Antenna Simulation: Tackling RePack and Beyond

Presented By:
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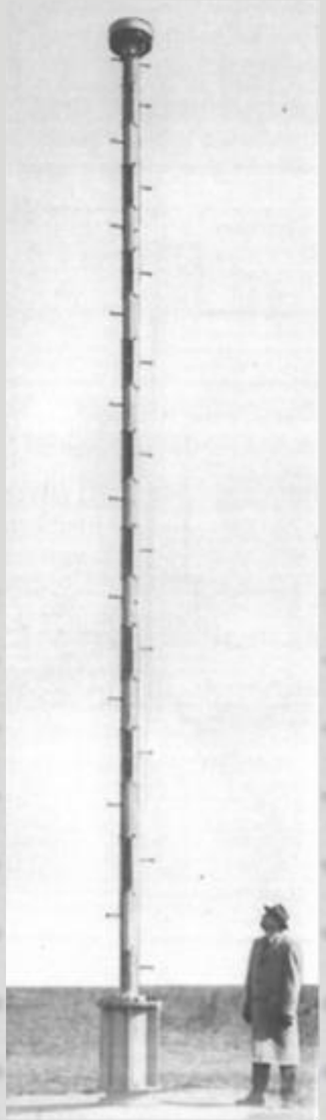
AGENDA

- History of Antenna Design at Dielectric
- Physical Single layer Data Process
- Transition to Software Design
- Post RePack Applications
- Conclusions

History of Antenna Design at Dielectric



- RCA shipped the first slotted coaxial antenna in 1952 and their 500th in 1982

- Dielectric acquired RCA antenna broadcast division in 1985
- Single layer data process developed by RCA in the 1960's and continues to be used today

Physical Single Layer Data Process - Overview

- Review antenna specifications
- Choose appropriate physical model from inventory
- Model set up in anechoic chamber
- Azimuth pattern and axial ratio development
- Transfer model to test stand
- Determine characteristic data matrix
- Extract specific design using proprietary software

Model Set Up/Azimuth Pattern Development

Process:
- Pattern is adjusted with fins, directors, or other pattern shapers
- Vertical component adjusted with floating or "Z" Dipoles

Restrictions:
- Model set up/pattern development time
- Short lead times limit model choices
  (150-200 models in storage)
- Added expense and time for new models
- Tolerancing variance on steel poles
  (up to 12% variance for wall thickness)
- Anechoic chamber variance – not pure free space
- Human error

Characteristic Data Matrix

Process:
- Adjust coupling for different loading levels
- Adjust slot length for phase variance

Restrictions:
- Machining time for each coupler size
- Calibration error
- Lengthy measurement process
  (over 600 manual measurements)
- Human error

Transition to Software Design – Pre-RePack

To prepare for RePack:

- Tested model set up against extensive library of historic data
- Developed robust customizable HFSS computer models
- Build library of 40+ computer models

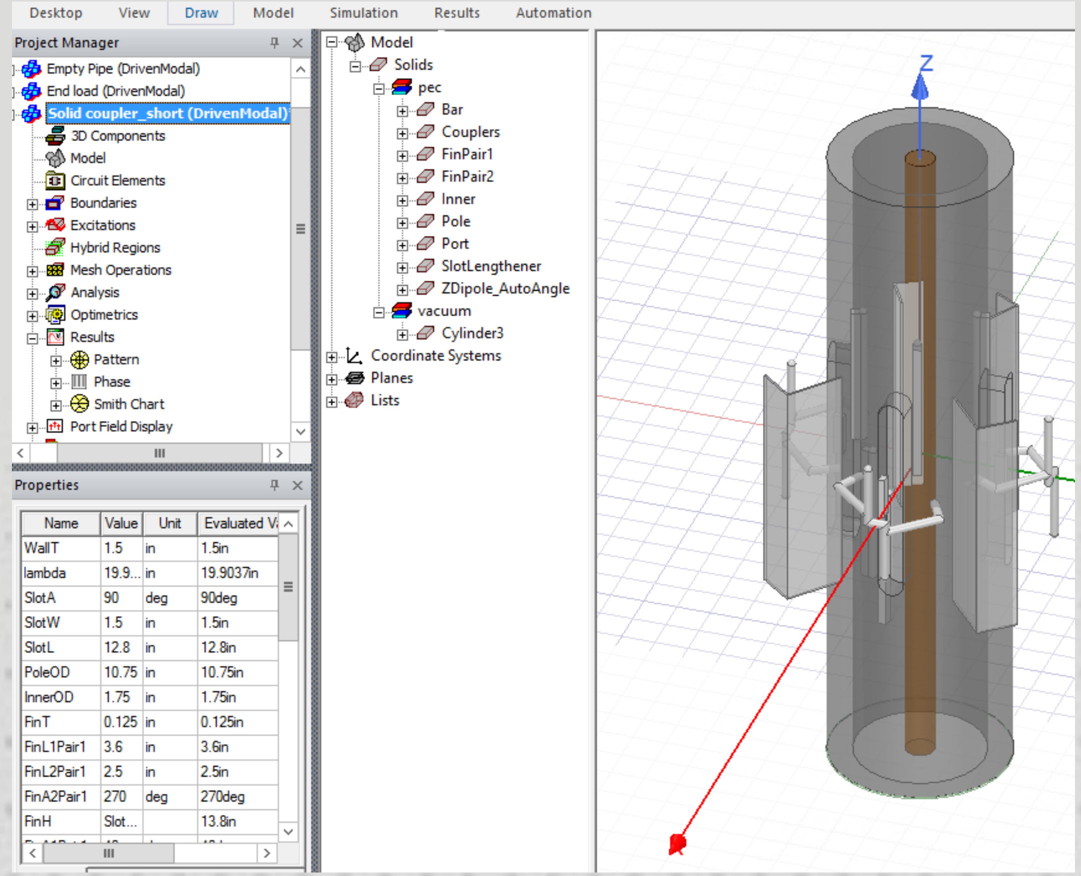
Software enables:

