Modeling Antennas with CREATE-RF's SENTRi Application

CREATE RF

SENTRi

DOD HPC MODERNIZATION PROGRAM

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CREATE-RF Requirement Summary

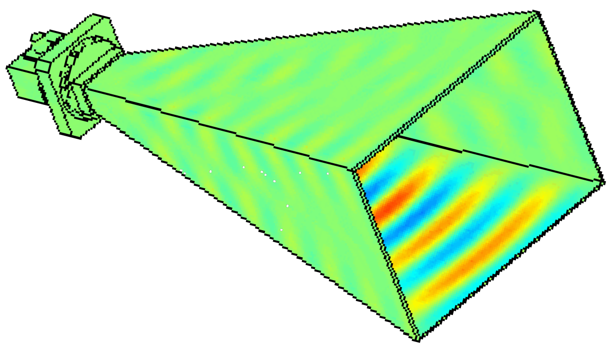
- **Antennas on Air, Sea, Ground, and Space Platforms**
- **Communication, Navigation, Surveillance, Target Recognition, Electronic Attack, Countermeasure, Observables, etc.**

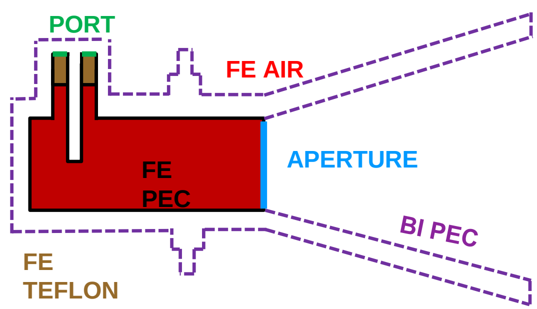
Computational Electromagnetics Applies to Almost All DoD Systems

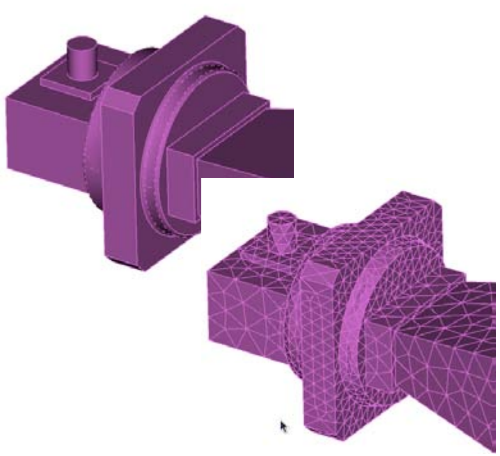
SENTRi

Scalable Engineering Tool for RF Integration

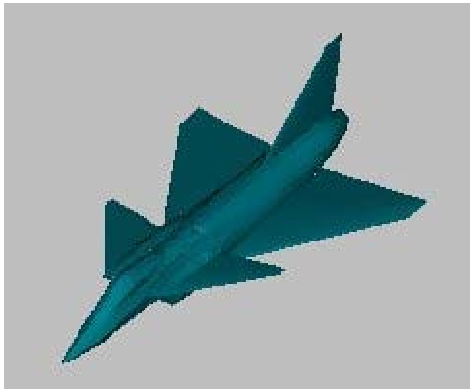
- **Full-wave analysis code for high-fidelity solutions**
- **Targeted for use by design engineers: user-intensive CAD and mesh generation requirements kept to a minimum**
- **Models complex material configurations, complex shapes, multi-scale geometries**
- **Combines the finite element and boundary integral numerical methods for a robust analysis system**







