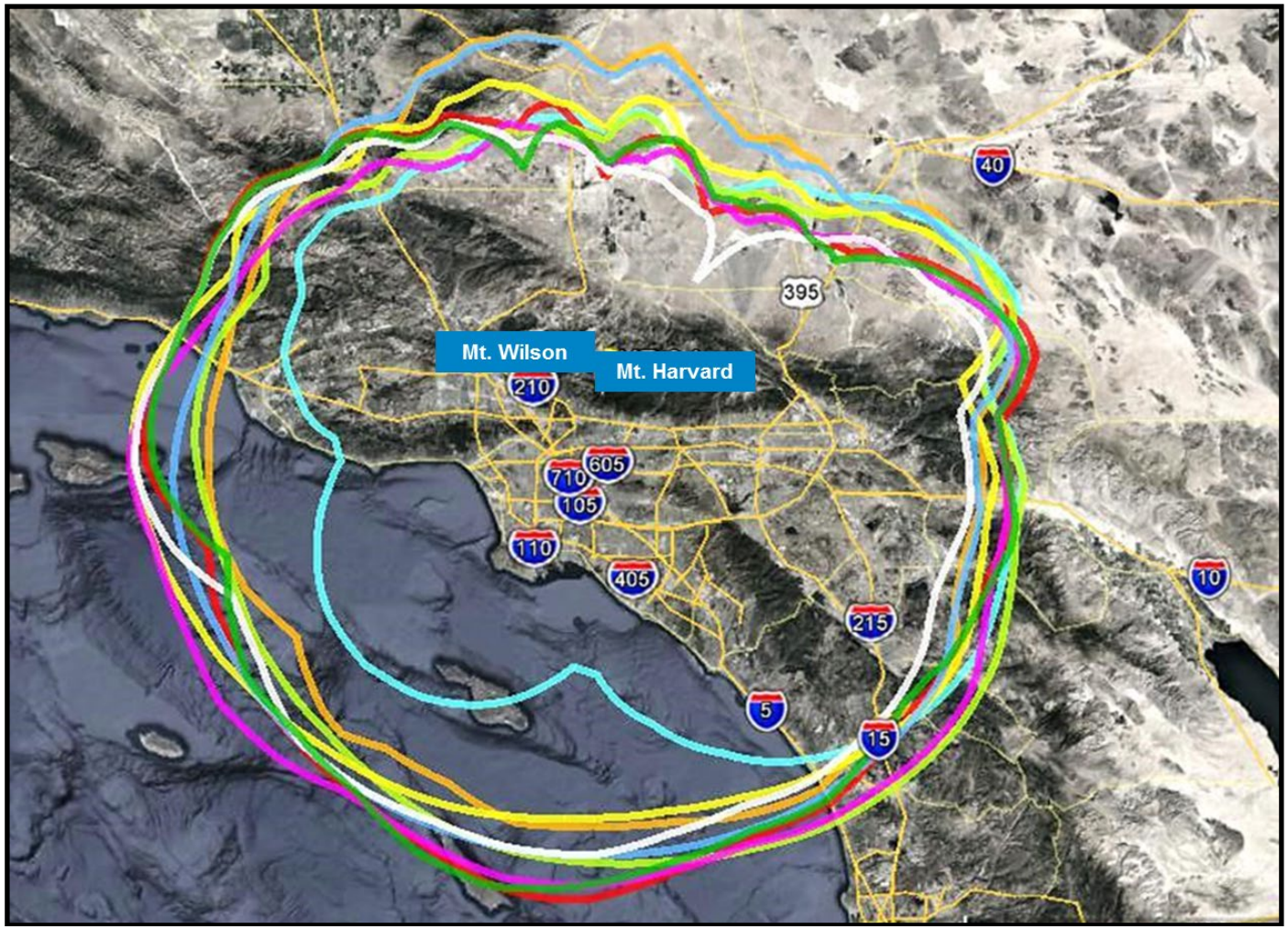
- 1 full power tv
- 1 “likely” repack tv
- Numerous FM operations

Getting the signal out

Goals of an Antenna System:

- **Maximize population covered with highest signal levels**
  - More height, = more coverage
  - Design pattern for highest population
  - Optimize tower location
- **Minimize interference with other stations**
  - Directionalize pattern
  - Reduce height and/or ERP
- **Operate under applicable FCC rules**
  - City of license coverage
  - ERP limits

Getting the signal out



LA Station Coverage Contours

Getting the signal out

Goals of a Broadband Antenna System:

- **Maximize Coverage**
  - Tailor element arrangement for market
  - Increase ERP
  - Maximize signal saturation
- **Maximize number of stations in system**
  - Increase gain
  - Increase power handling
  - Decrease losses

Getting the signal out

Goals of a Broadband Antenna System:

- **Minimize tower loading**
  - Reduce cross section
  - Lower height
  - Smaller Transmission line
- **Minimize station costs**
  - Divide capital costs across multiple users
  - Reduce operating expenses

Getting the signal out

Components of a Broadband Antenna System:

- **Antenna**
  - Top or Side Mount
  - Slot or Panel
  - Horizontal, Elliptical or Full CP
  - Single or Dual Input
- **Transmission Line**
  - Rigid or Flexible Coax
  - Rectangular, or Elliptical Waveguide
- **Channel Combiner**
  - Starpoint, Manifold or Constant Impedance
  - Coax or Waveguide

Antennas

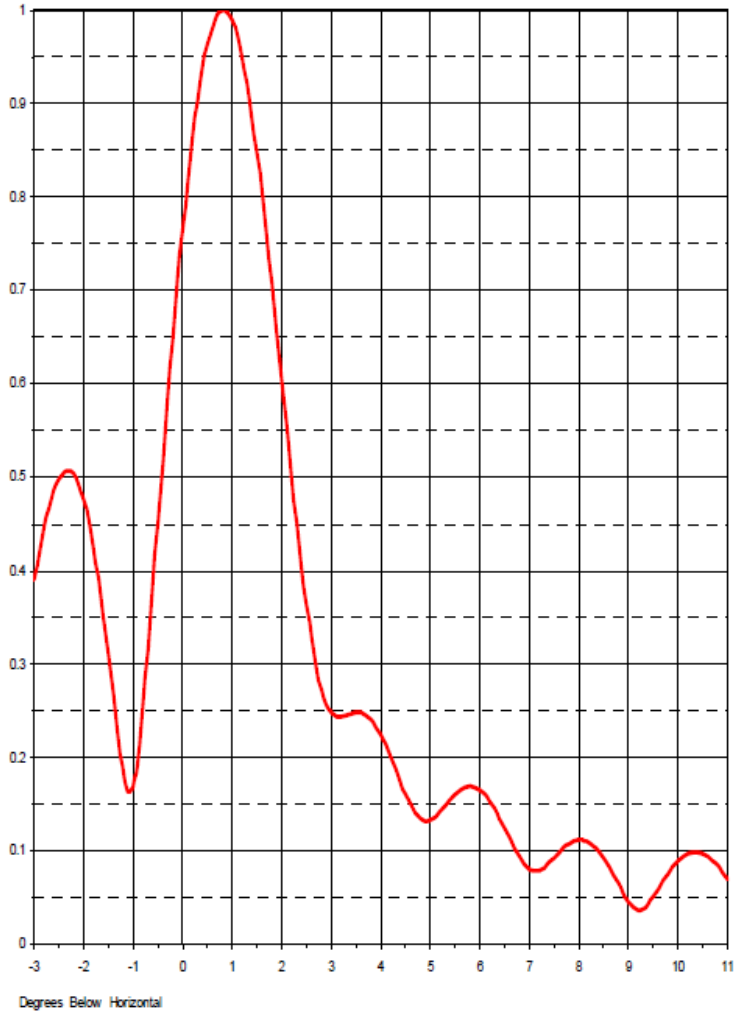
Direct RF energy as efficiently as possible over the desired coverage area