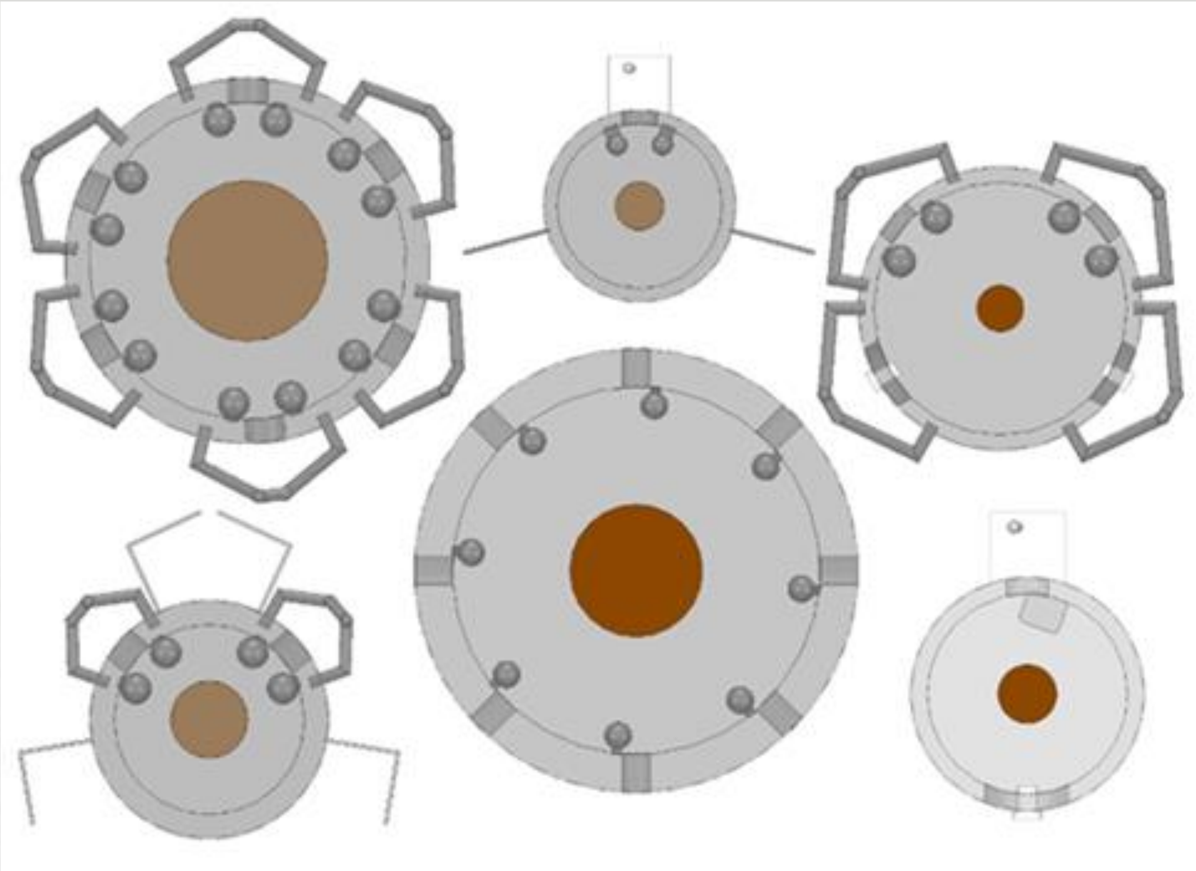
- Less lead time
- Reduced non-recurring engineering cost
- High level of confidence in measurements

Software Single Layer Data Process - Overview

- Review antenna specifications
- Choose appropriate HFSS computer model from library
- Set all variables to desired values
- Azimuth pattern and axial ratio development
- Determine characteristic data matrix
- Extract specific design using proprietary software