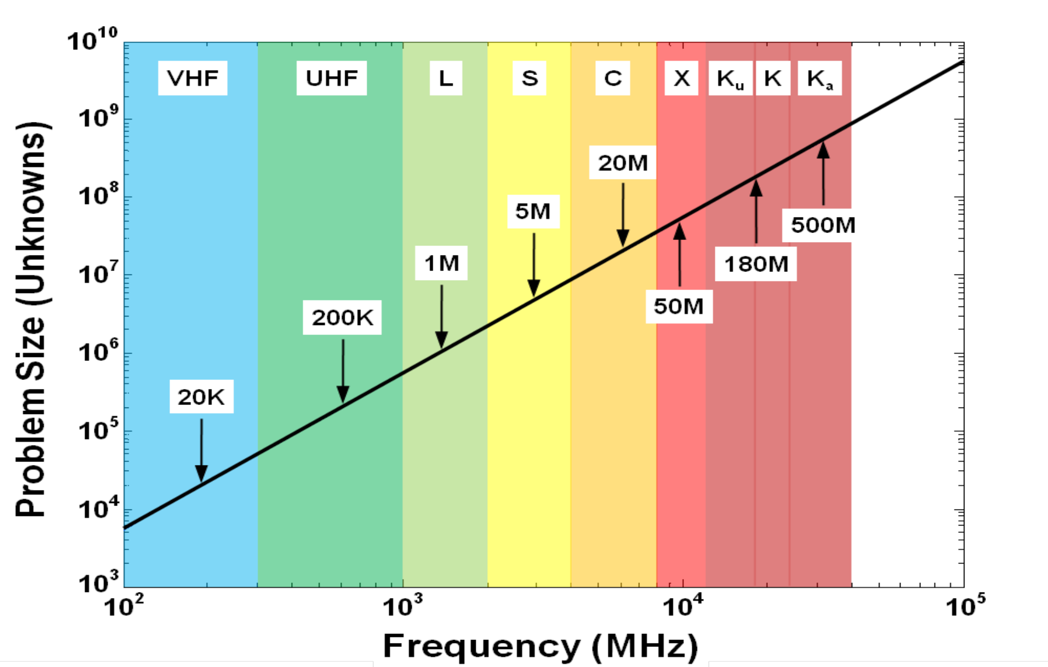
Unique CREATE-RF Requirements



	VHF	X-Band
Frequency	200 MHz	10 GHz
Wavelength [λ]	1.5 meters	0.03 meters
Aircraft Surface Area	200 λ^2	500,000 λ^2

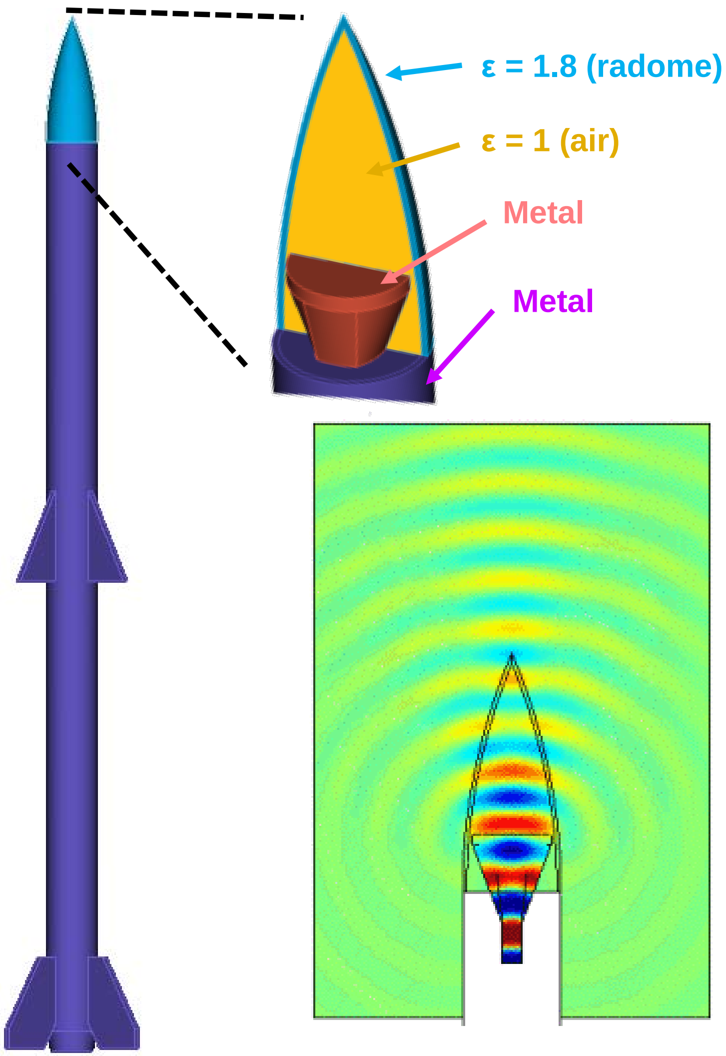
- **Length = 15.5 m**
- **Width = 8.9 m**
- **Height = 4.1 m**