Antennas

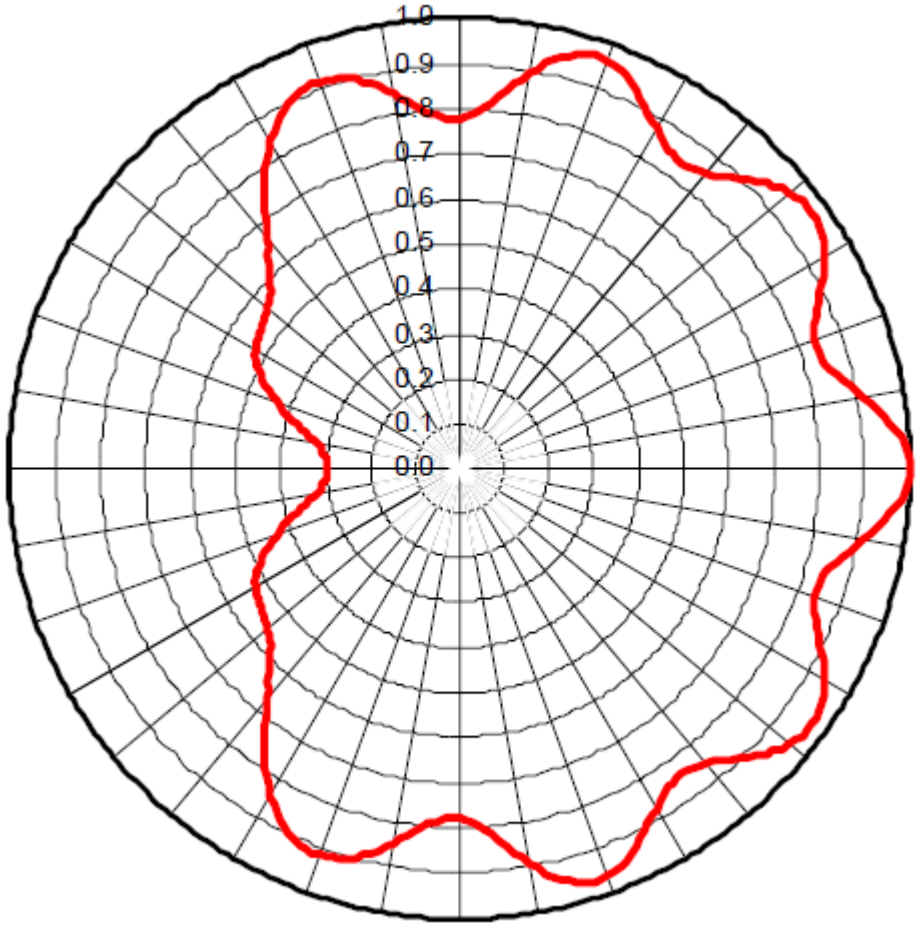
Arrangement of elements

- Horizontal position
  - How they are placed around a horizontal plane
  - Determines azimuth pattern
  - Omnidirectional often desired (G=1)
- Vertical position
  - Narrows elevation beam width
  - More elements = higher gain
  - Optimum between ½ and full wavelength

Antennas



Elevation



Azimuth

2D Array Patterns

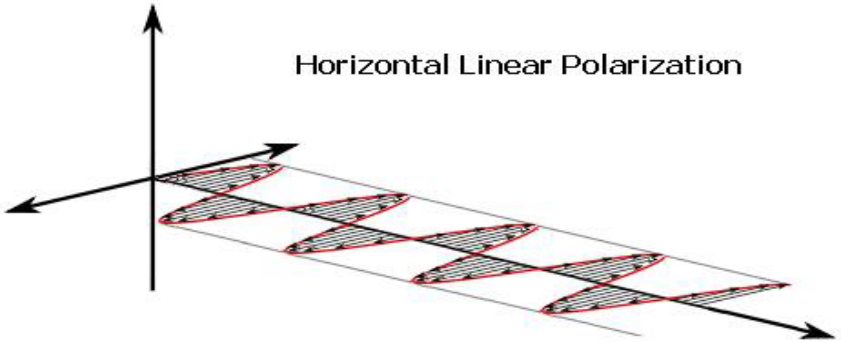
Antenna Locations

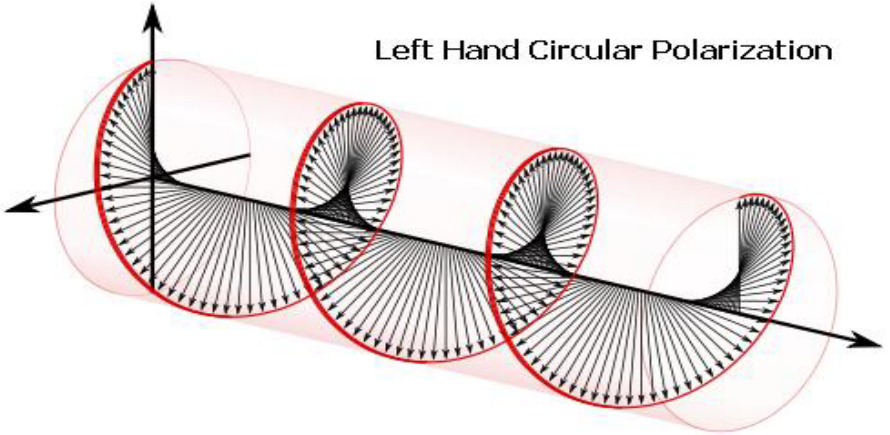
- **Top Mount**
  - Highest spot
  - Little to no pattern distortion
    - Preferred for Omnidirectional
  - Allows for stacking
  - Requires structural strength
  - No mounting pole or tower section
  - Higher cost

