

# Near Field Drone Measurements for Broadcast Antennas

Presented By:  
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## *First - A Special Acknowledgement and Thank you!*

The team at Cavell, Mertz & Associates and Eric Wandel played a large part in the success of the near field drone measurement technique.

- Cavell, Mertz & Associates, Inc
  - Helping to develop the near field drone measurement process, including collecting and analyzing drone-based near field data at multiple sites
- Eric Wandel, Wavepoint Research, Inc.
  - Helping to develop and promote the near field drone measurement process

**CAVELL, MERTZ & ASSOCIATES, INC.**

**Wavepoint Research, Inc.**



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## *Overview*

- Field pattern verification and what it can tell us
- Current methods for field verification
- Defining near field vs far field for a broadcast antenna
- Modifying current drone methods for the near field
- The use of HFSS software for near field measurements
- Data analysis and comparison examples
- Summary of near field drone measurements



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## *Field Pattern Verification Study*

- Ensure that a broadcast antenna is operating as designed
  - Is it reaching the intended audience?
  - Is the antenna operating as expected?
  - Is it installed correctly and in the correct orientation?
  - Older antenna does not perform as it did originally

Currently a reimbursable re-pack item!



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## *Current Choices*

- Ground based measurements
- Helicopter measurements
- Drone measurements



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## *Growing Appeal to Use Drones*

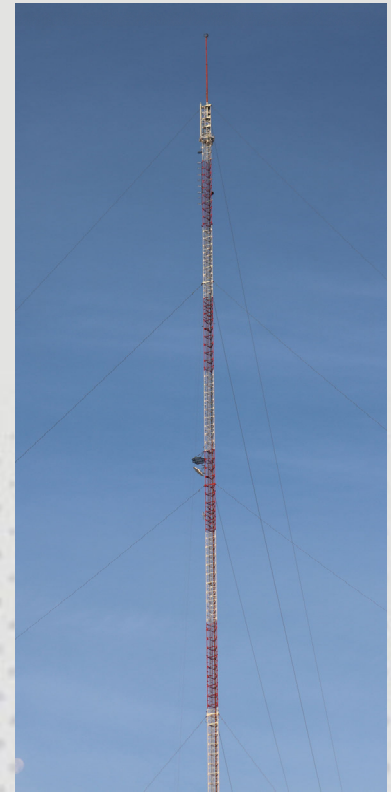
- Drones can make measurements quick and cost effective
- Eliminate the statistical analysis required by ground based measurements
  - FCC - 100' runs at 30' above ground



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## *FAA Restrictions on Drone Flights*

- FAA has restrictions on flying drones for commercial use
  - Title 14, Chapter I, Subchapter F, Part 107
- 400' altitude restriction
  - Unless it can be operated within 400' of a structure
- Measurements taken outside of this “shield” will require a waiver
  - Select all applicable regulations
  - Demonstrate the flight can be conducted safely/mitigate risks
  - File all associated documents (cannot be amended after completion)
  - Up to 90 day processing time



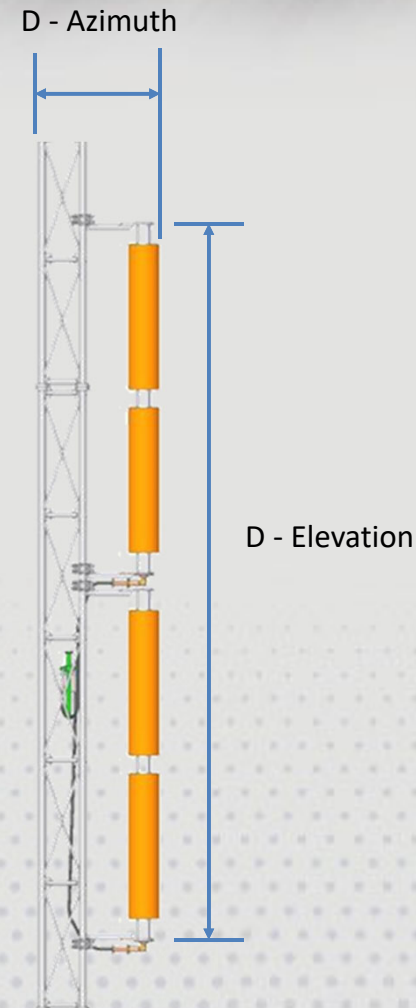
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## Antenna Far Field

- Basically defined as the distance at which the radiation pattern no longer changes with distance

$$d = \frac{2D^2}{\lambda}$$

- Radiation patterns made inside of the far field limit are not yet focused and tend to be spread out exhibiting much less gain than as defined in the far field.



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## *Broadcast Antenna Far Field*