- **100 MHz to 40 GHz**
- **100 unknowns per λ^2**



Source: Riverside Research Institute

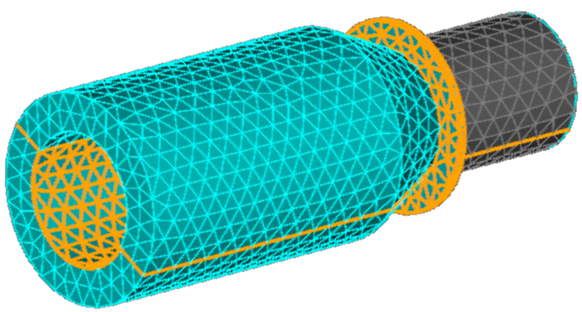
Finite Element – Boundary Integral (FE-BI) Method

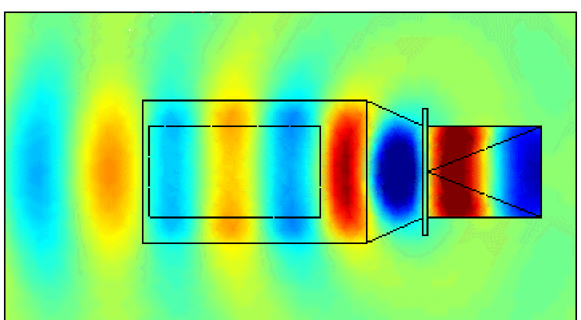


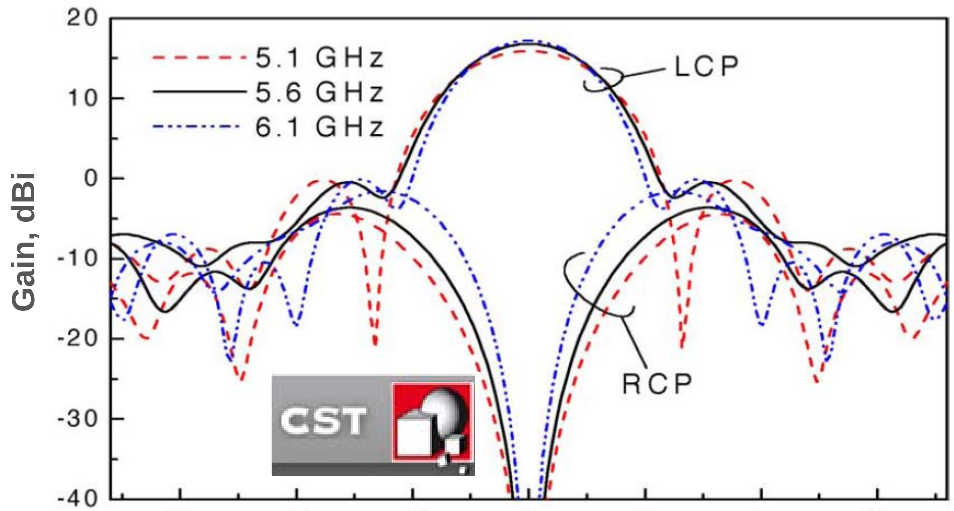
- Antennas, radome, and air inside radome is volume meshed for FE region
- Non-penetrable metal surfaces of fuselage are surfaced meshed for BI region
- Exterior BI surface can also be an Impedance Boundary Condition - approximation of a thin material treatment

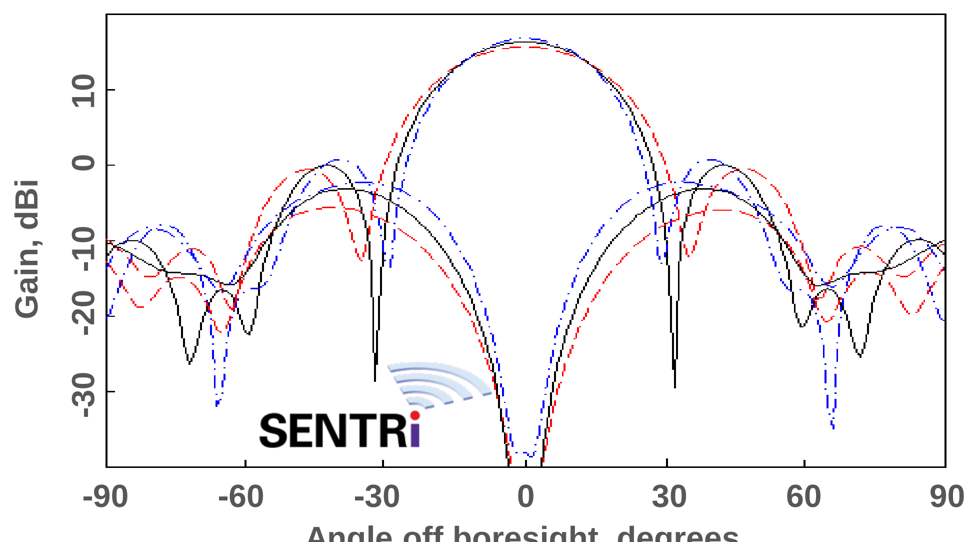
Compact dielectric rod antenna.