HFSS Computer Model Set-Up

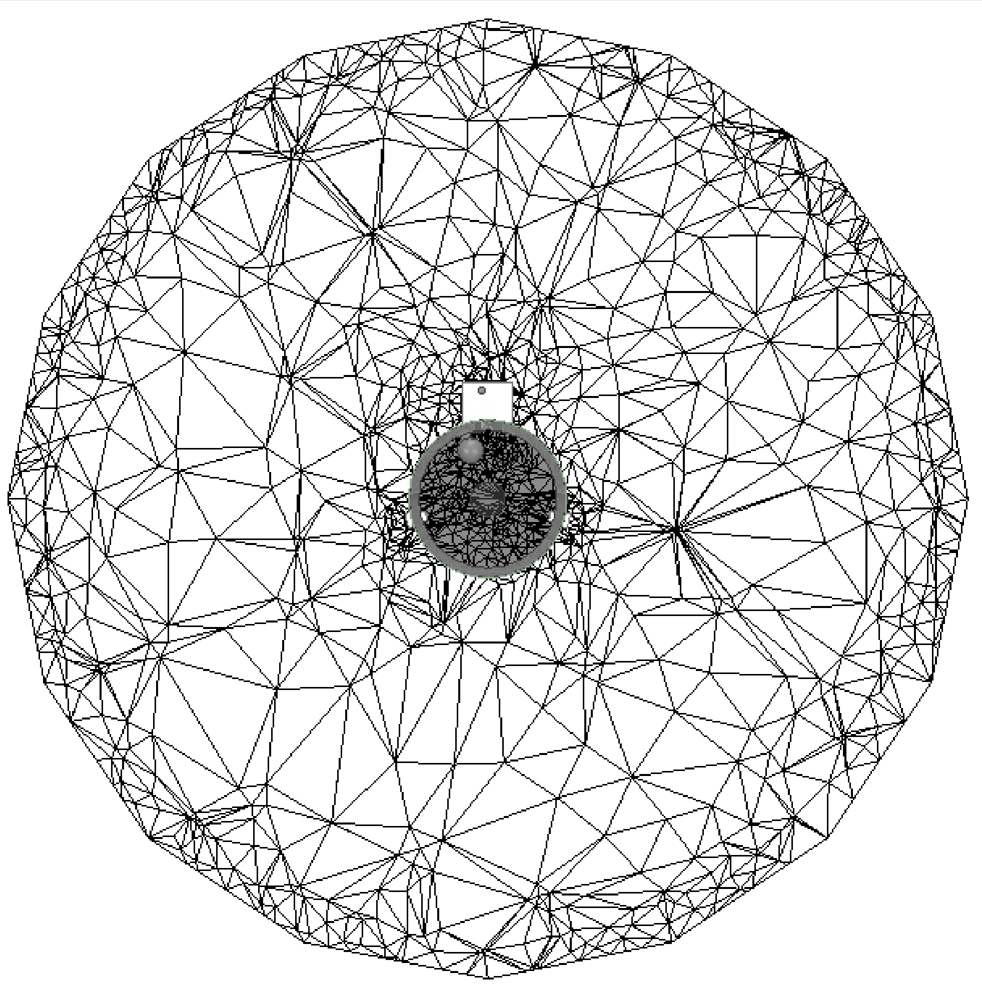




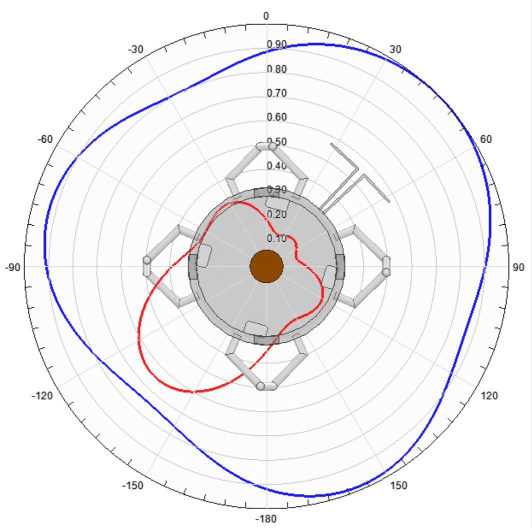
HFSS Computer Model Analysis

- Model is broken down into a tetrahedral mesh

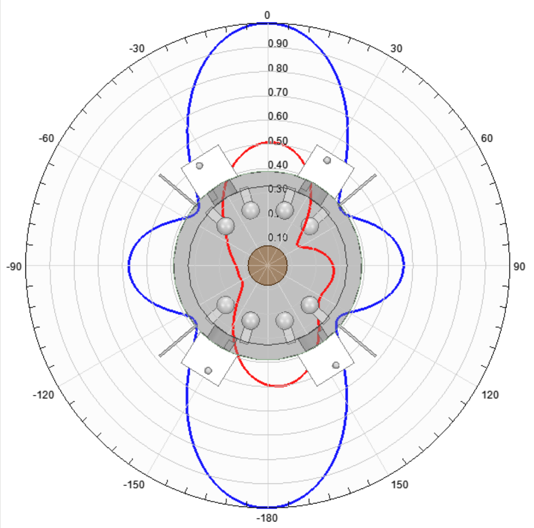
- Maxwell's Equations solved at each vertex

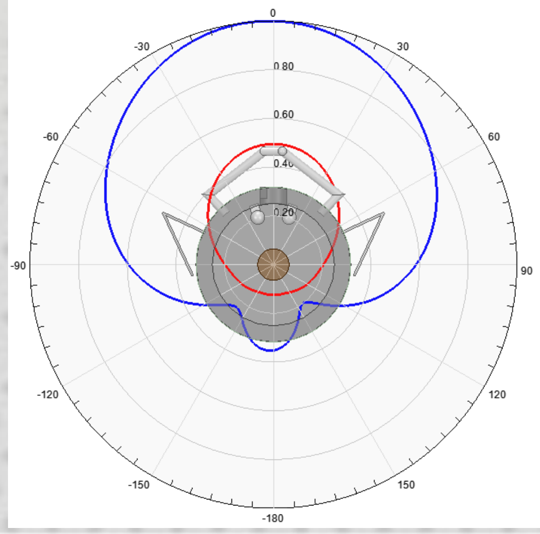


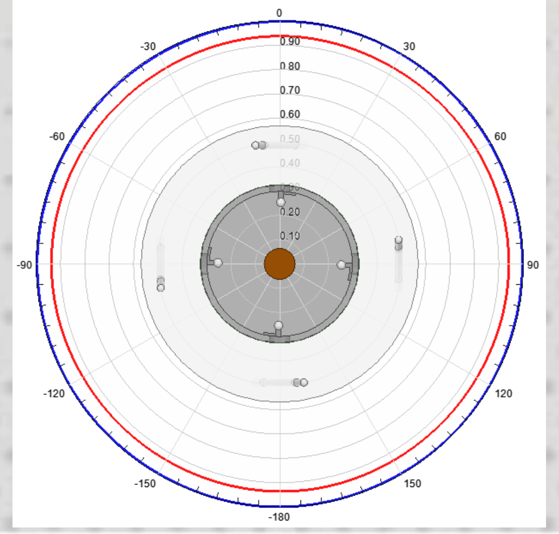
HFSS Azimuth Pattern Development

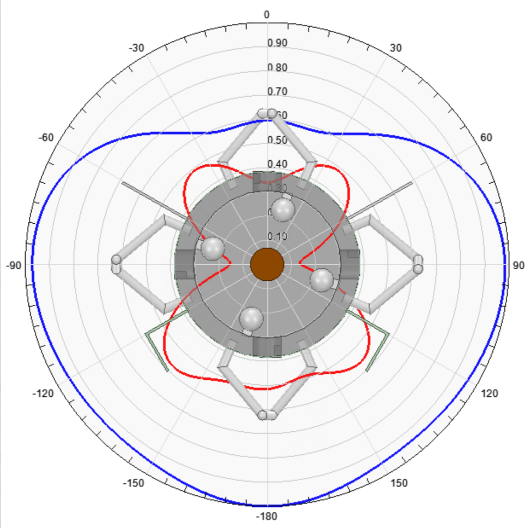


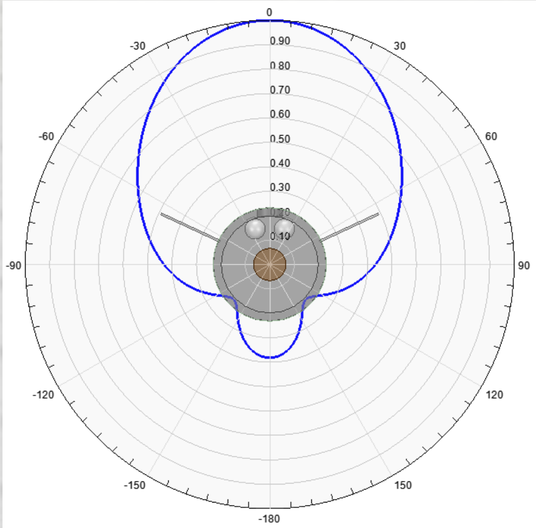
- Fins, directors, and other pattern shapers are used to adjust the shape of the horizontal component
- Floating or “Z” dipoles are used to adjust amount of vertical polarization and phase
- H/V ratio and axial ratio are set per specifications