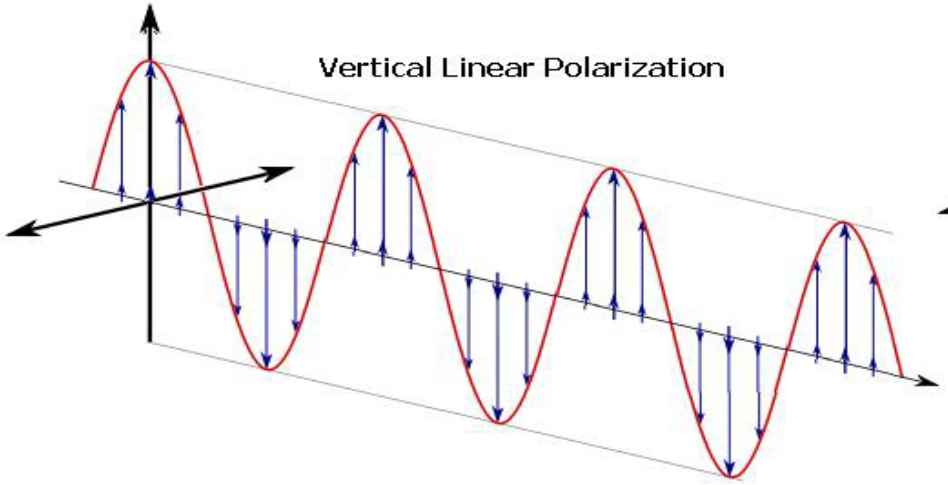
- **Side Mount**
  - Rest of the tower
  - Significant pattern distortion
    - Difficult to make Omnidirectional
  - Leg or face mount
  - Allows light antennas
  - Lower cost

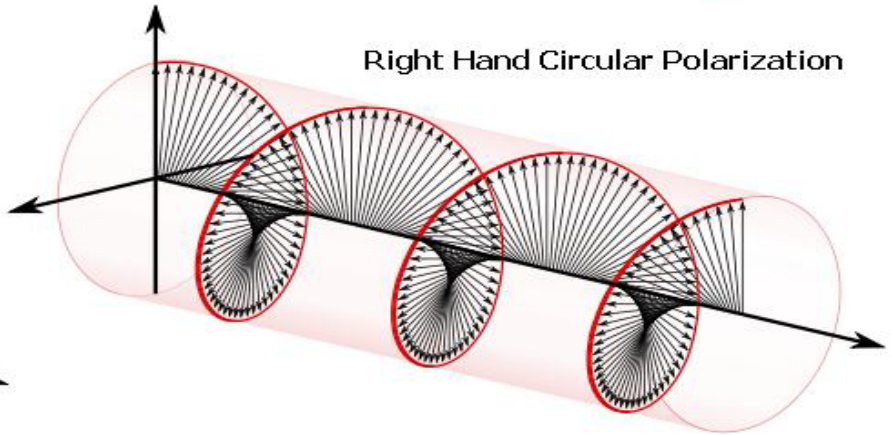
Antennas

- **Horizontal polarization** — **TV, LPFM**
- **Vertical polarization** — **LPFM**
- **Circular polarization** — **FM**
- **Elliptical polarization** — **TV**