All exposed dielectric (aperture BC). Yields 100K/20K FE/BI unknowns.



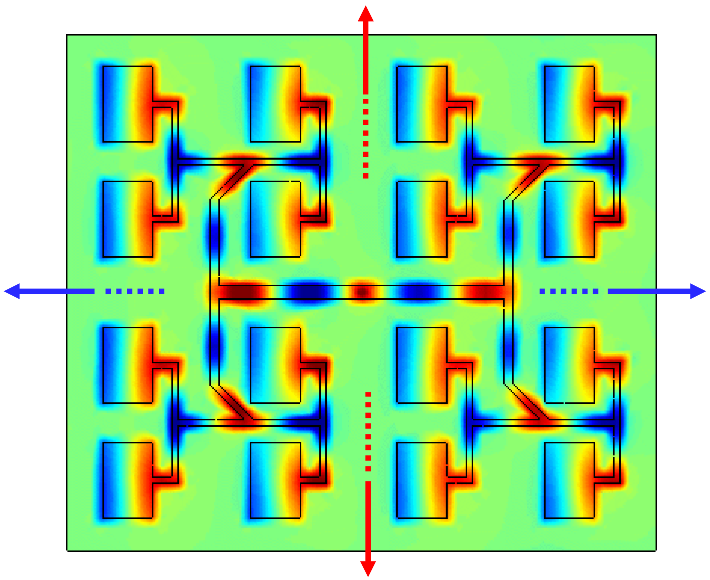


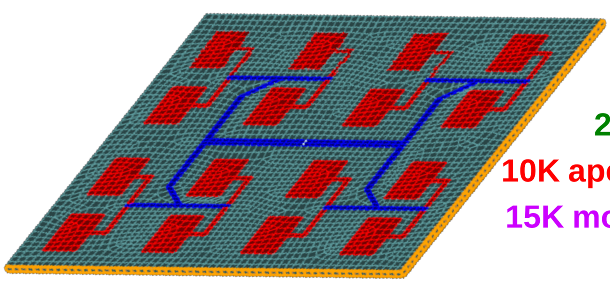




Validate ACA-enabled outward solver.

Patch array with corporate microstrip feed. Driven at center by one wireport.

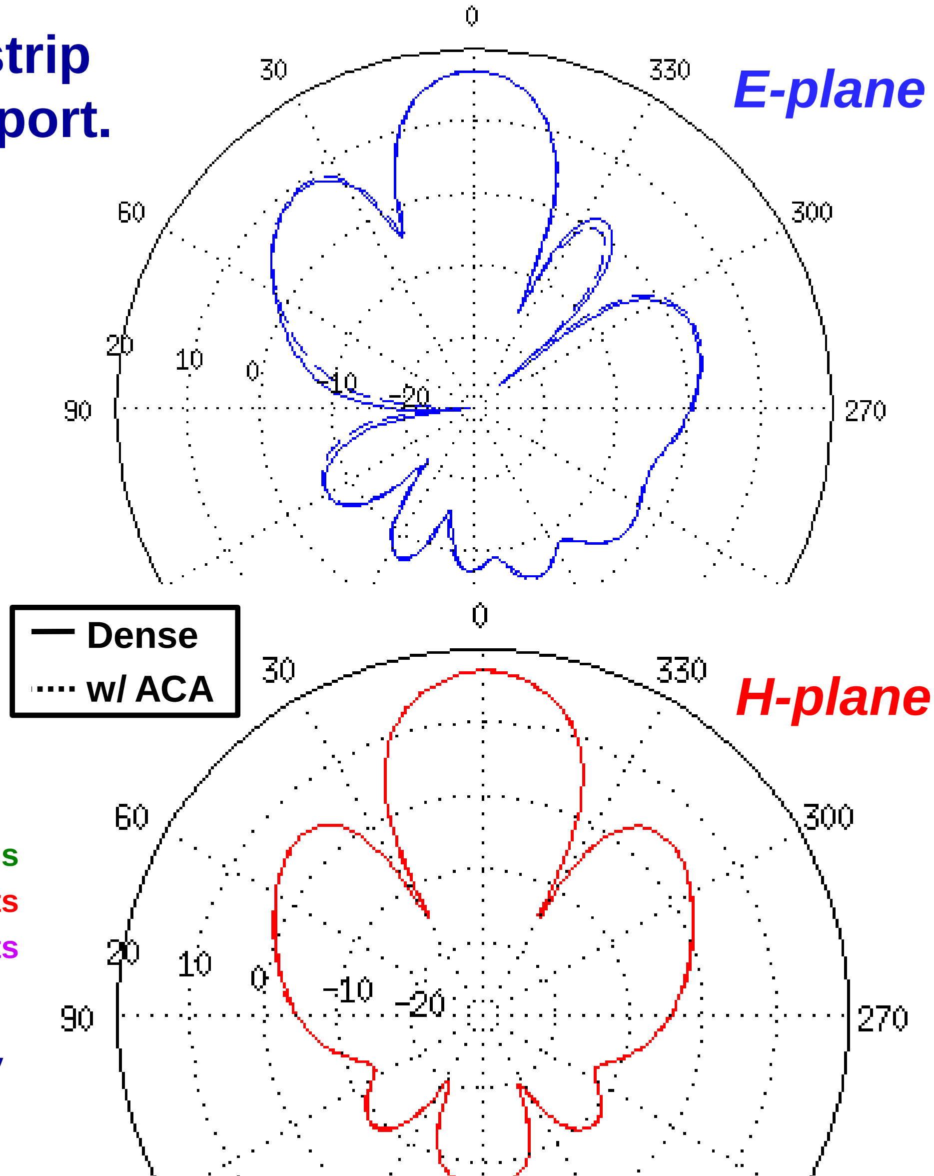




24K FE unknowns

10K aperture M-currents

15K moldline J-currents



ACA-enabled solution essentially overlaid with non-ACA solution.

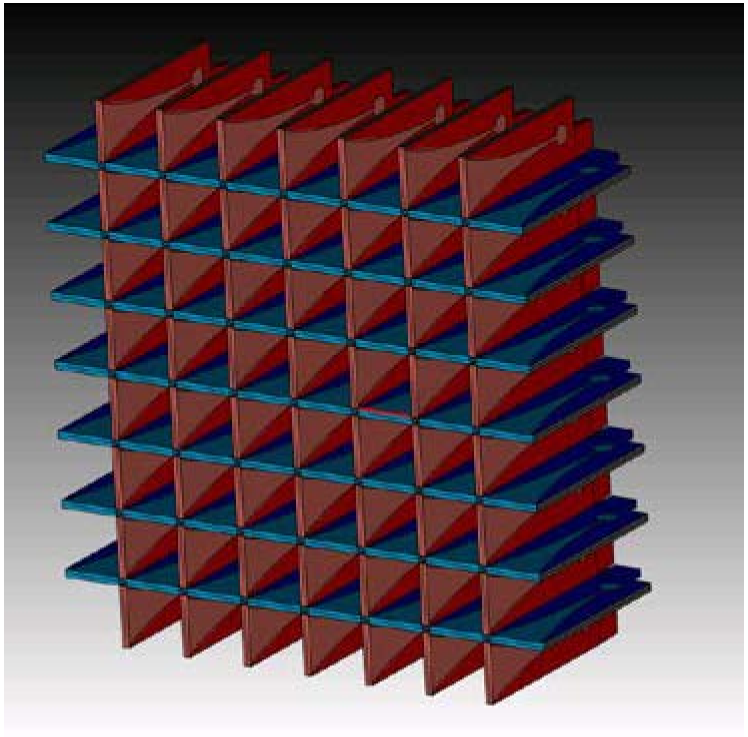
Finite Element – Boundary Integral (FE-BI) Method

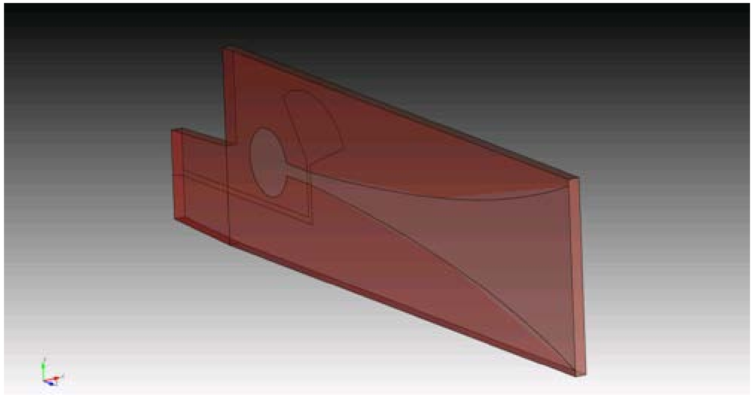
- High-order, curvilinear elements; all shapes (except pyramid) → brick and prism shaped elements are very efficient at modeling thin material layers; tetrahedral elements for automatic mesh generators
- Calculates all antenna parameters (gain, input impedance, power loss, …)
- Lumped L,R,C elements
- Matched waveguide ports for antenna excitation → standard ports (e.g. coax, TE, TEM) plus arbitrary shaped ports calculated by eigenvalue solver
- Extensive documentation, tutorials, example problems
- GUI application for pre- and post-processing; runs on 64-bit Linux and Windows
- Version 3.0 released

Example Problem:

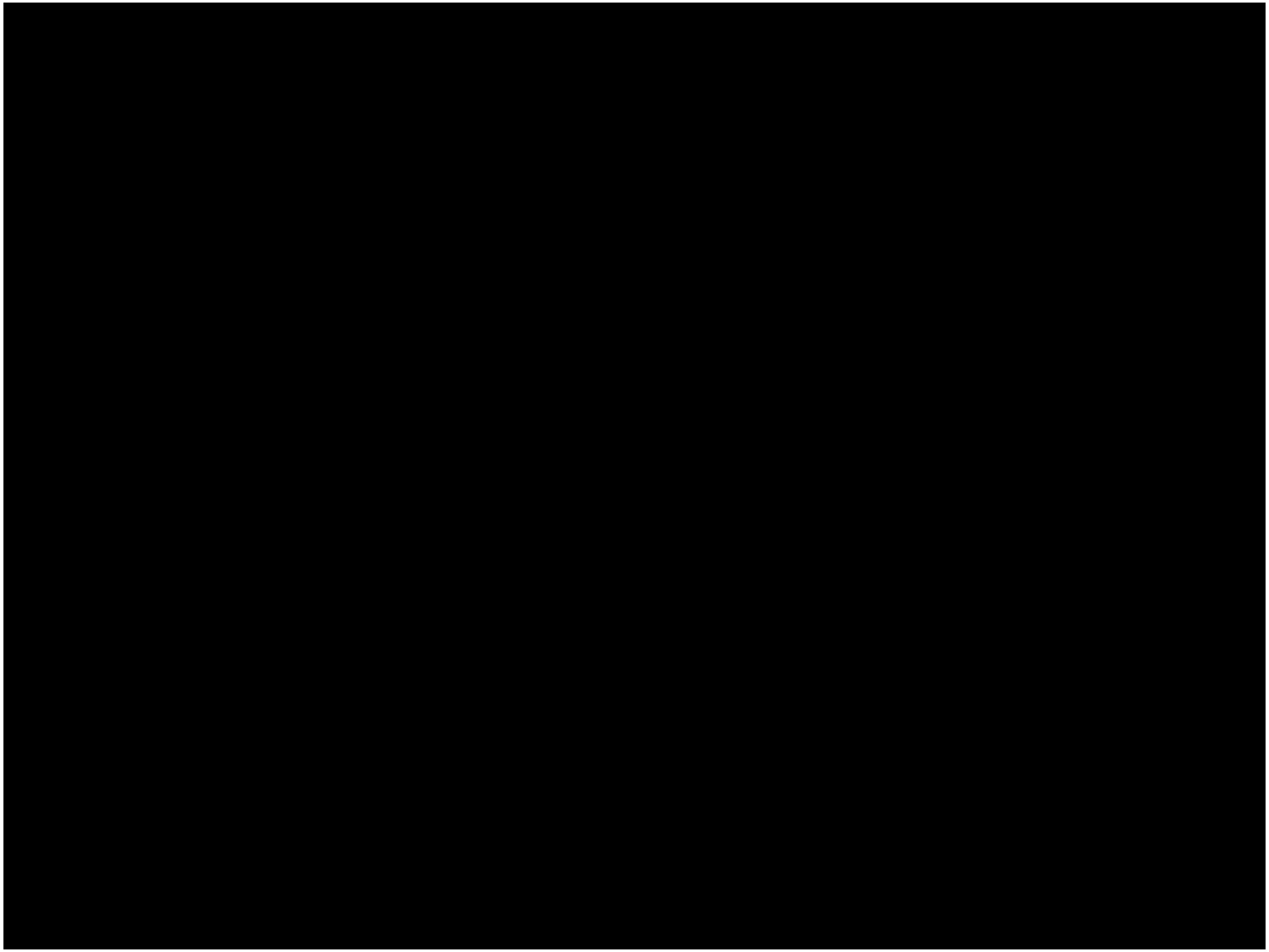
8x8 dual polarized phased array antenna

Antennas: strip-line Vivaldi notch printed circuit

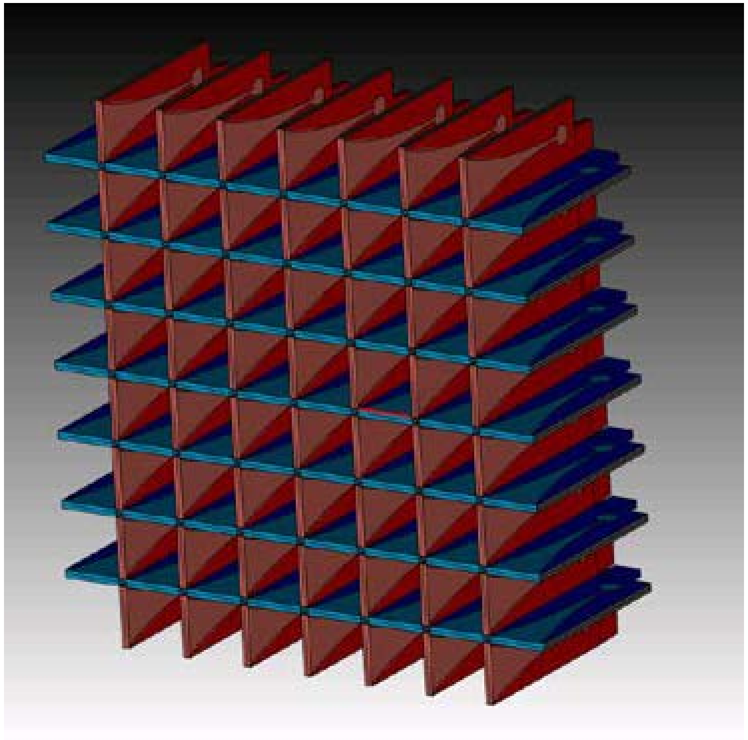




8x8 Dual Polarized Phased Array Antenna



Reducing User Burden



Geometry was straightforward to build: make one antenna, copy and paste 127 times

Challenging: amplitude and phase variation across 128 elements → python scripts

Where we are going

- Higher frequencies → currently at 2M unknowns, need to get to 100+M
  - Incorporating advanced numerical methods on HPC resources
- Continuously tailoring the code for design work
  - Reducing user-burden while increasing high-fidelity modeling
  - Use of optimization, automatic design-space exploration
  - Multi-discipline design
- Distribution to government agencies and defense contractors
  - Training and support infrastructure
- Build-up of CREATE-RF & AFRL Computational Electromagnetic Group and Resources
  - Consulting contracts with Professors in CEM

Weapon Systems Analysis

Operational Requirements

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Technical Specifications

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Identify Risks in Proposed Solutions to Meet Technical Specification

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Evaluate Performance of Technical Solution

Computer Aided Engineering provides:

- Faster evaluation than ‘build and test’
- Ability to explore larger design space
- Insight to unknown, unrealized effects
- Communication & design validation between gov’t and contractors
- Closer multi-discipline design