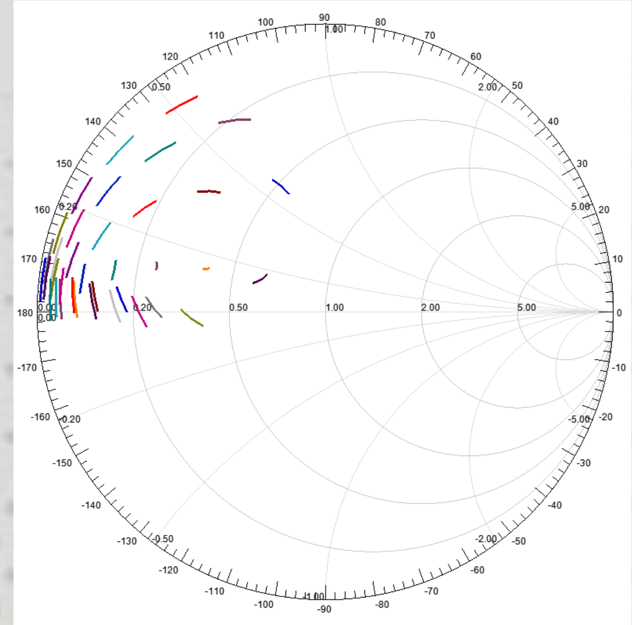


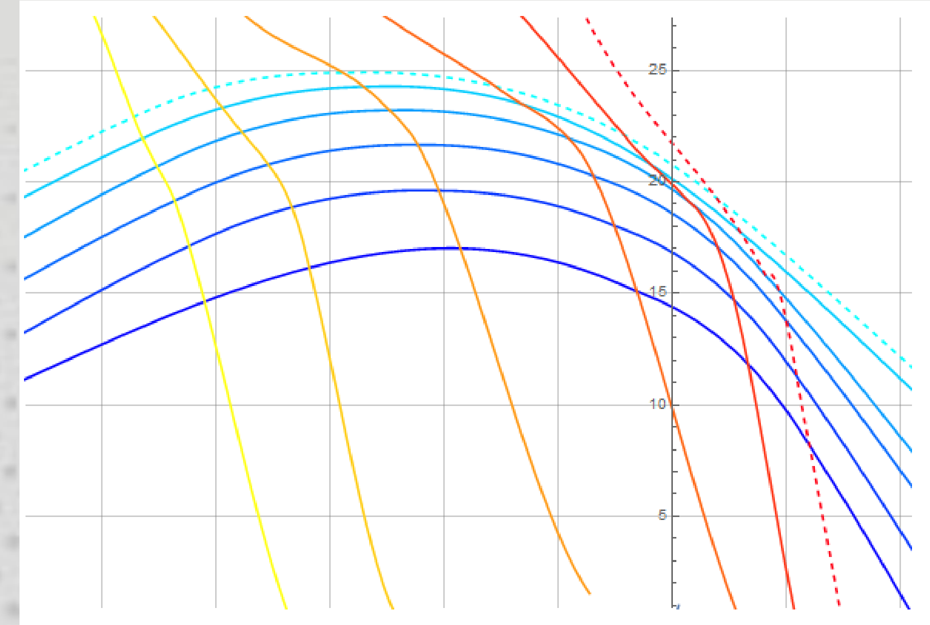


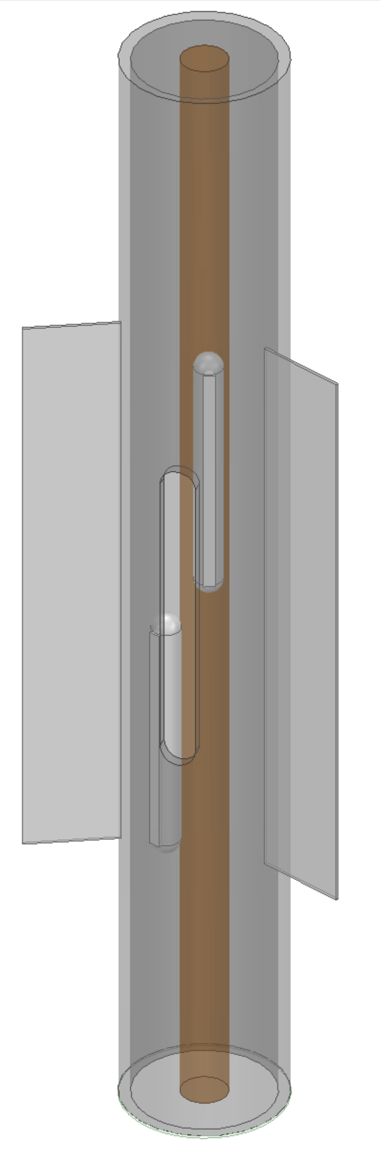


HFSS Characteristic Data Matrix

- Amount of coupling and slot length varied
- Solved at multiple frequencies across the channel band
- Desired amplitude and phase overlaid to extract a specific design







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- Efficiency: optimetric set-ups allow simultaneous designs

Post RePack Aplications

- Single Frequency Network (SFN)
  - Antenna development
  - Network planning

- Voltage analysis for ATSC 3
  - Planning for higher PAPR
  - Modify geometries in real time for higher power rating

Post RePack Applications

Single Frequency Network Planning

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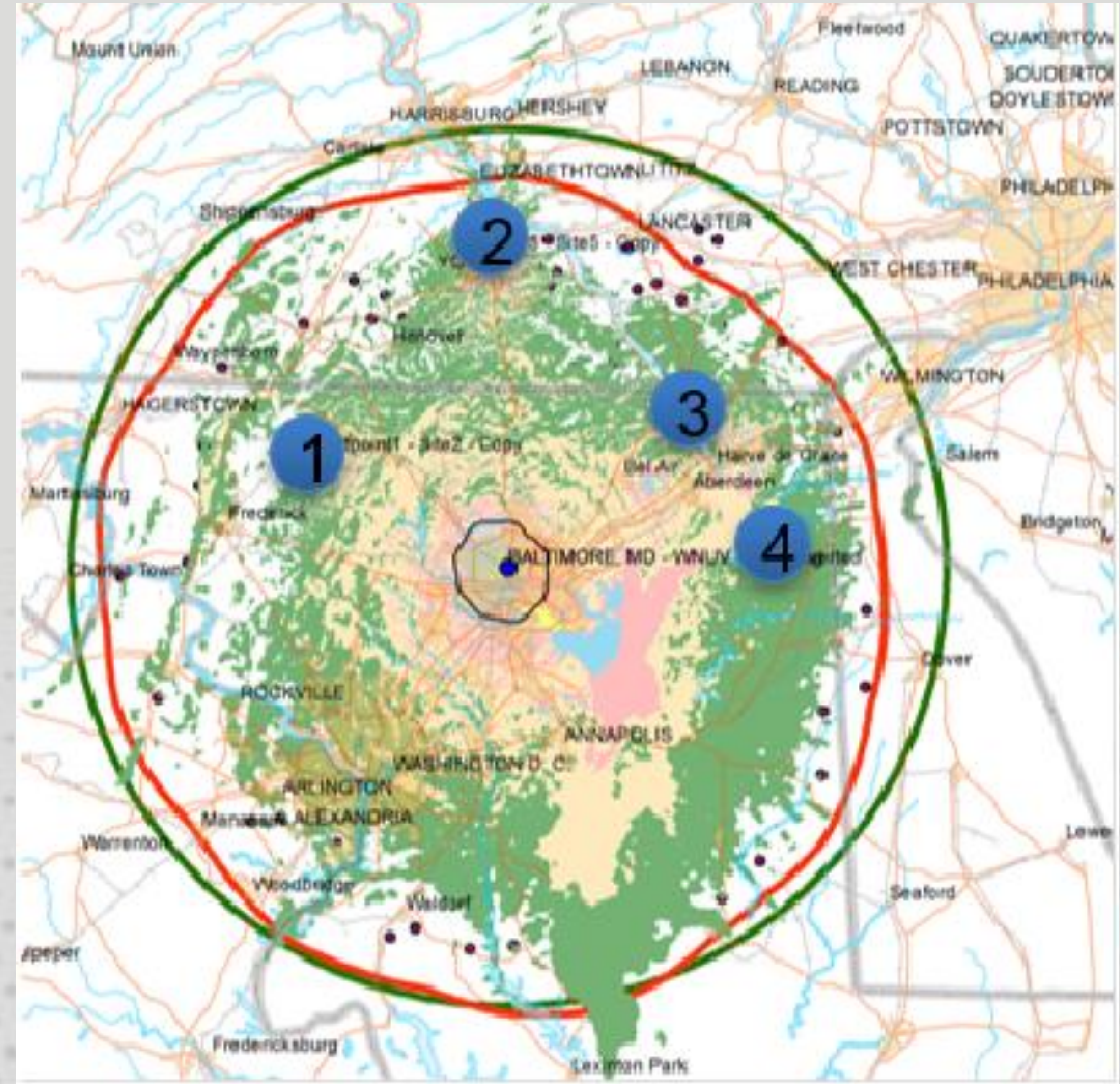
Single Frequency Network Planning



Single Frequency Network Planning

- Examine existing tower sites in the designated market area (DMA)

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- Reduce power in each direction until coverage and interference guidelines are met, creates “perfect” patterns

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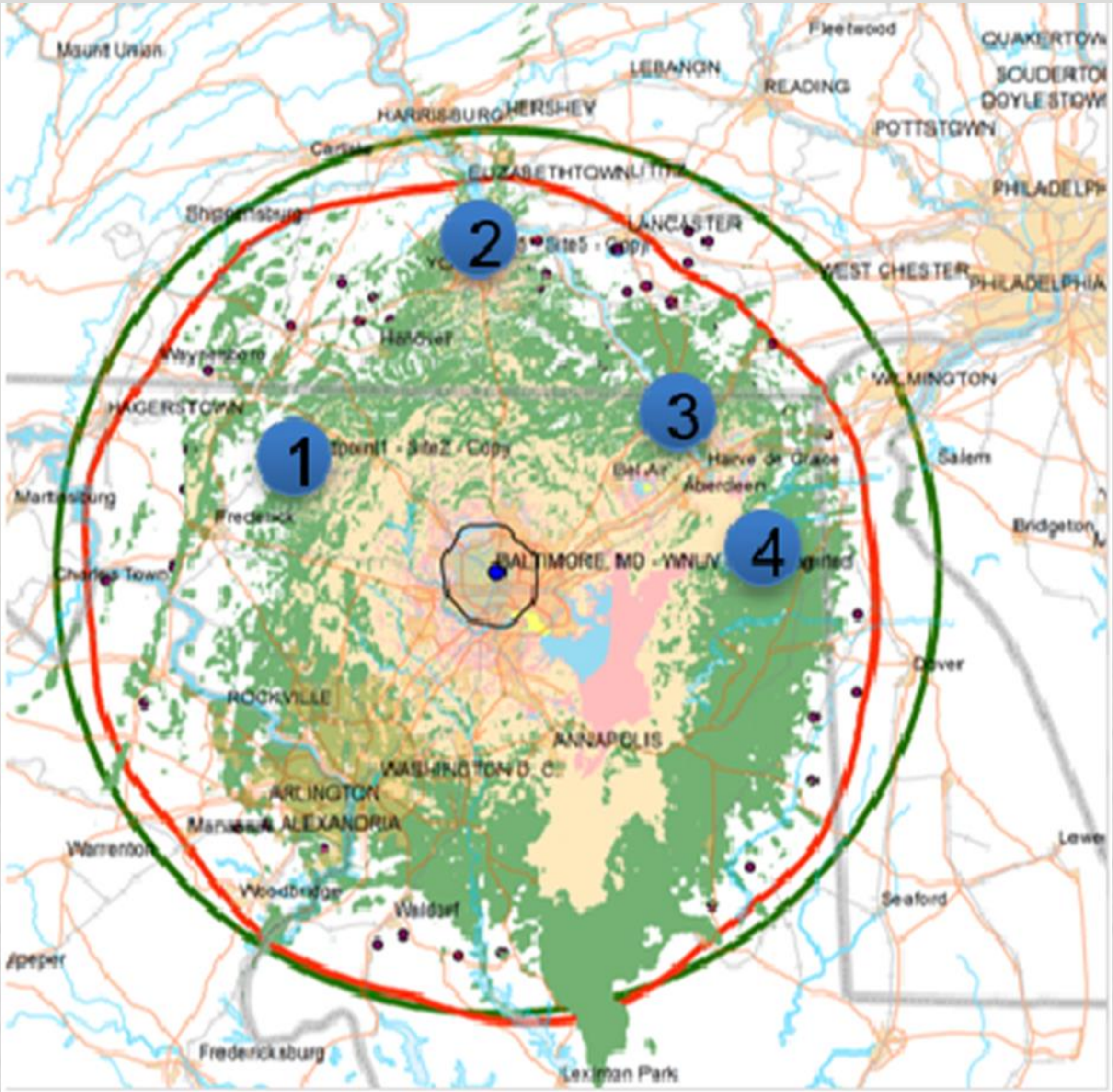

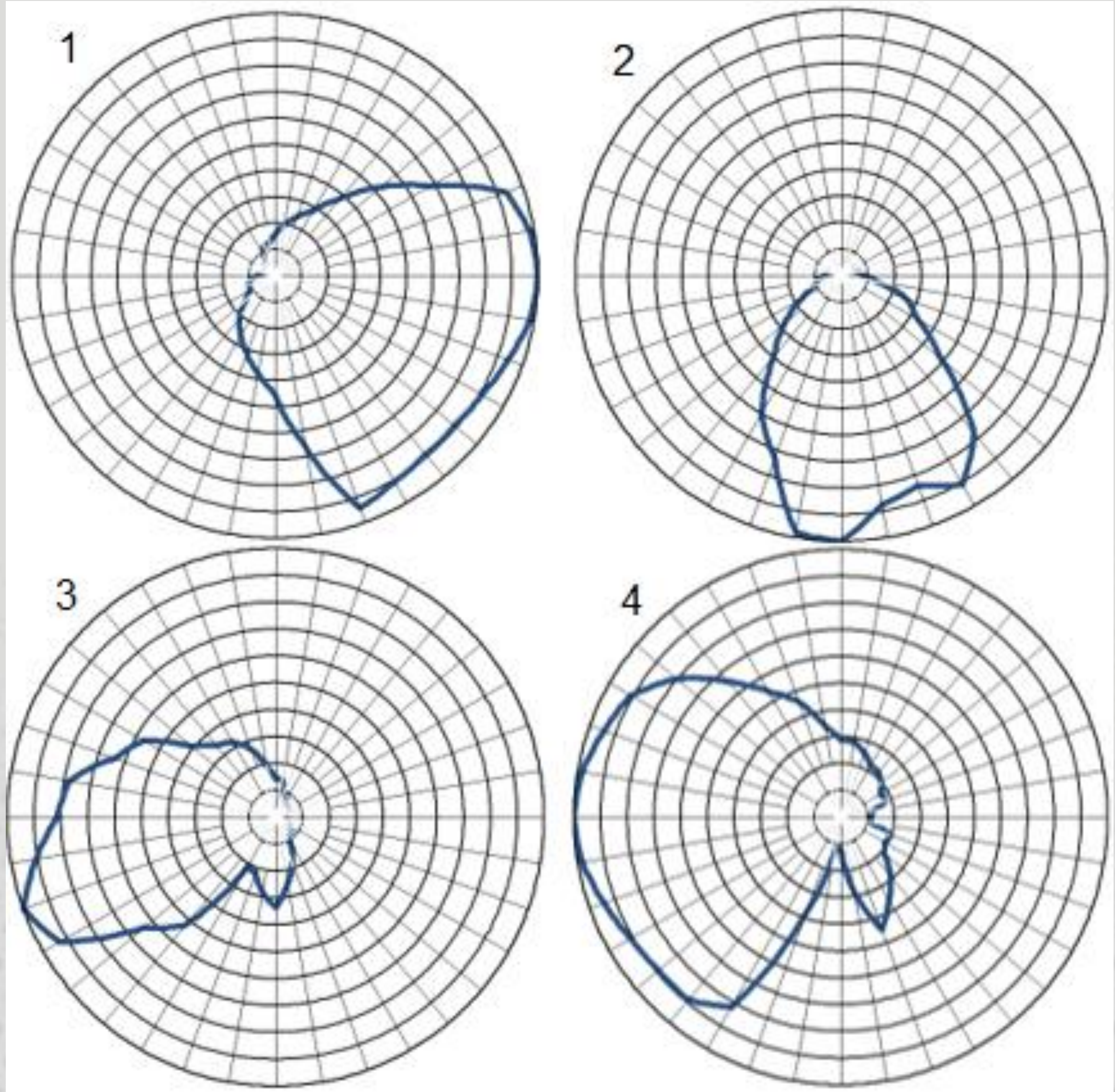

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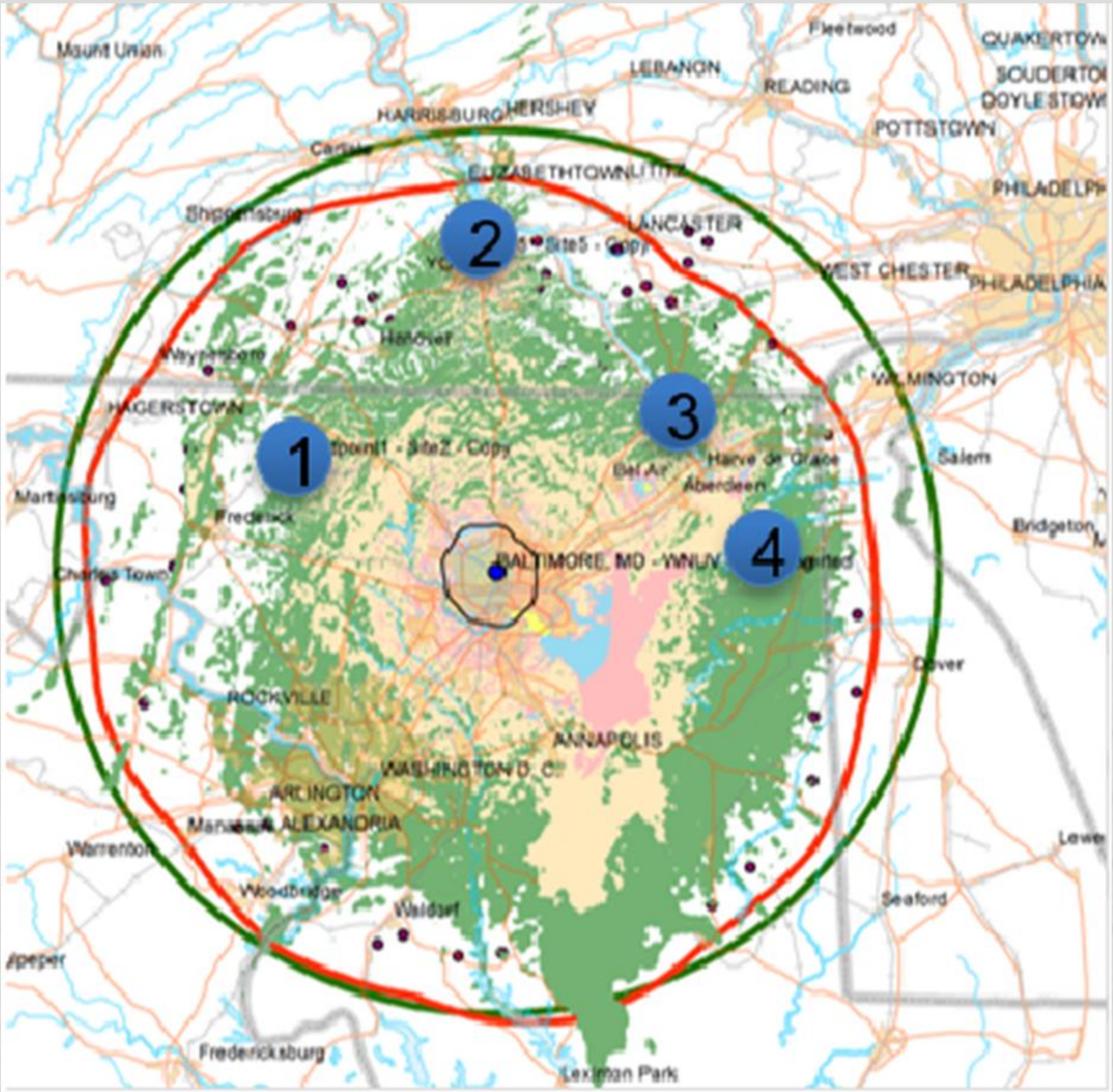

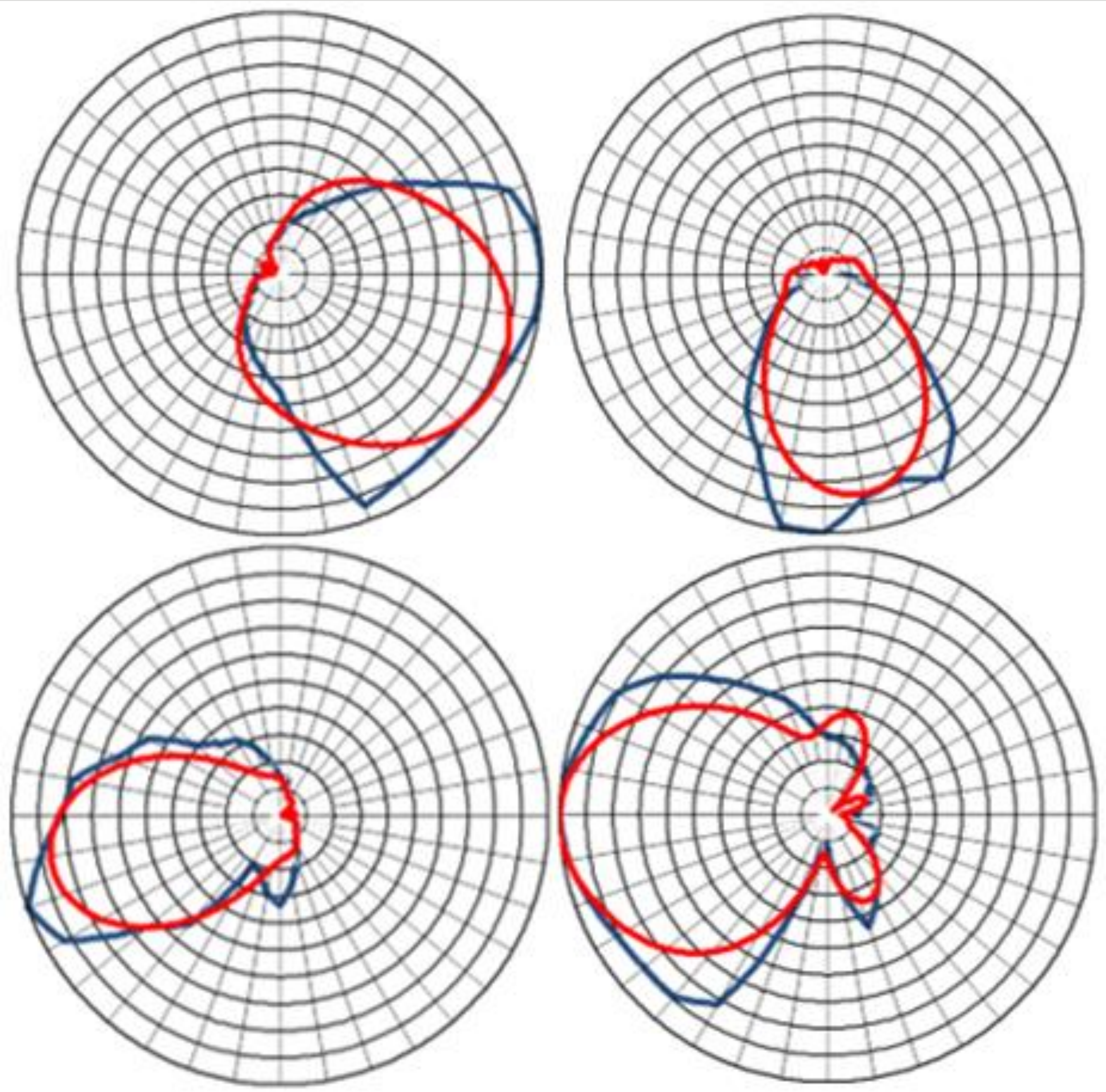

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- Examine existing tower sites in the designated market area (DMA)
- Choose desirable sites and apply omni directional antenna at each
- Reduce power in each direction until coverage and interference guidelines are met, creates “perfect” patterns
- Design antennas to approximately match each SFN pattern
- Apply “real” patterns to SFN
- Adjust patterns as needed