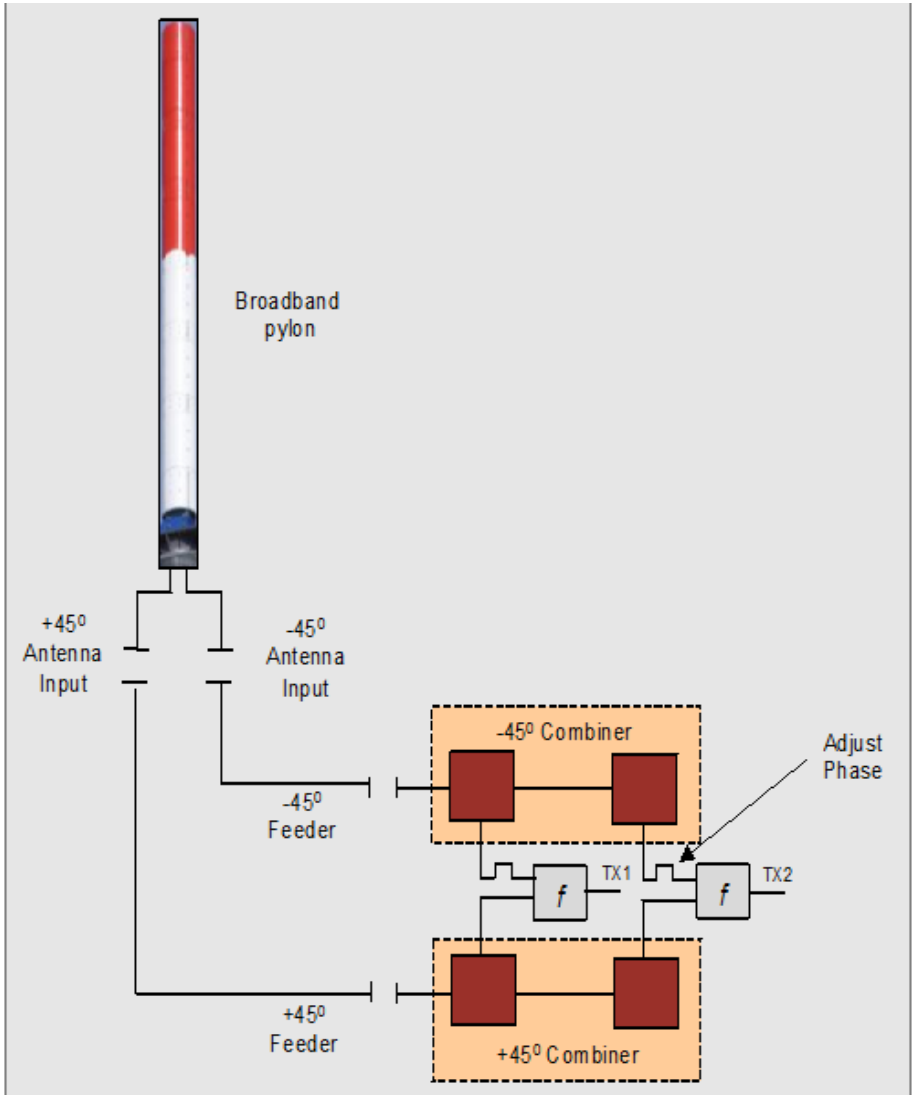






Dual Chains for Dynamic Polarization

- Half power in each chain independent of Polarization setting
- Phasing at inputs for Polarization adjustment
- No output splitter
- Easily adjusted by station



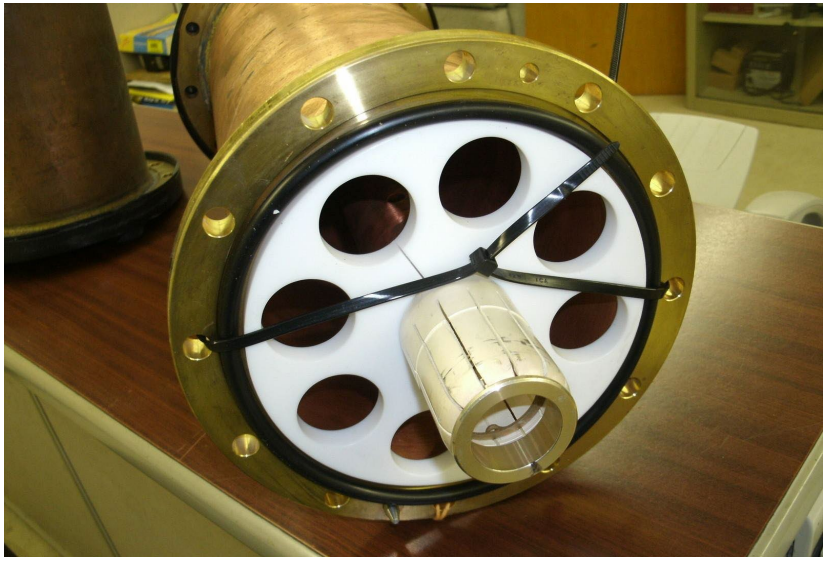
Transmission Lines

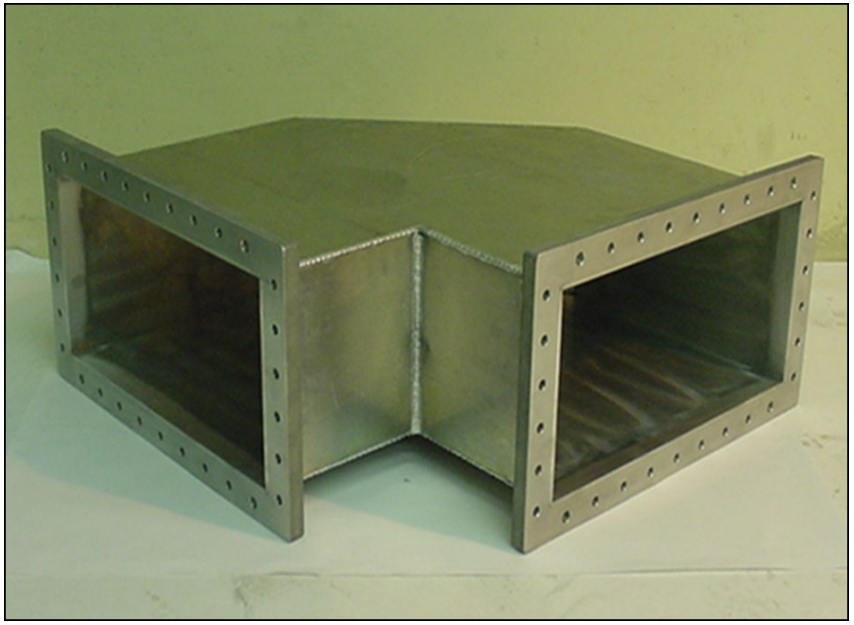
Carry RF energy as efficiently as possible to the antenna with minimum windload on the tower