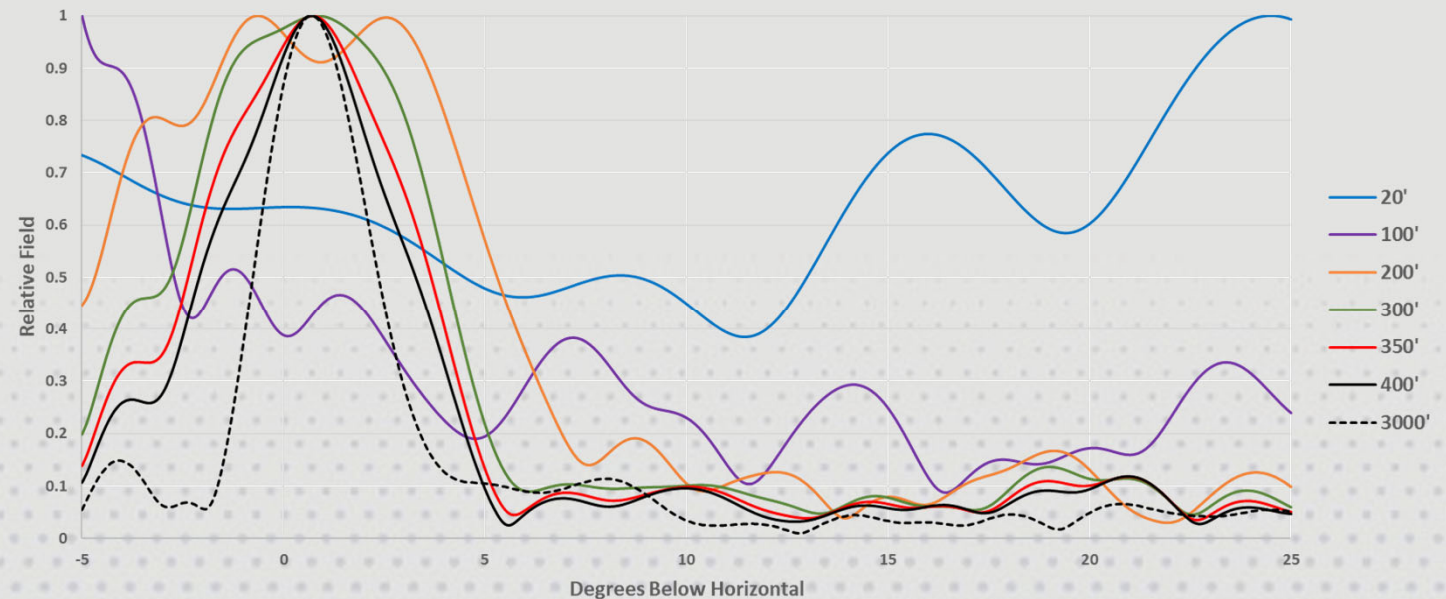
- Top mount UHF pylon antennas are typically around 14" in diameter by approximately 50' tall.
- At 600 MHz
  - Azimuth far field is 1.7'
  - Elevation far field is 3000'
- Within the 400' shield
  - Obviously azimuth pattern measurements not a problem
  - Elevation pattern measurements are well inside the near field



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## Antenna Elevation Pattern Near - Far Field

- Beam becomes more focused the farther you are from the antenna
- Can't measure too close to the antenna
- Get out as far as possible to have the most defined shape



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## *Current Choices - Recap*

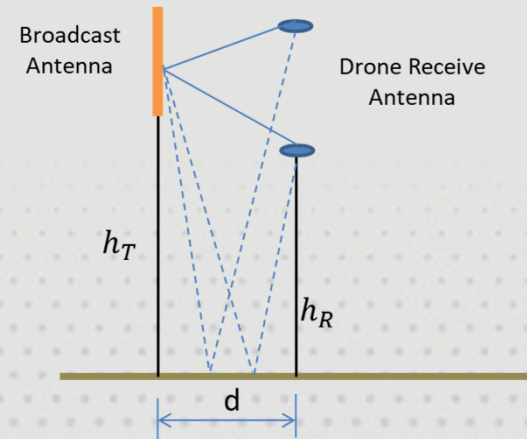
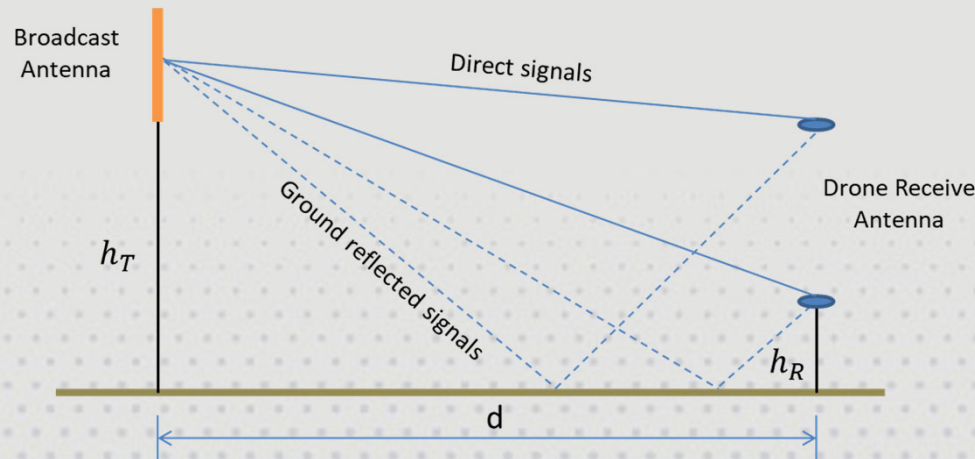
- Ground based measurements
- Helicopter measurements
- Drone measurement on just the azimuth pattern only within 400' of the tower
- Apply and obtain a waiver to fly a drone outside of the 400' shield to collect elevation data



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## Ground Reflections - Multipath

- Affect the accuracy when measuring the elevation pattern with a drone from a distance.
- In general, the > the distance, the < the refraction angle and the > the measurement error.
- SL levels for both the broadcast antenna and the drone antenna decrease with elevation angle.



We can assume no energy directed toward the ground in the very near field of two elevated high gain antennas.

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## *Modifying the Drone Method*

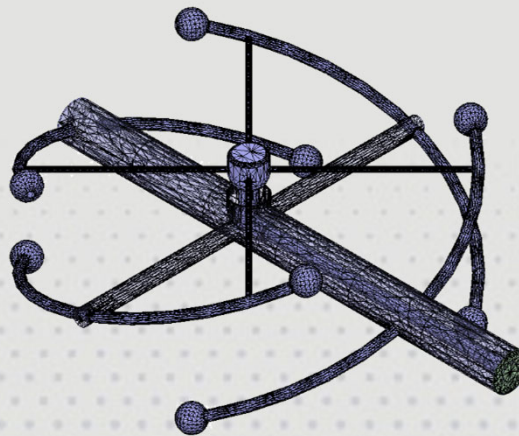
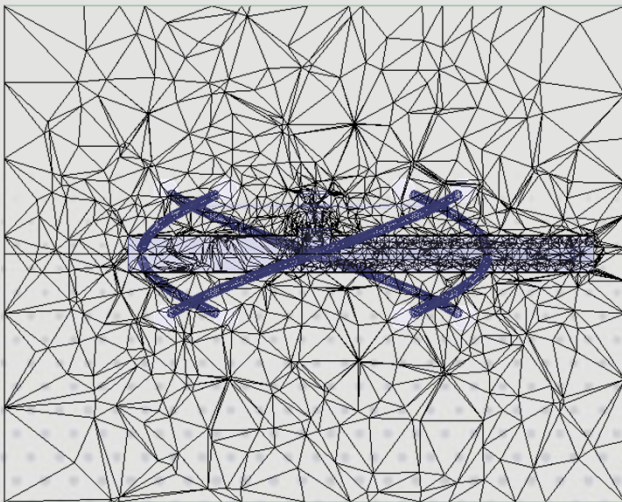
- Easiest/quickest way to measure and antenna with a drone is within the shield of the tower
- Eliminates the need for other measurement techniques/statistical analysis
- Need a way to compare near field data collected to factor measurements



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- ANSYS HFSS is a 3D electromagnetic (EM) simulation software tool
  - Design, simulate and evaluate antennas, antenna arrays, and RF or microwave components.