ATSC 3 Voltage Analysis

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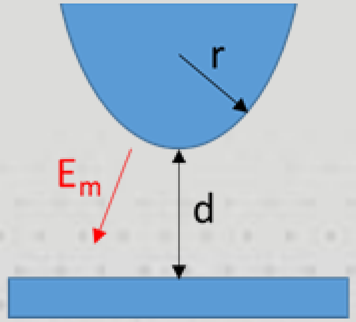
- ATSC 3 has higher PAPR, PAPR and peak voltage are related by:

$$V_p = \sqrt{2Z_0 P_{avg} PAPR_{Linear}}$$

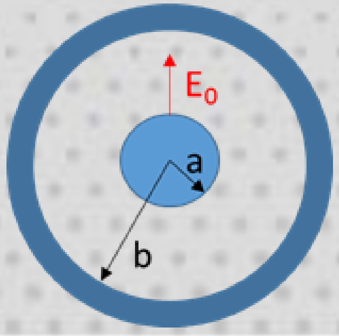
- Electric field near a conductor is inversely proportional to the radius of curvature

$$E_m \approx \frac{2V}{r\ ln\left(1+\frac{4d}{r}\right)}$$



- Sharp edges have greater potential for voltage breakdown
- Electric field in a coaxial line:

$$E_0 = \frac{V}{a\left[\ln\left(\frac{b}{a}\right)\right]}$$



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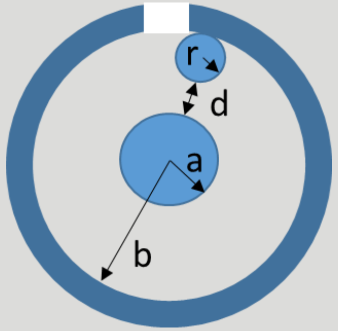
ATSC 3 Voltage Analysis

- Breakdown between coupler and inner in a slotted coaxial antenna:

$$V_b = \frac{E_m}{E_0} = \frac{2a\left[ln\left(\frac{b}{a}\right)\right]}{r\left[ln\left(1+\frac{4d}{r}\right)\right]}$$



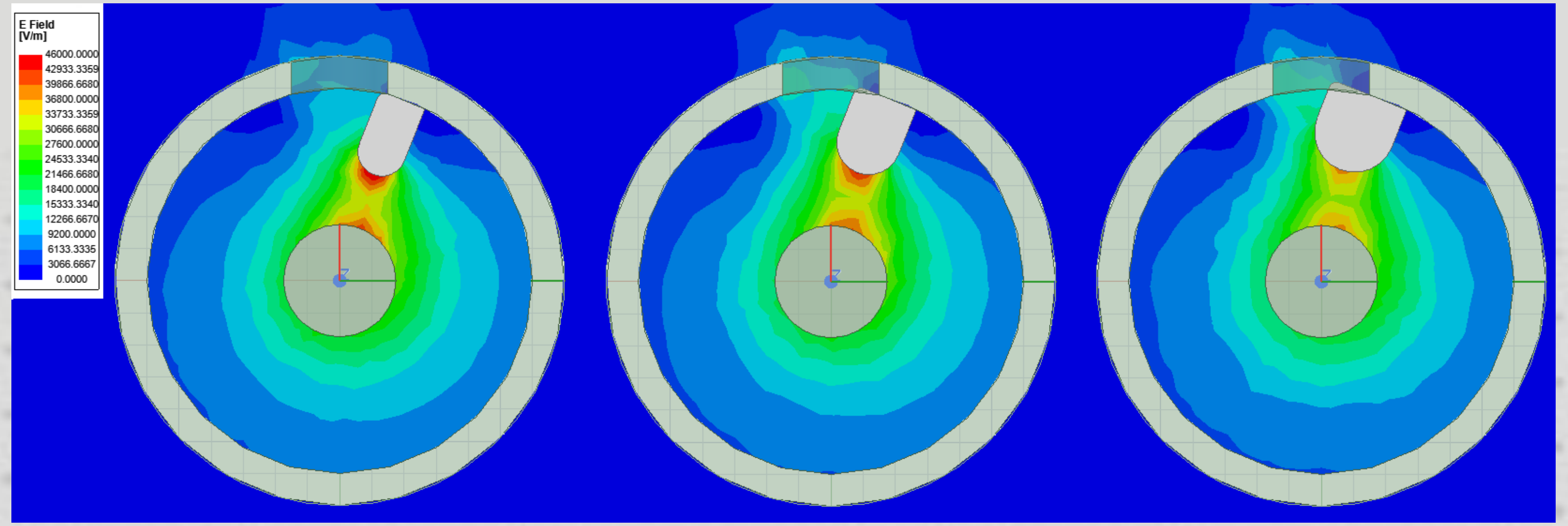
- PAPR and voltage breakdown are related:

$$PAPR = \frac{{V_b}^2 {F_V}^2}{2n^2 SF^2 Z_0 P_{avg} {C_{vswr}}^2}$$

- Therefore: internal antenna geometry becomes increasingly important with higher PAPR

ATSC 3 Voltage Analysis

- Need to understand where high voltage areas exist within the antenna
- Adjust antenna geometry to reduce high voltage areas (increase breakdown voltage)



- Use this design process to create true ATSC 3 ready products

Summary

- Design techniques remain the same, dating back to RCA developed process
- Single layer Data process adapted for HFSS software
    - Reduced lead time
    - Customizable antenna designs
    - Increases accuracy and efficiency
- Process can be utilized further
    - Plan, design, and optimize SFN sites
    - Examine ATSC 3 voltage breakdown for higher PAPR
- Future of broadcast depends on continuous advancement

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