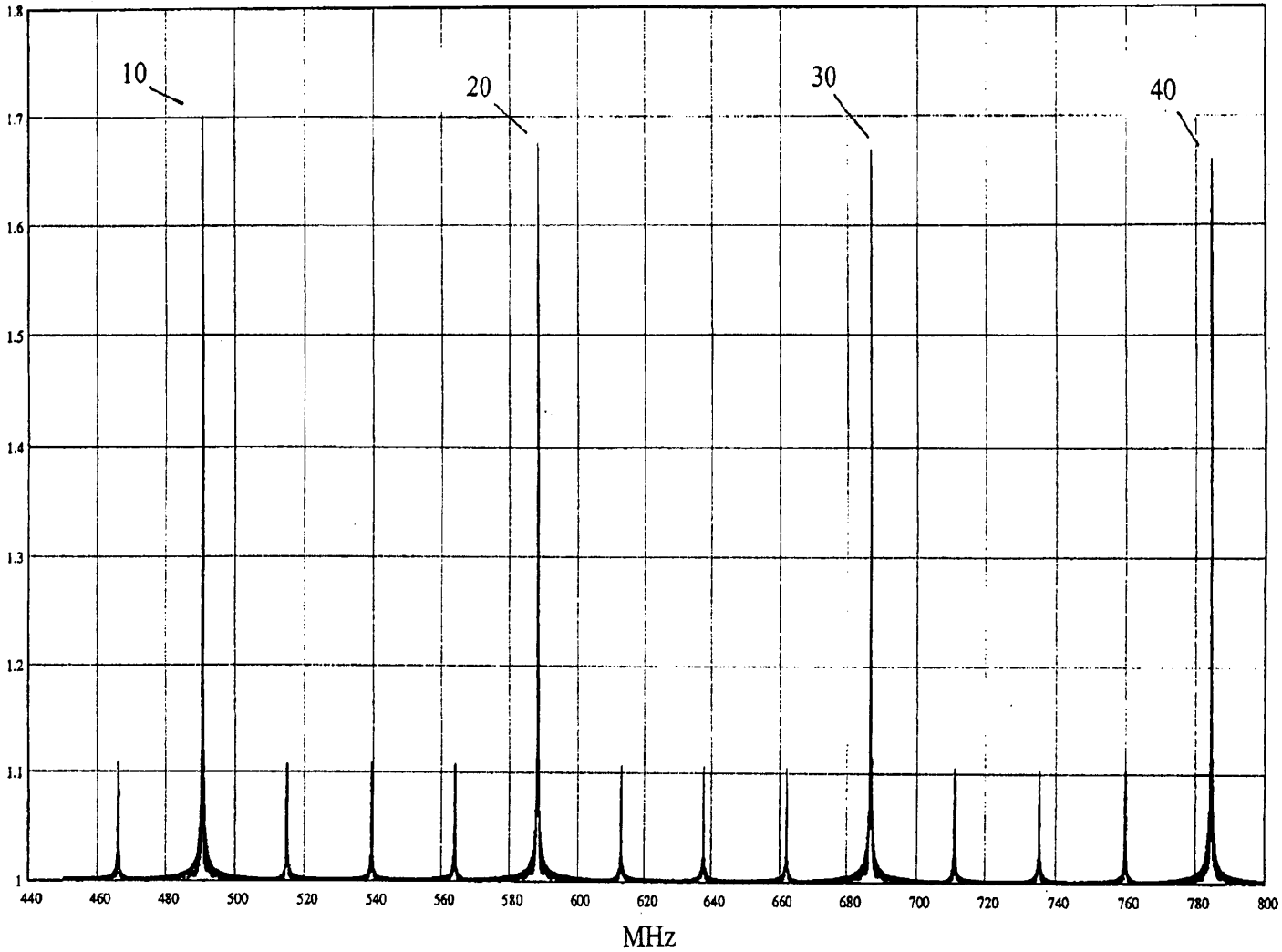
Transmission Lines

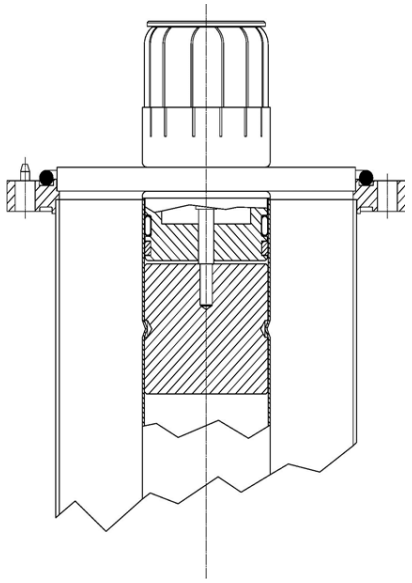
Important concepts

- Construction material controls loss
  - Copper
  - Aluminum
  - Silver Plate
- Mode determined by physical size
  - TEM desired for coax
  - Fundamental TE or TM desired for waveguide
- Flange Reflections due to fixed section lengths
  - Each flange has small reflection
  - Randomizing lengths can disperse over broadband
- Hangers must allow for differential expansion
- Pressurization required to keep moisture out