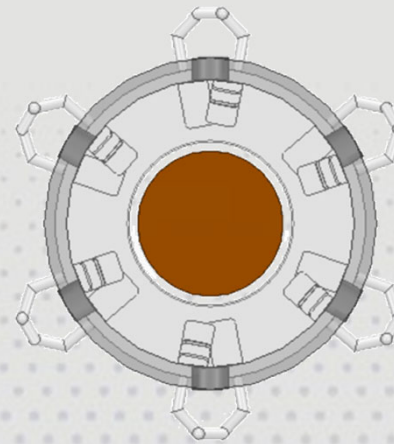


- Model broken down into thousands of tetrahedra
- Maxwell's equations solved at each vertex/node
- Calculation is not an estimate, but an exact solution at every node in a mesh

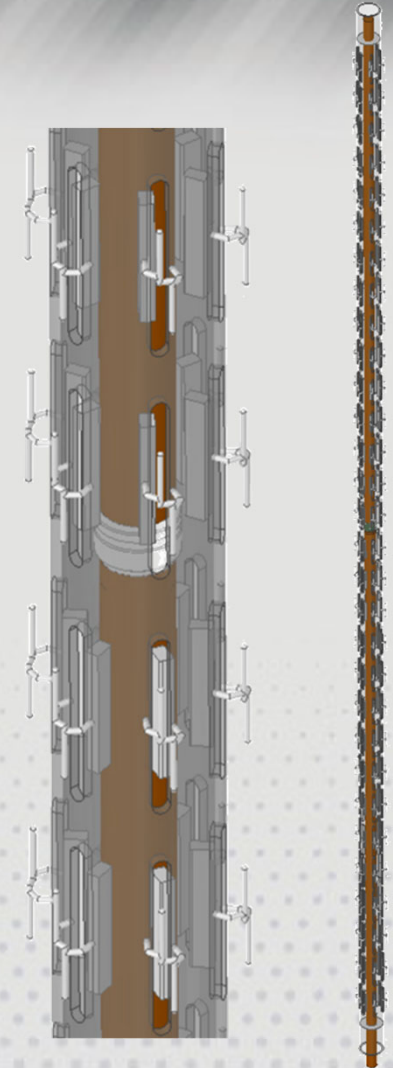
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## *Model Set-Up in HFSS*

- With HFSS, the full broadcast antenna can be modeled as designed and tested
- Requires the full knowledge of all the antenna features
- For example: Each layer of a slotted coaxial pylon antenna is unique
  - Couplers
  - Slot lengths
  - Vertical dipole elements
  - Fins / directors
  - Short locations
  - Feed point location
  - Etc....



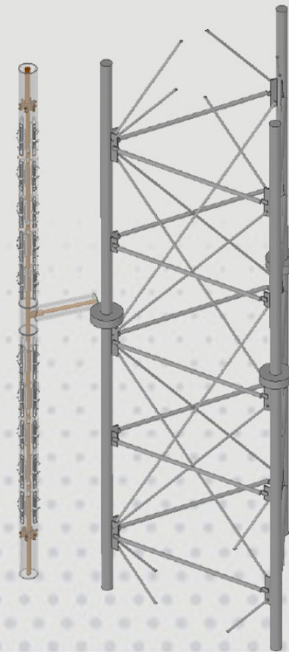
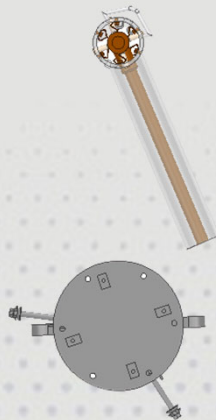
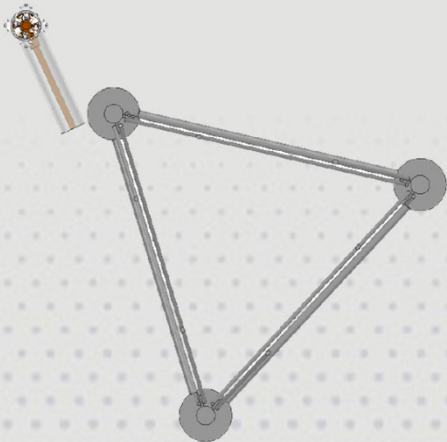
Accuracy is key!



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## *Model Examples*

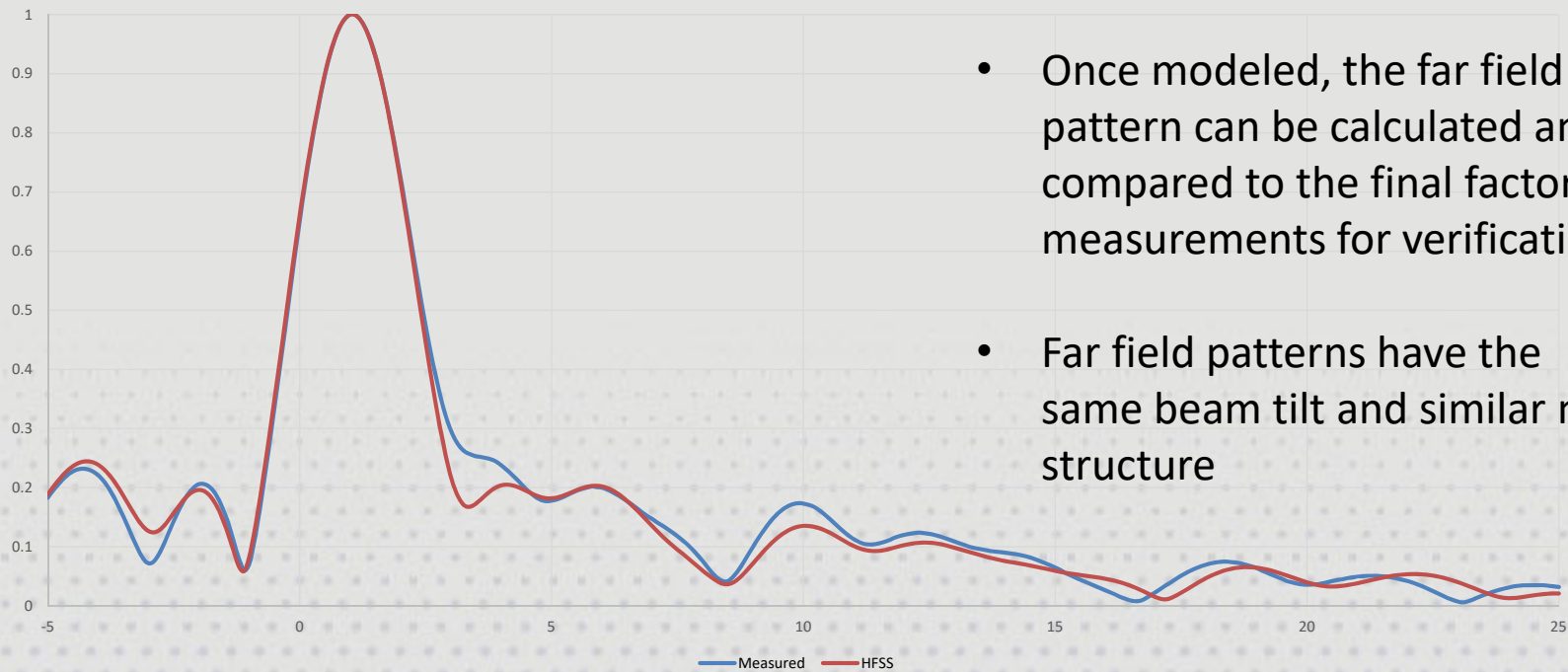
- Antennas must be modeled with anything in the aperture
  - Support poles, tower section, transmission line, etc.



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## Data Analysis – Far Field Comparison



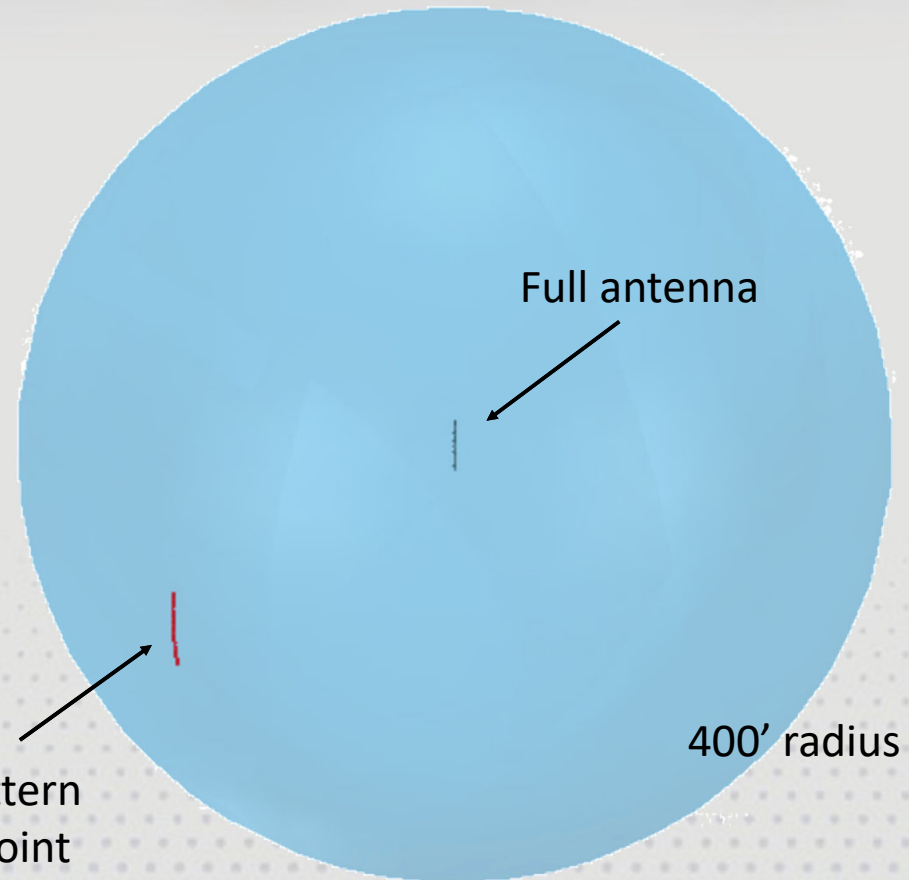
- Once modeled, the far field pattern can be calculated and compared to the final factory measurements for verification
- Far field patterns have the same beam tilt and similar null structure

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## *Data Analysis*

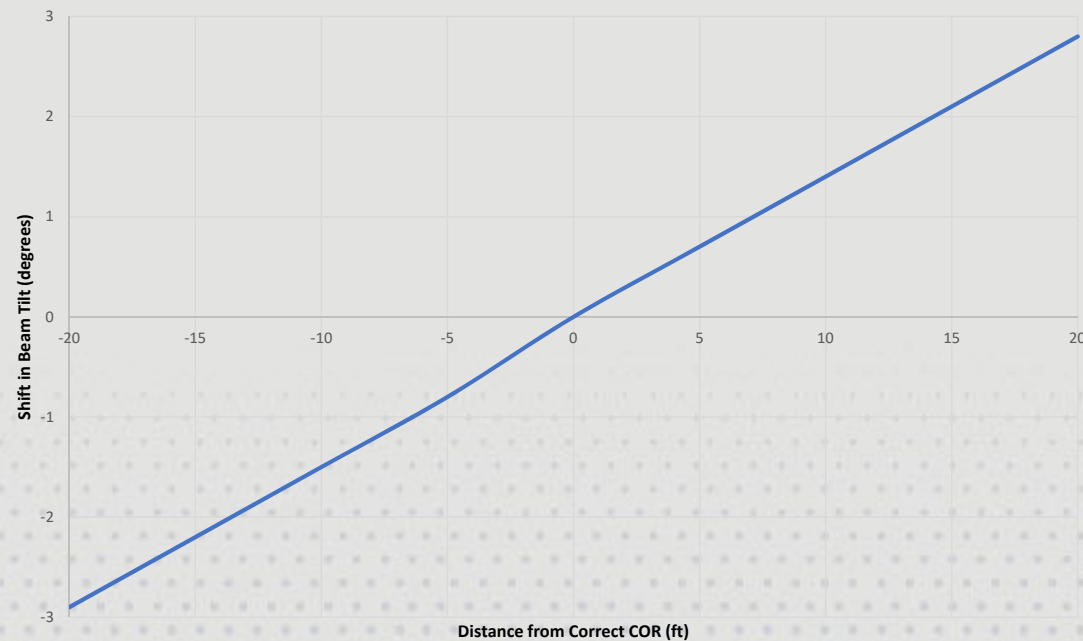
- Since HFSS produces a full 3D electromagnetic solution, a radiation sphere can be placed around the antenna at 400' to calculate the fields at this distance.
- Near field elevation patterns are calculated at points on this sphere

Elevation pattern  
calculation point



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## *Data Analysis – Center of Radiation Accuracy*

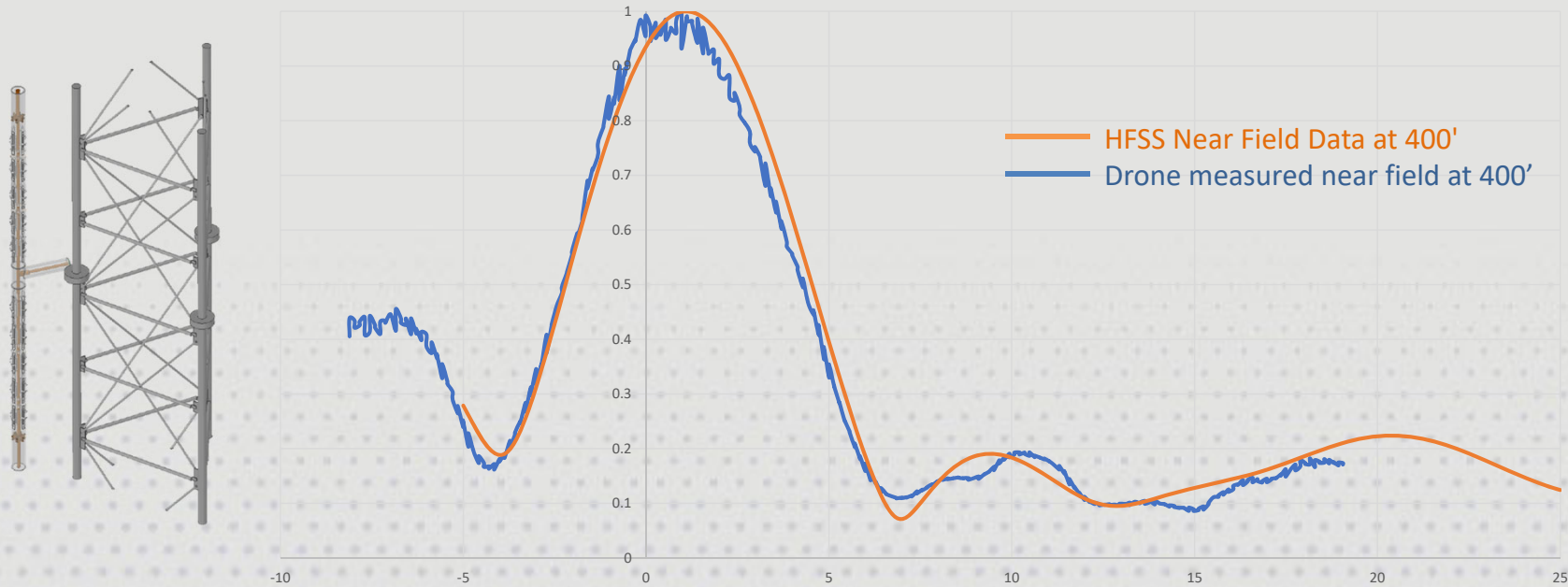


Shift in center of radiation can dramatically affect beam tilt!

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## Data Comparison - Elevation

- Example: Side mounted TFU-10DSC/VP-R O4 for Channel 36 on tower

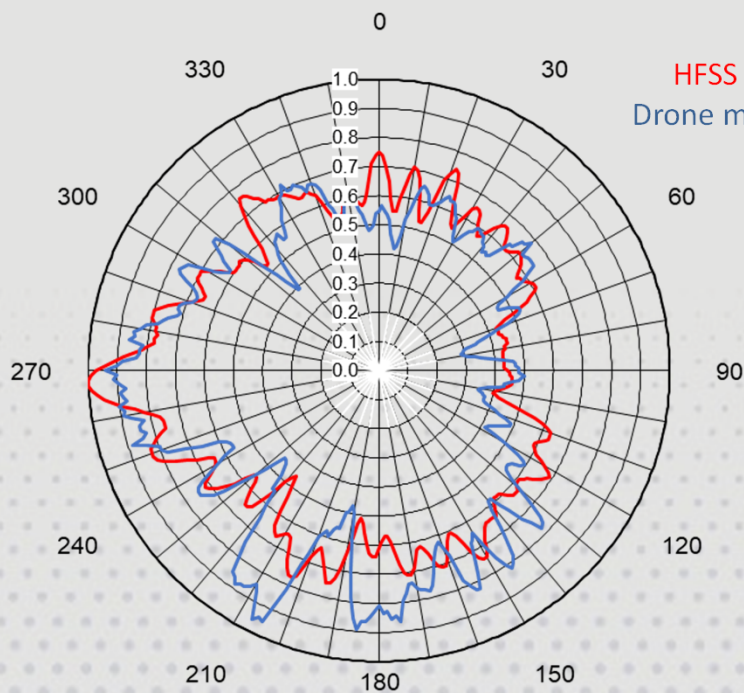


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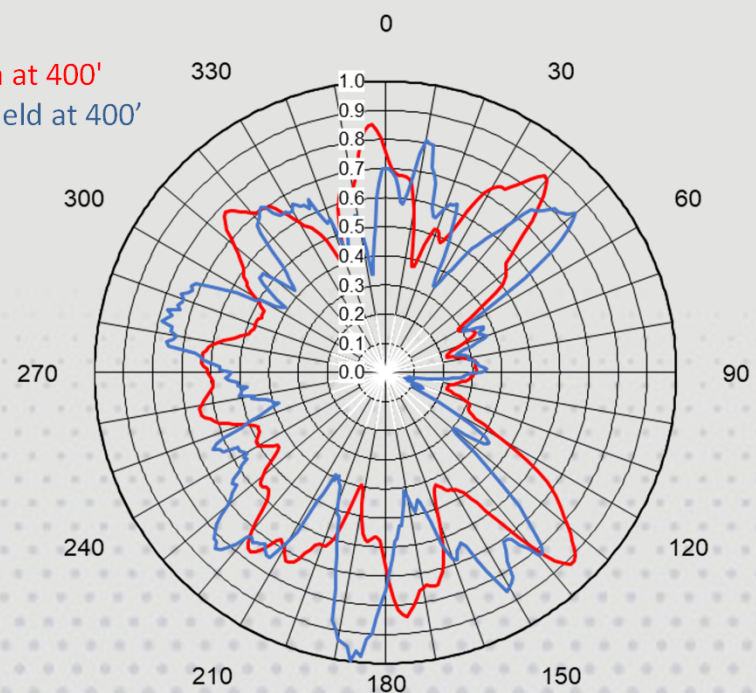


## Data Comparison - Azimuth

- Example: Side mounted TFU-10DSC/VP-R O4 for Channel 36 on tower



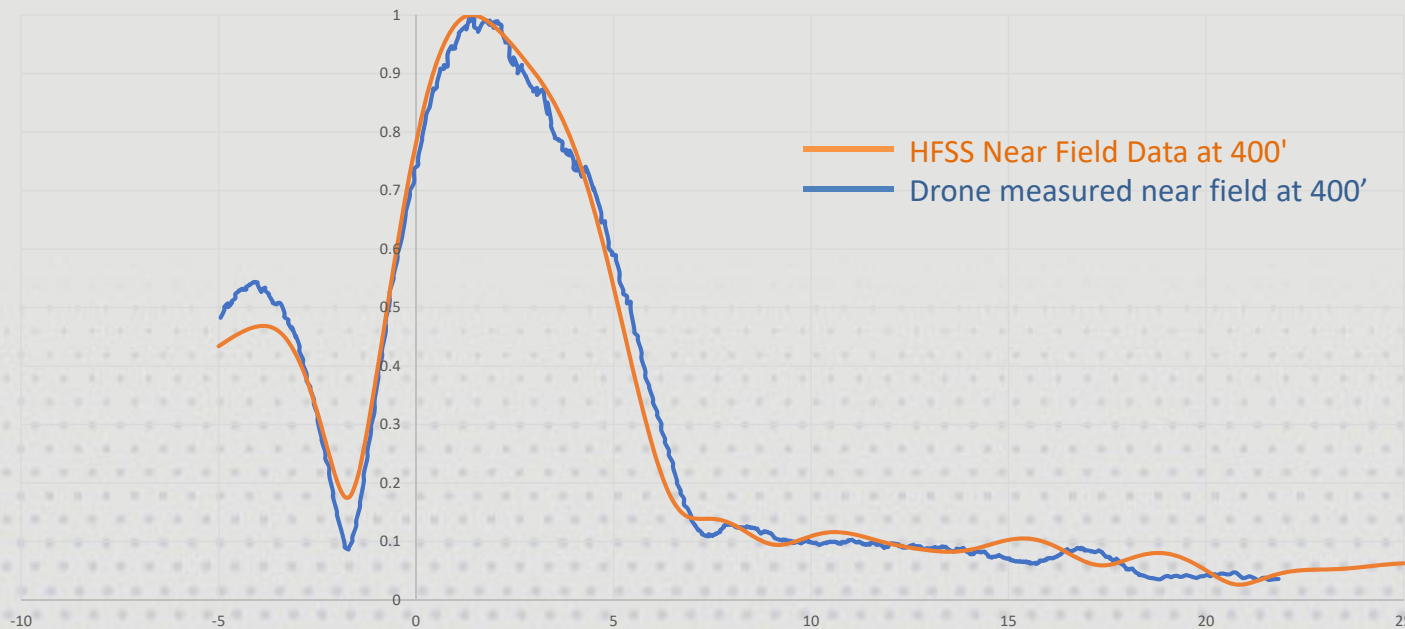
HFSS Near Field Data at 400'  
Drone measured near field at 400'



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## Data Comparison - Elevation

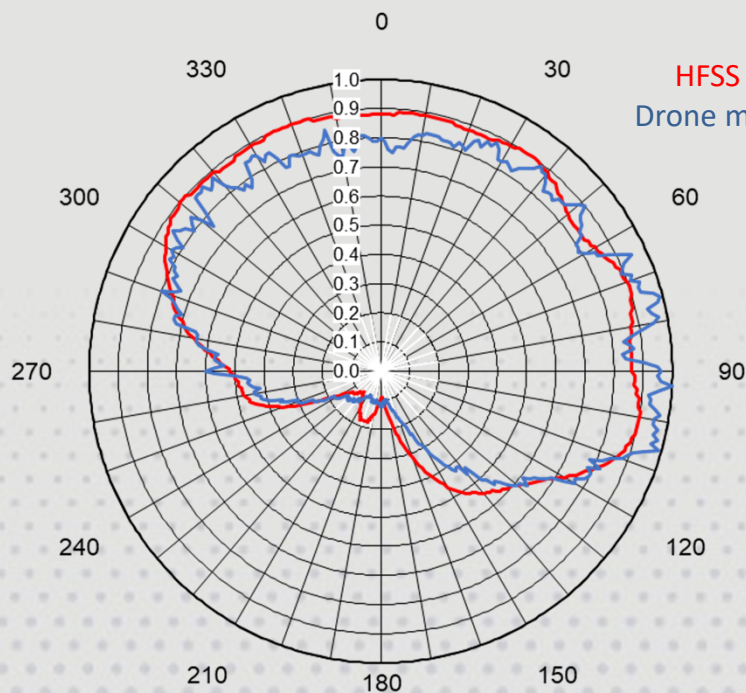
- Example: Side mounted TFU-20DSC/VP-R C170 for Channel 30 on support pole



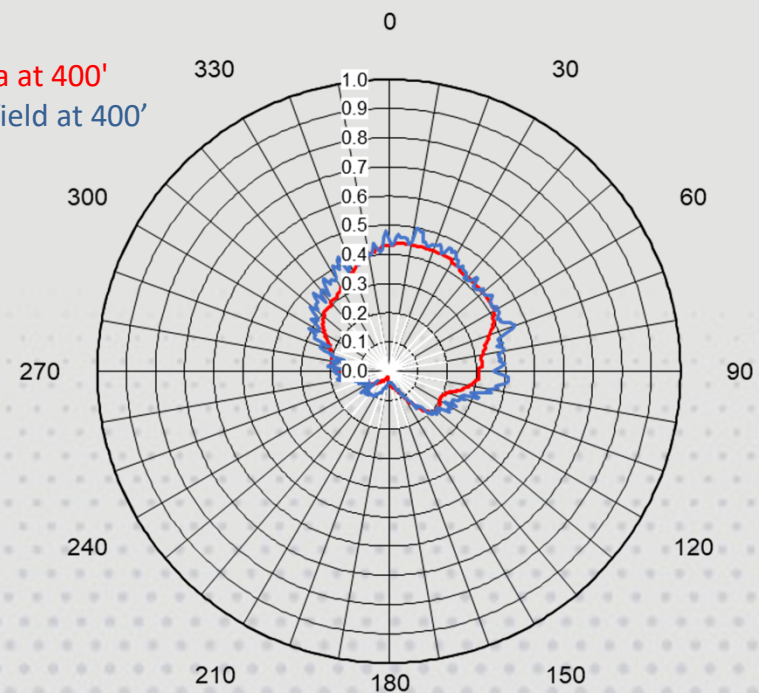
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## Data Comparison - Azimuth

- Example: Side mounted TFU-20DSC/VP-R C170 for Channel 30 on support pole



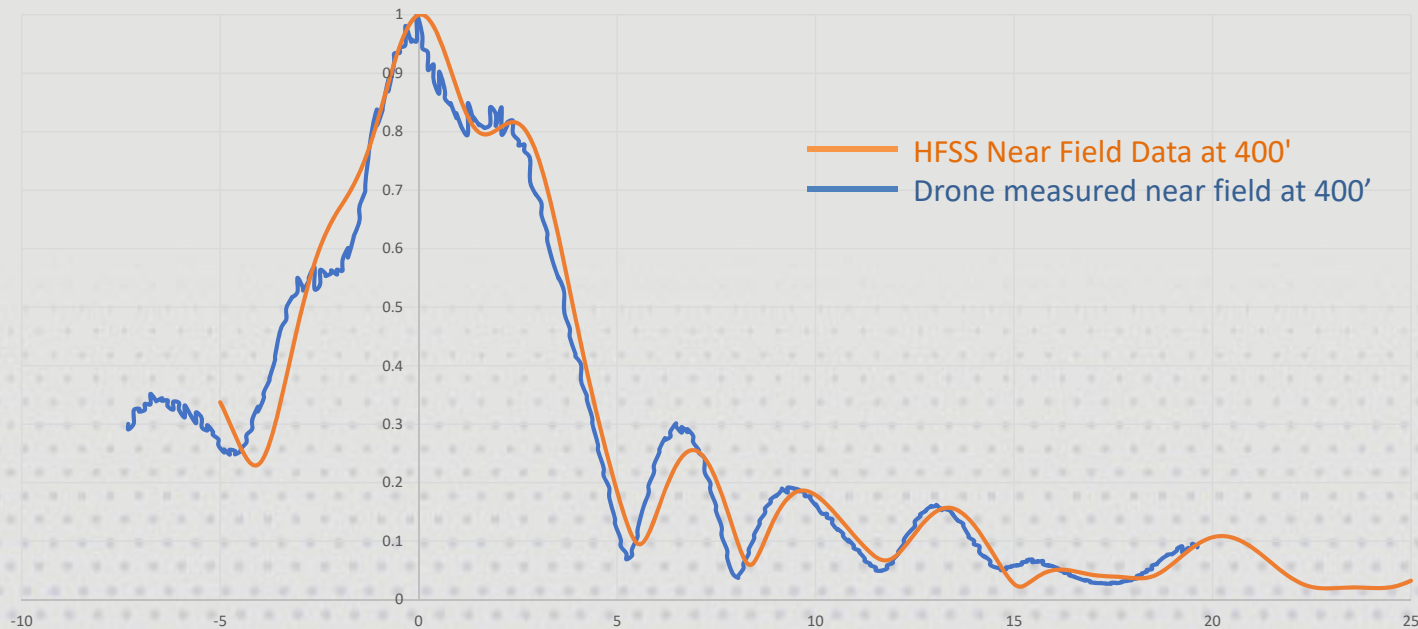
HFSS Near Field Data at 400'  
Drone measured near field at 400'



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## Data Comparison - Elevation

- Example: Top mounted TFU-29JTH/VP-R O6 for Channel 32

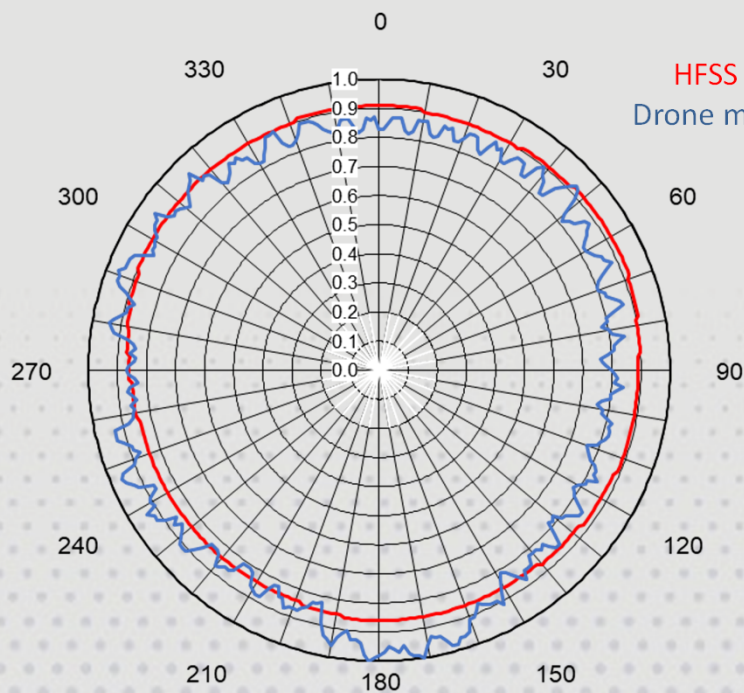


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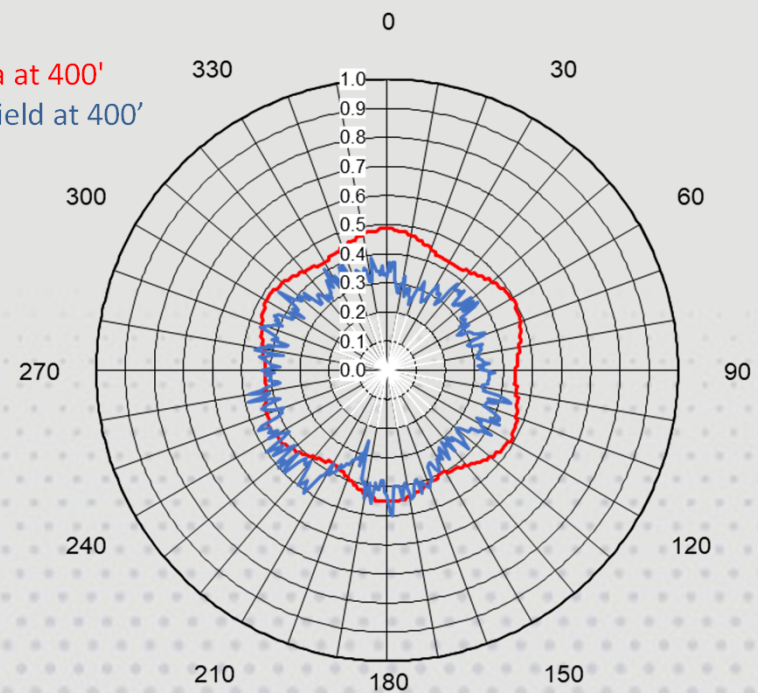


## Data Comparison - Azimuth

- Example: Top mounted TFU-29JTH/VP-R O6 for Channel 32



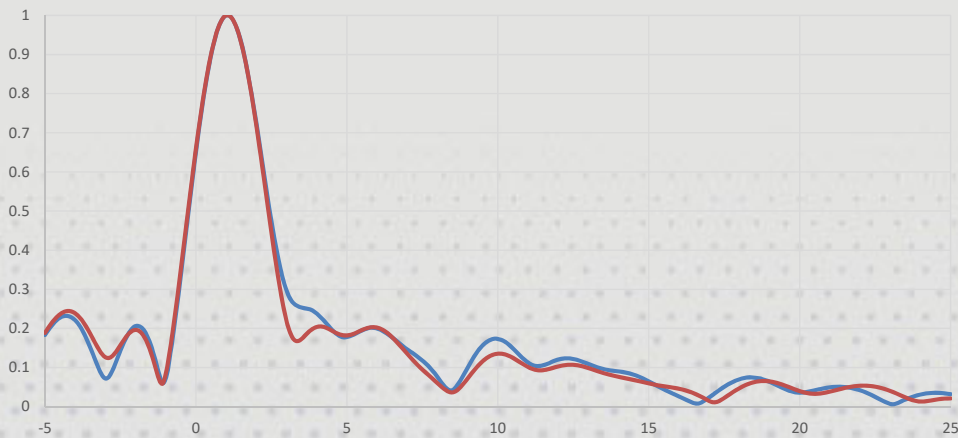
HFSS Near Field Data at 400'  
Drone measured near field at 400'



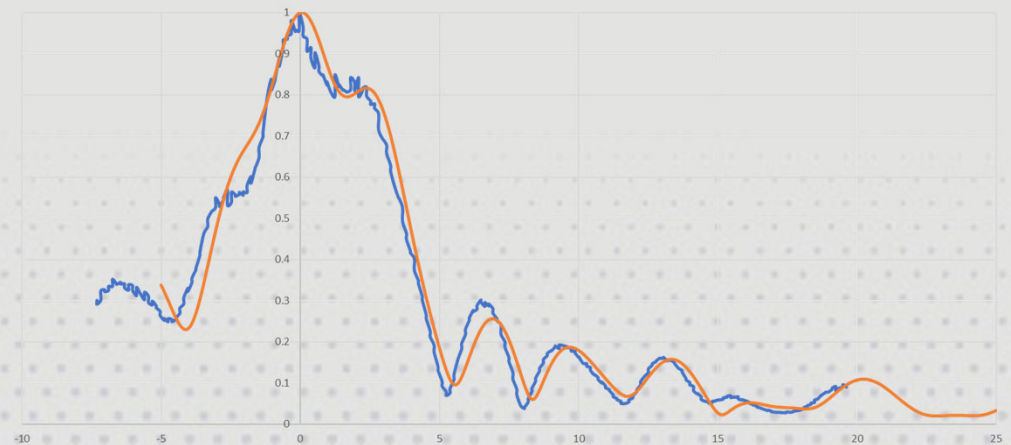
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## Data Comparison – Take Away

- Far field in HFSS matches factory measurement
- Near field in HFSS matches drone measurement
- Therefore the antenna is functioning as expected in the field



Far Field



Near Field

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## *Near Field Drone Measurements - Summary*

- Azimuth pattern measurement verifications
  - Azimuth footprint is as specified
  - Installation orientation
- Elevation pattern measurement verifications
  - Beam tilt is as specified
  - Approximation of null structure

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THANKS FOR YOUR TIME!

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