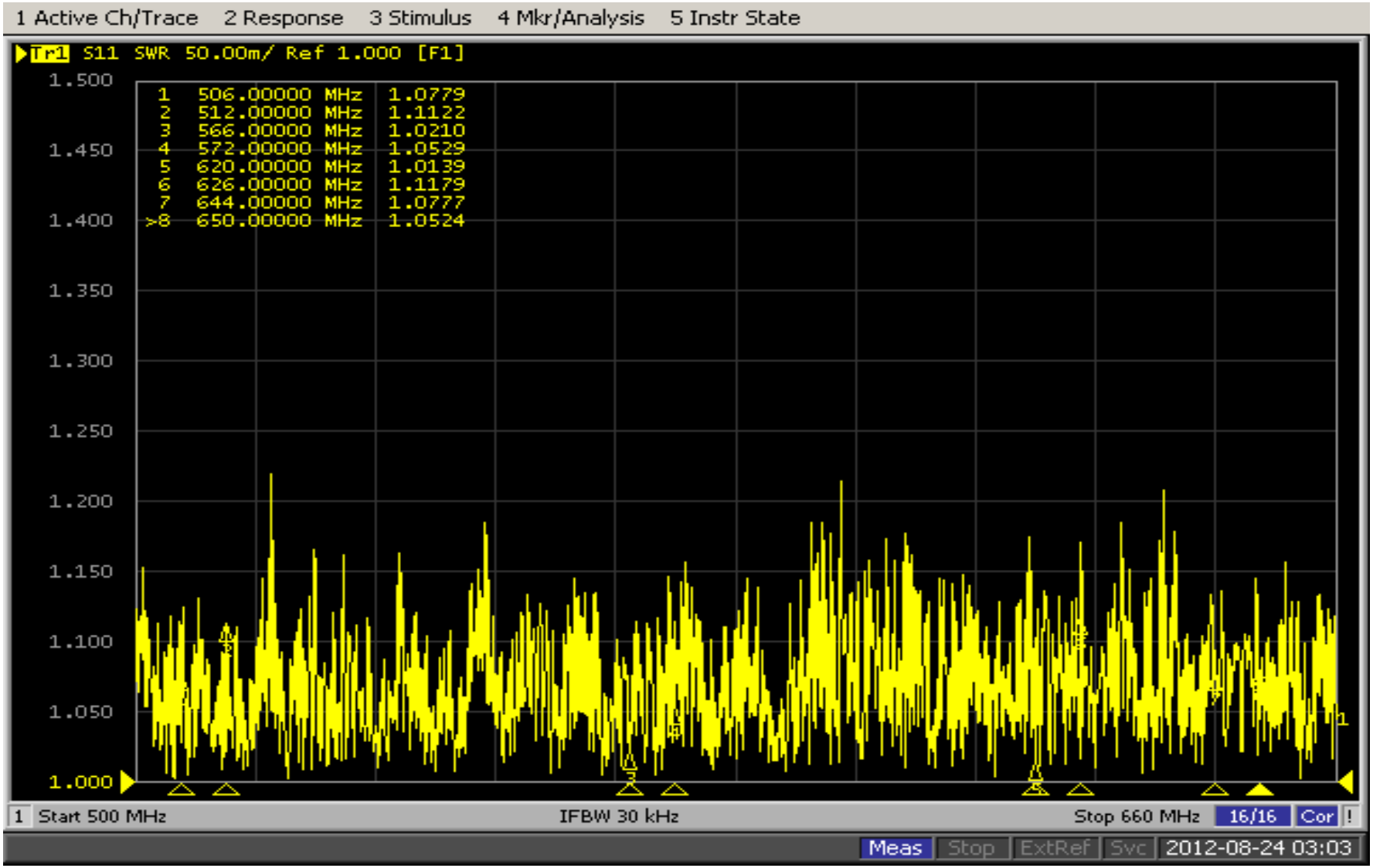






VSWR vs Frequency

Spikes are due to flange reflection addition



VSWR vs Frequency w/ Line + Antenna
Spikes removed through length randomization

Channel Combiners

Put more than one channel into an antenna

Channel Combiners

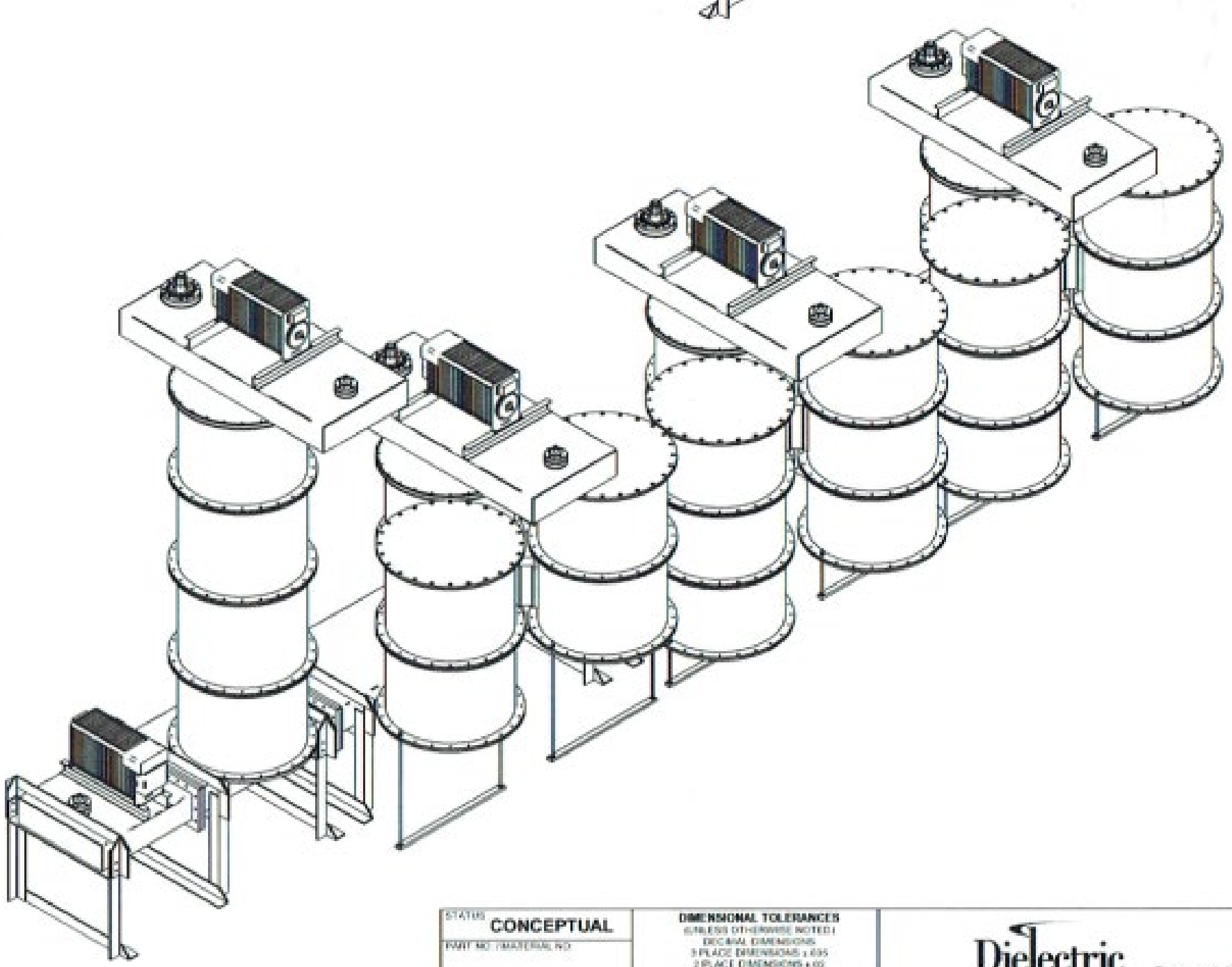
Important concepts

- Isolation
  - Minimize intermodulation products
  - Independent operation
- Insertion Loss
  - Materials
  - Arrangement
- Expandability
  - Trade-off with expense and size
  - More versatile
  - Future proof

Channel Combiners

Types

- Starpoint/Branch/Manifold
  - Parallel connection at output
  - Not expandable
  - Simple and Inexpensive
- Constant Impedance
  - Series connection
  - Expandable broadband input
  - Complex, large and expensive



STATUS: CONCEPTUAL	DIMENSIONAL TOLERANCES (UNLESS OTHERWISE NOTED) DECIMAL DIMENSIONS 3 PLACE DIMENSIONS ±.005 2 PLACE DIMENSIONS ±.02 FRACTIONAL DIMENSIONS 6" 4" ±1/32" ABOVE 6" UP TO 12" ±1/16"	Dielectric Raymond, ME
PART NO / MATERIAL NO:		
SAP DOCUMENT NO:		TITLE: