High Performance Computing Modernization Program

Computational Research and Engineering Acquisition Tools and Environments (CREATE)

CREATE-RF Status

National Defense Industrial Association
June 21, 2011

CREATE RF

Distribution A: Approved for public release; distribution is unlimited

Product: SENTRI

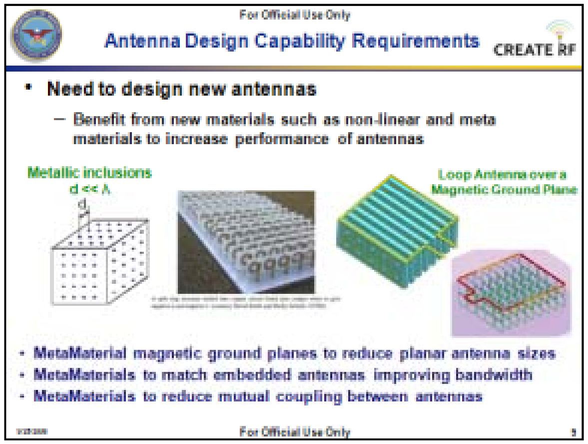
SENTRI – Scalable Engineering Tools for RF Integration

SENTRi

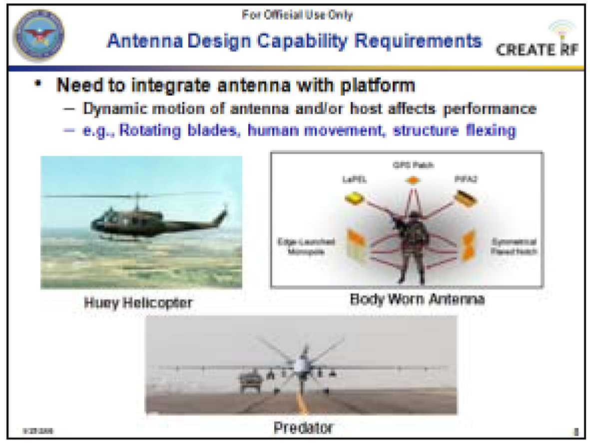
What it is:

- Computer Aided Engineering Software for DoD Electromagnetic Applications
- Designed for High Accuracy – Full Wave (non-optical) Numerical Methods
  - Finite Elements
  - Boundary Integral
  - Harmonic Expansions
- Designed for Extensibility, Maintainability, and Flexibility
  - Not All Electromagnetic Applications are the same
  - Need for Specific and Tailored Methods for Unique Applications
- Designed to Run on Wide Range of Computers
  - from Engineering Workstations to High Performance Computers

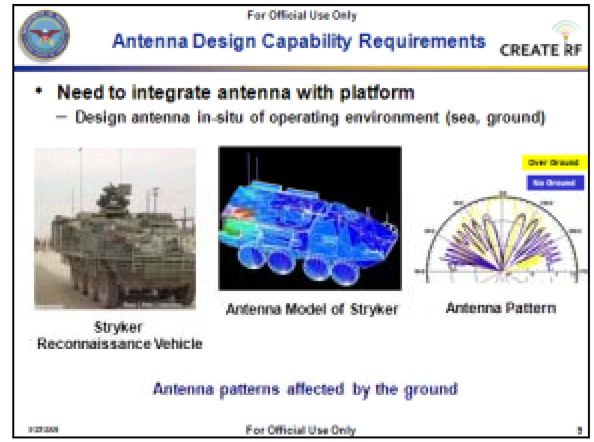
CREATE-RF Requirement Summary



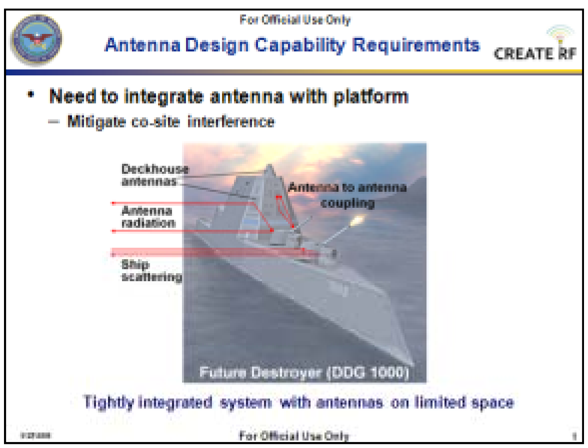
New antenna design



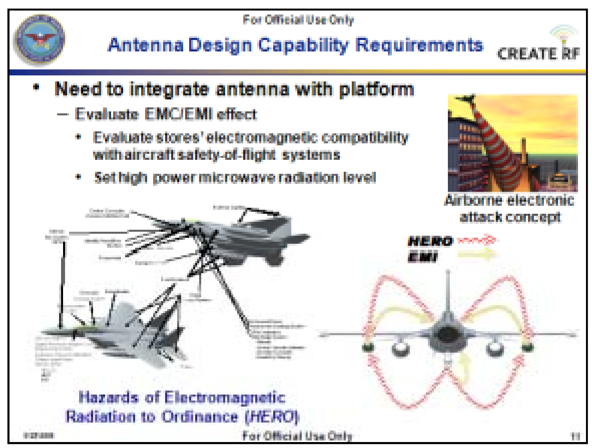
Dynamic geometry



Environmental effects



Co-Site interference



EMC/EMI assessment

Multiple disciplines

Computational Electromagnetics Applies to Almost All DoD Systems

Distribution A: Approved for public release; distribution is unlimited

Development Approach Background

Benefits to DoD Acquisition Community

‘First-Pass’ Designs

- Develop High-Fidelity Codes to Model All Design Variables Reducing Risk That Design Goals Will Not Be Met

Less Prototyping → Faster and More Productive Engineering

- Hardware Prototyping is Time Consuming, Expensive, Provides Little Insight to Physical Phenomena

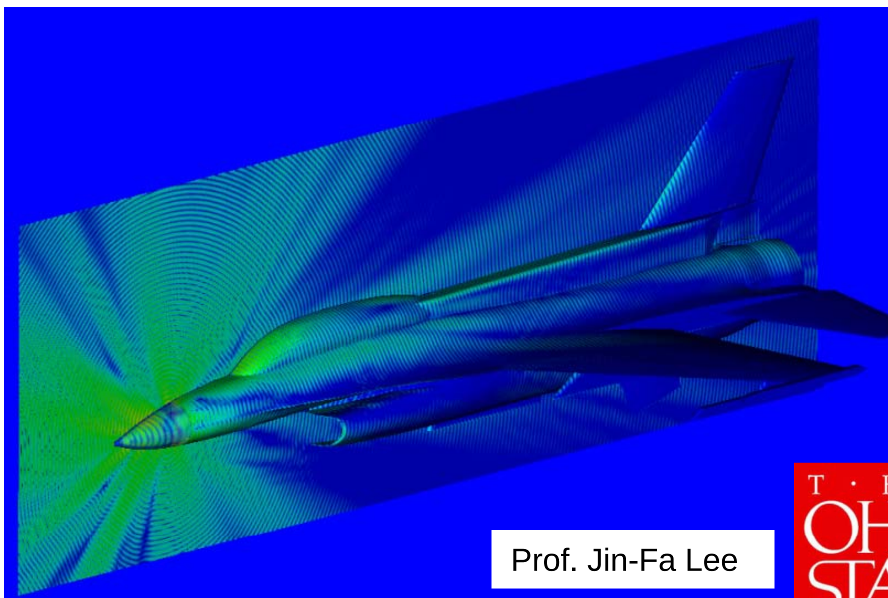
New Concept Designs → Higher Performance at Lower Cost

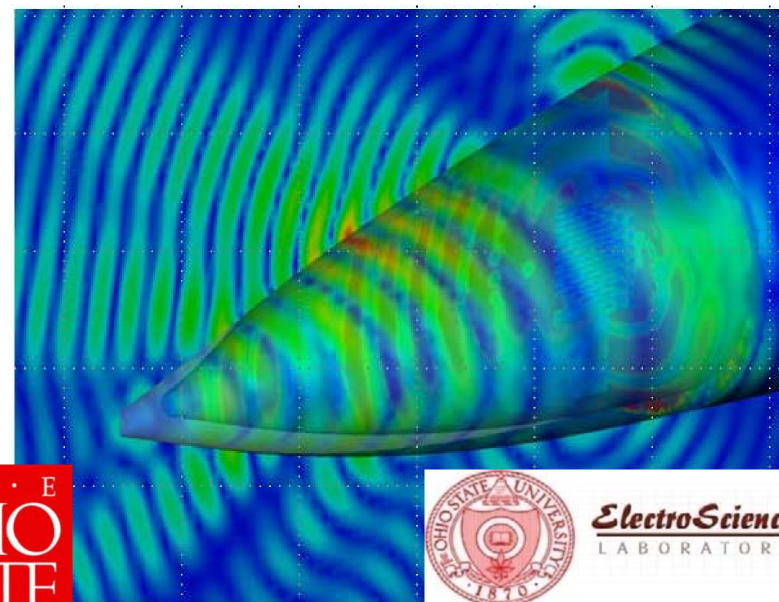
- Methods Allow for the Exploration of Entire Design Space
- Higher Performance Requires New Designs and Materials to be Explored

A Single DoD Vehicle can have More Than 100 Antenna Systems

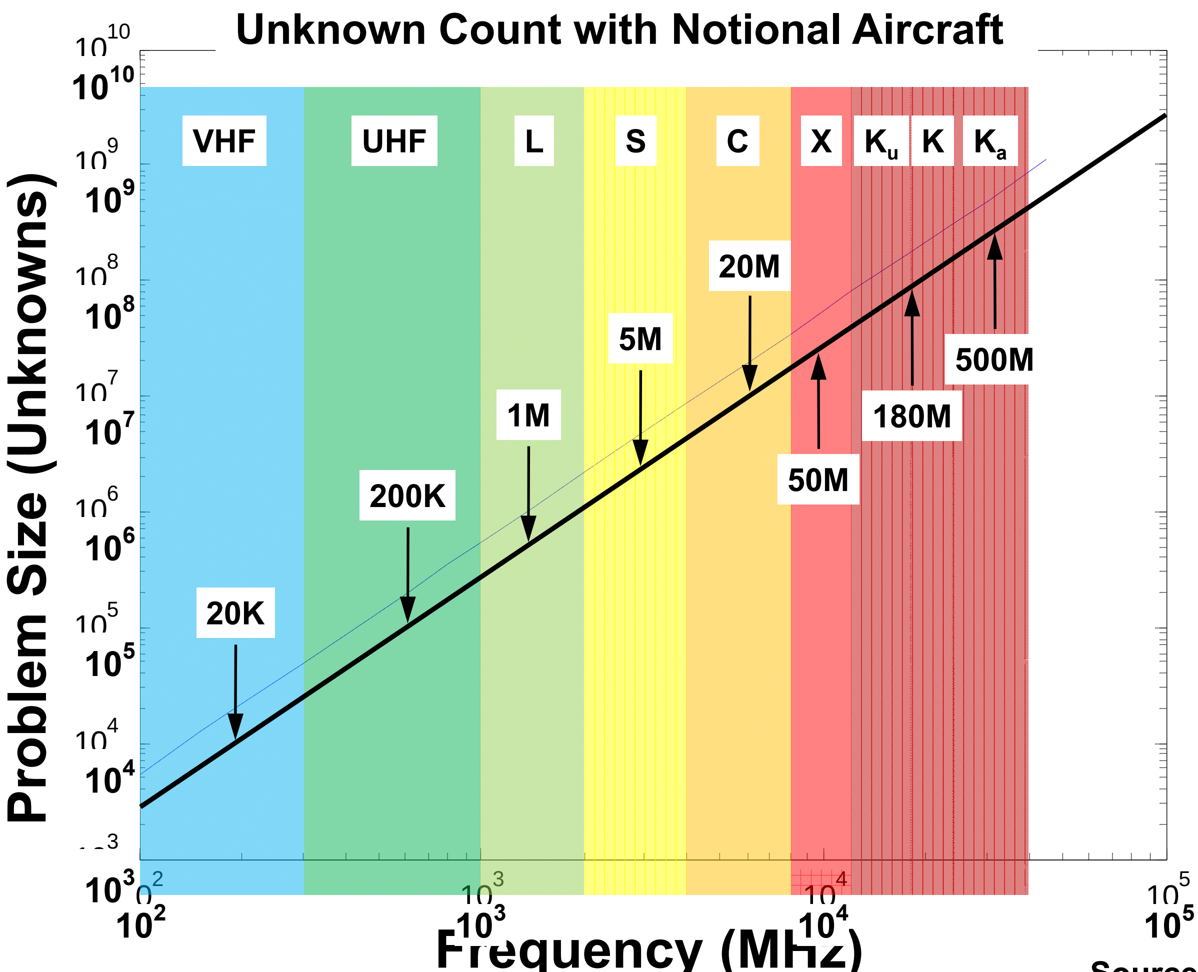
Challenge of Computational Electromagnetics

- Complex Geometries, Complex Material Application, Multi-Scale Geometries
- Computationally Expensive for Accurate Full-Wave Analysis
- Electromagnetic Phenomena (Singularities, Resonances, Wide-Band)





Challenge of Computational Electromagnetics



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

- 100 MHz to 40 GHz
- 10 samples/λ

Source: Riverside Research Institute

Development Approach

Product Roadmap

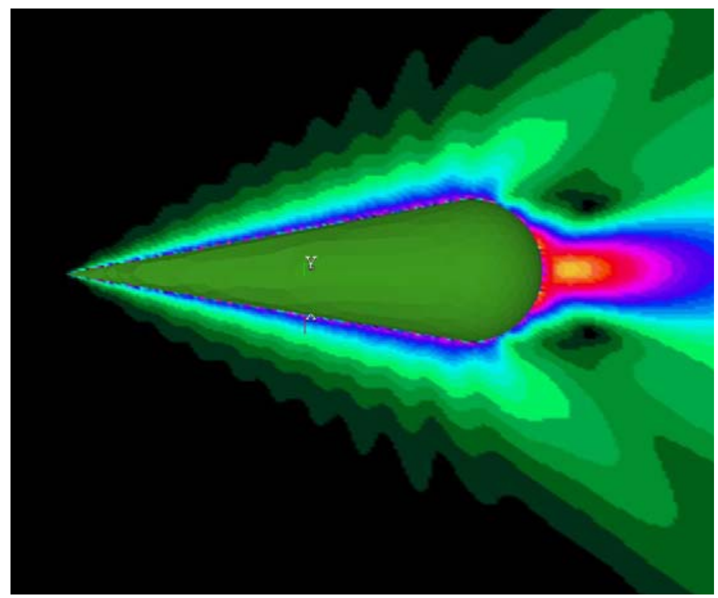
SENTRI at version 1.5

Antenna Modeling
- Patch, Notch, Horn, Spirals (Applications: Radar, Communication, GPS)
- Phased Array Antennas
- Cavity Backed Antenna (Approximate In-Situ Analysis)

Periodic Structures
- Frequency Selective Surfaces
- Circuit Analog Absorbers
- Metamaterials
- Infrared Filters / Absorbers

Microwave Circuits
- Power Splitting
- Material Measurement
- Filters
- Circulators

Radar Cross-Section Prediction



Development Approach

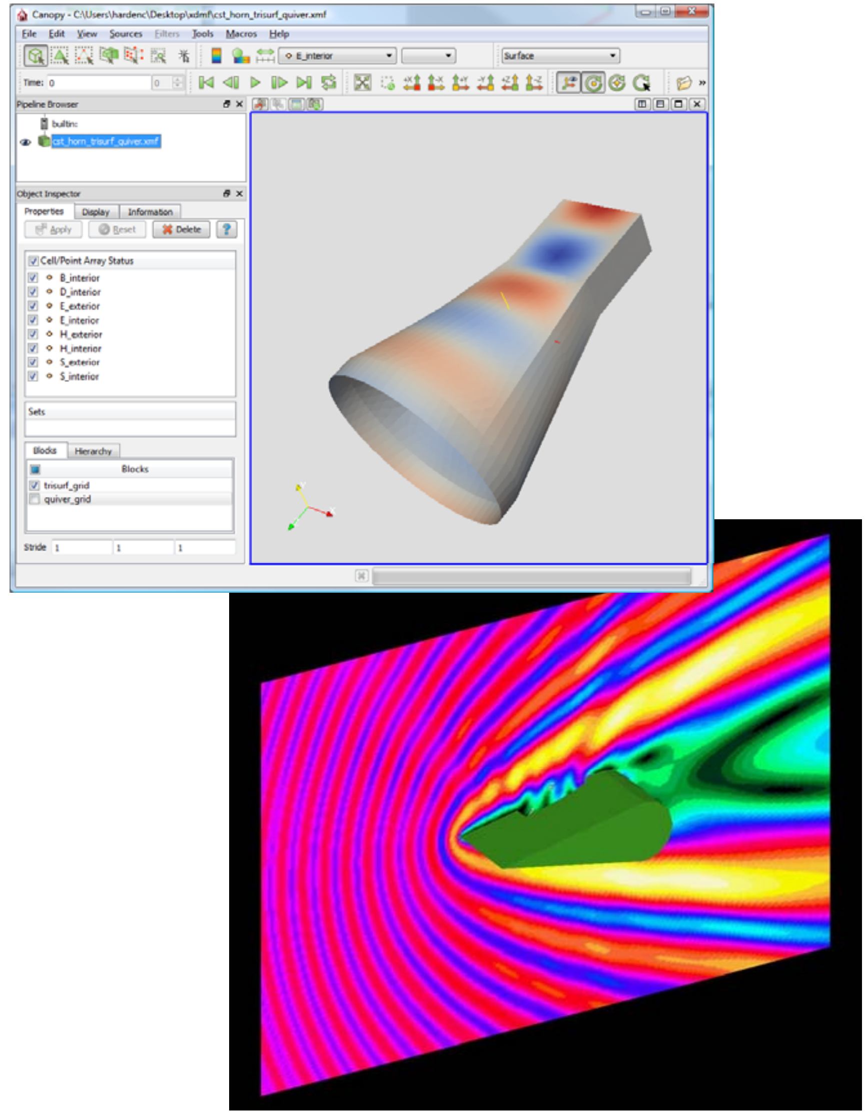
Product Roadmap

CREATE RF

Future Releases of SENTRI

Full End-to-End Analysis System

- Graphical User Interface
- Material Database
- Visualization of Solutions
- Analysis Traceability
- Optimization



Programmable System

- Software Release as a Application Programming Interface for Further Tailoring by End User

Development Approach

Development Strategy

CREATE RF

Rapid Design Codes

High Fidelity Codes

What Engineers Need for Their Design Work

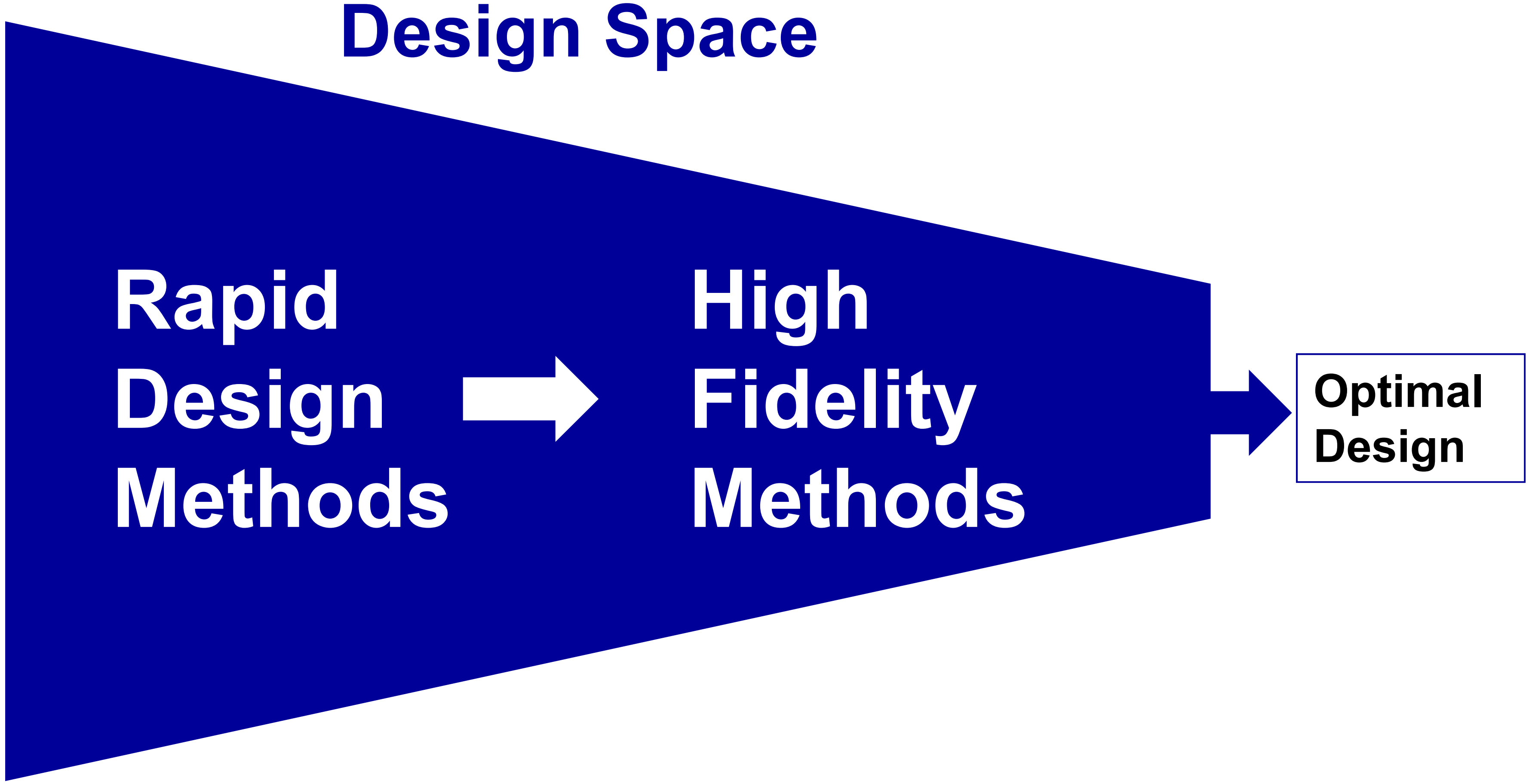
Design Optimization Techniques Integrated with Rapid Design / High-Fidelity Codes

Making Engineers Productive by Automating Design Tools

Specialized Codes for Particular Applications

Big Payoff – Solving Problems that Others Can't

Design Space



Rapid Design Methods → Narrow Design Space
High Fidelity Methods → Model All Variables, Optimal Design

Development Approach

Development Strategy

CREATE RF

Rapid Design Codes

High Fidelity Codes

What Engineers Need for Their Design Work

Design Optimization Techniques Integrated with Rapid Design / High-Fidelity Codes

Making Engineers Productive by Automating Design Tools

Specialized Codes for Particular Applications

Big Payoff – Solving Problems that Others Can't

Development Approach

Development Strategy

CREATE RF

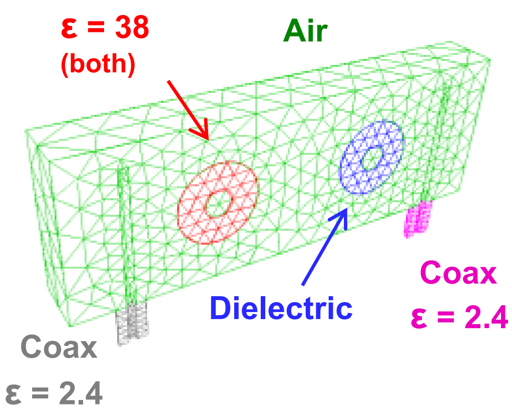
Rapid Design Codes; High Fidelity Codes	←	What Engineers Need for Their Design Work
Design Optimization Techniques Integrated with Rapid Design / High-Fidelity Codes	←	Making Engineers Productive by Automating Design Tools
Specialized Codes for Particular Applications	←	**Big Payoff → Solving Problems that Others Can't**

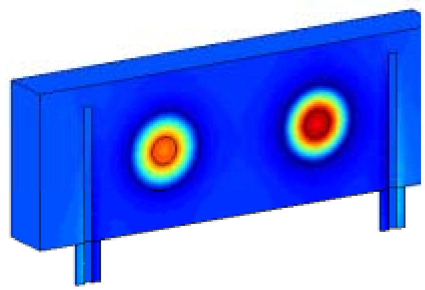
Application Examples

Microwave Circuit Analysis

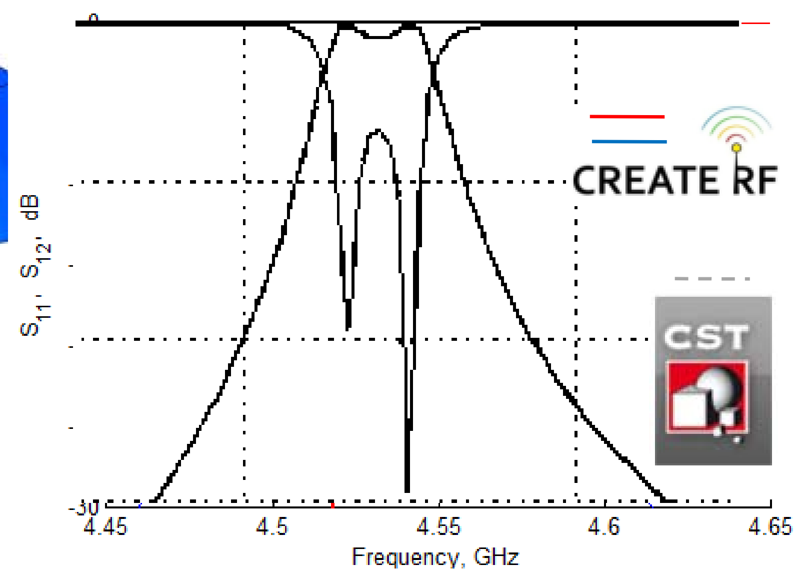
Sanity Check - Code to Code Comparison: SENTRI vs. CST Microwave Studio

High Dielectric Coupled-Ring Filter





Normal H on symmetry plane.

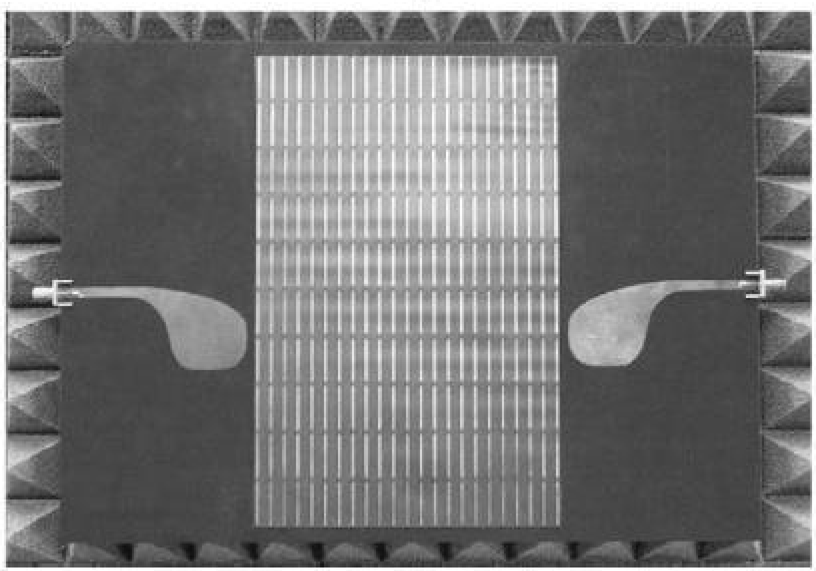


Successfully Benchmarked w/ Independent Software Vendor Tools

Sanity Check – SENTRI vs. Published Results

Closely Coupled Metallodielectric Electromagnetic Band-Gap Structures Formed by Double-Layer Dipole and Tripole Arrays

Alexandros P. Feresidis, *Member, IEEE*, George Apostolopoulos, *Student Member, IEEE*, Nikolaos Serfas, and John C. Vardaxoglou, *Member, IEEE*



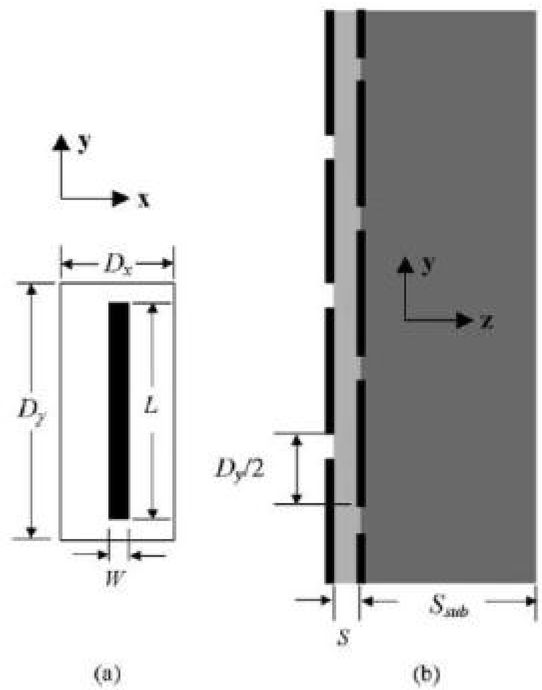


Fig. 2. (a) Geometry of dipole array unit cel. (b) Cross section of dipole CCMEBG.

Application Examples

Metamaterials

Sanity Check – SENTRI vs. Published Results

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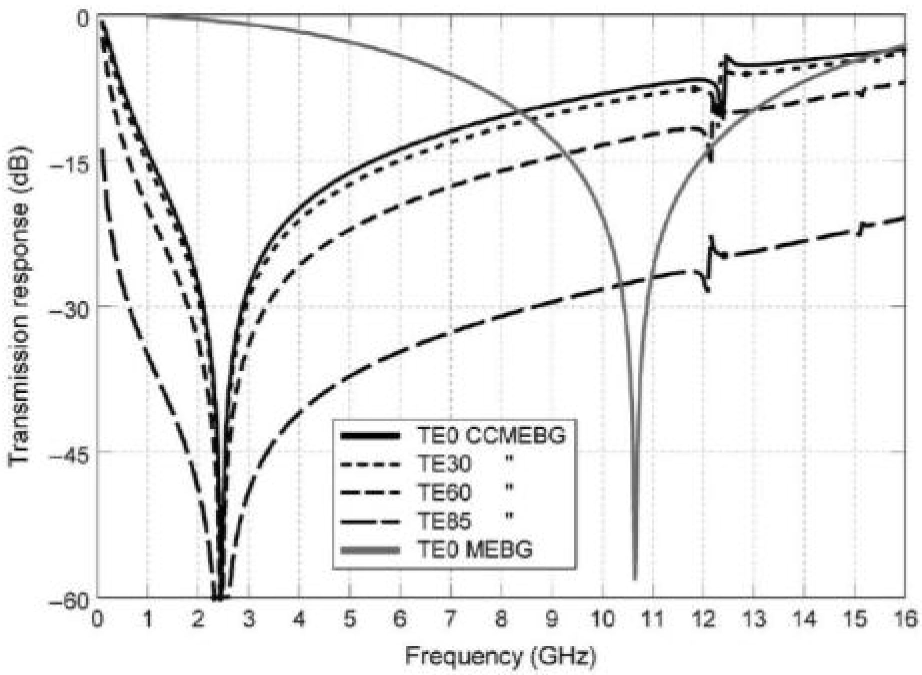
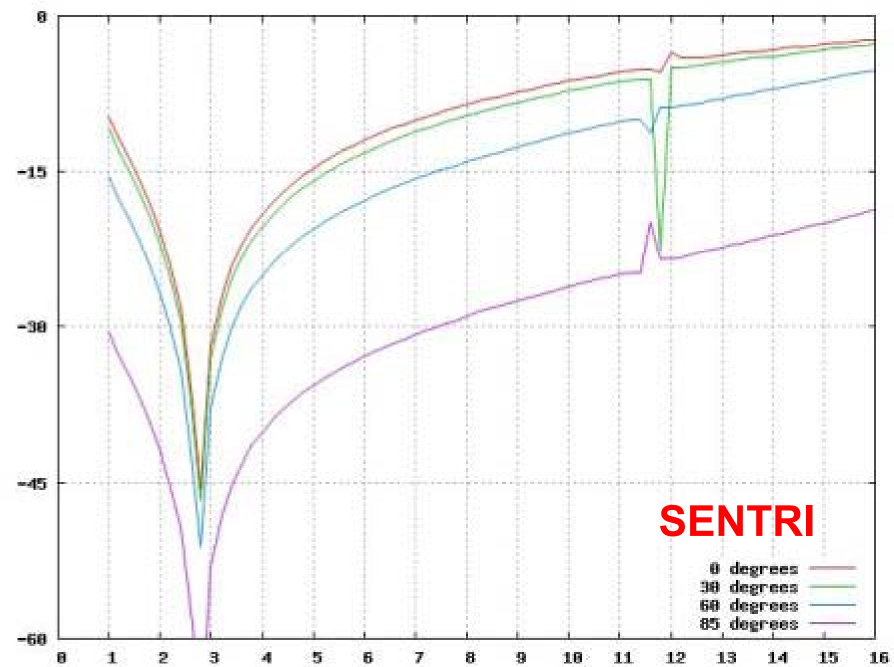
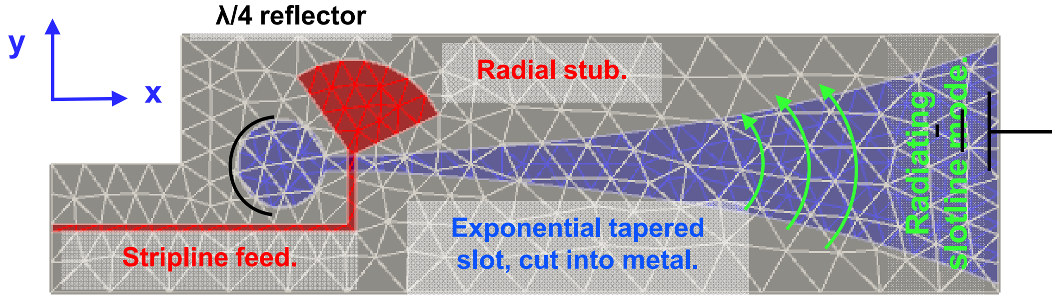


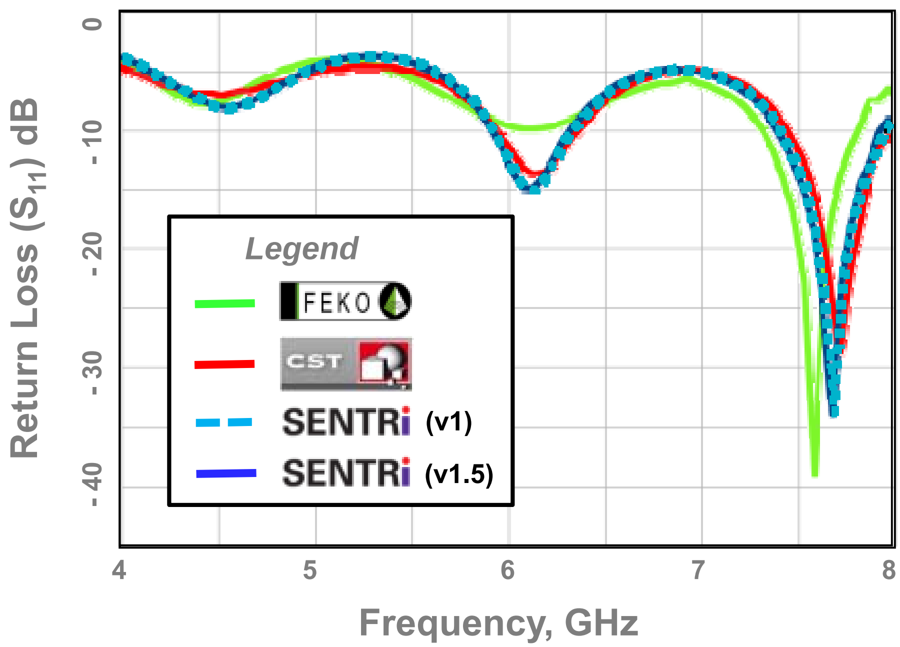


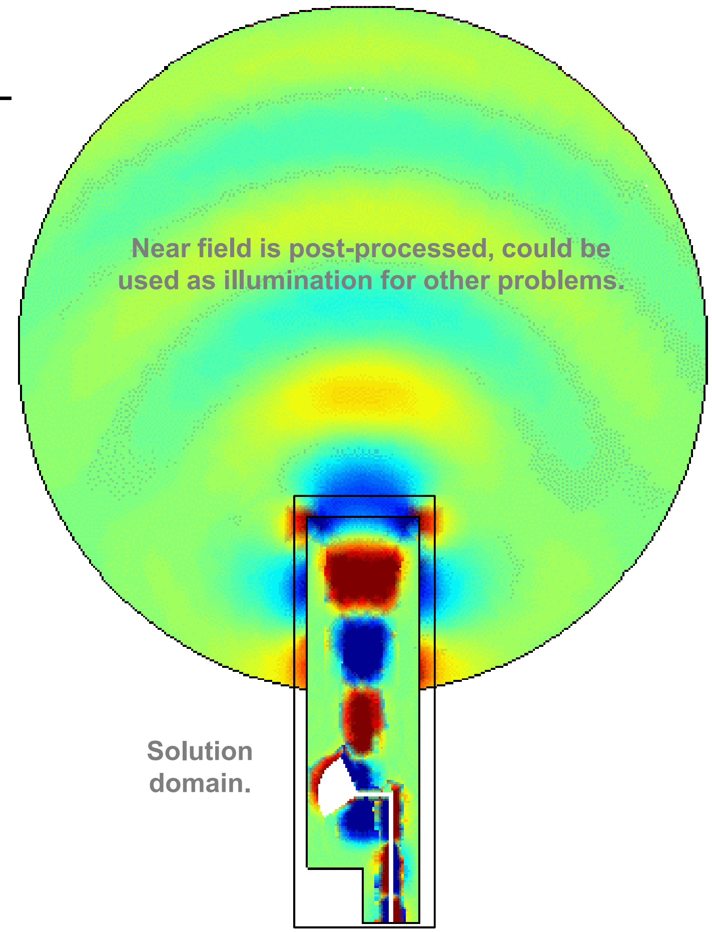
Application Examples

Printed Circuit Antennas

SENTRI vs. Commercial Codes





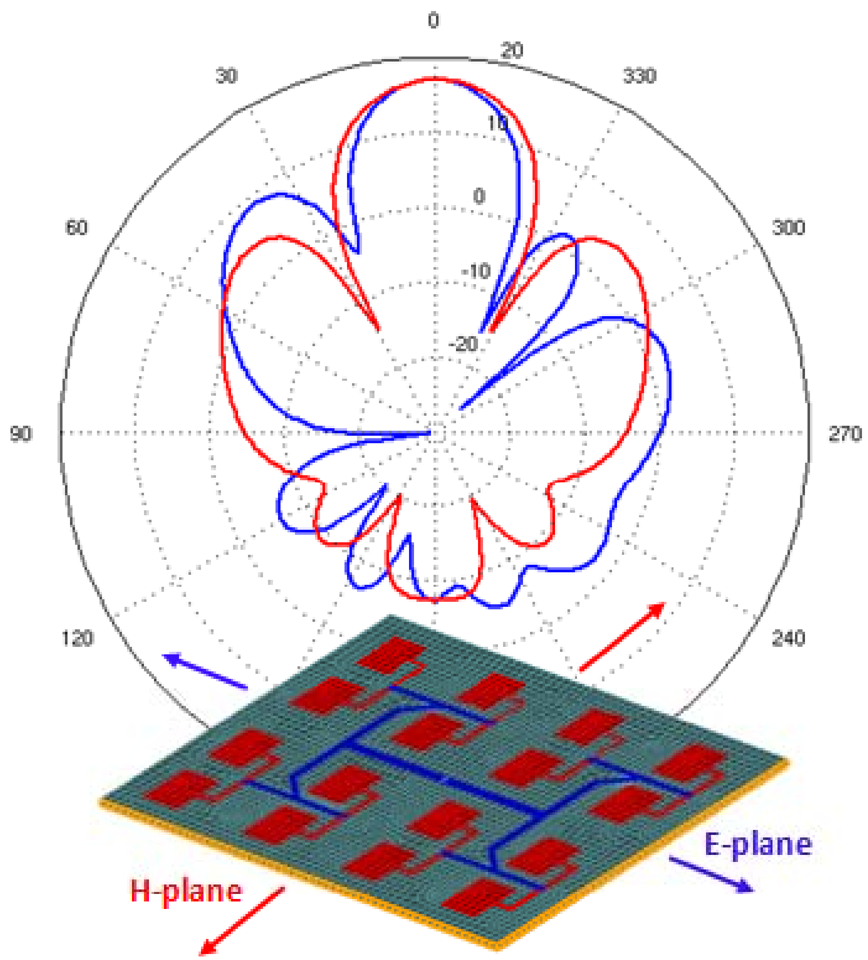


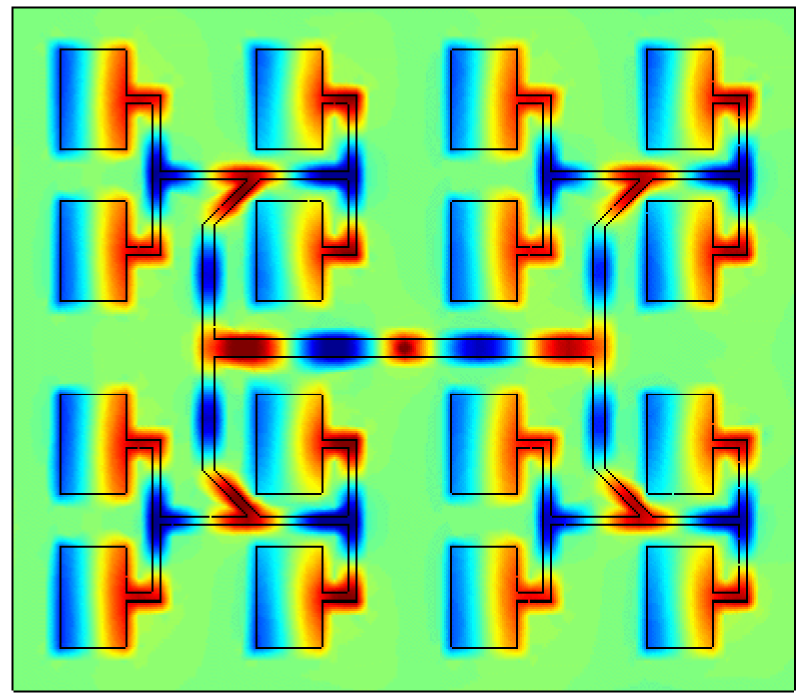
Successfully Benchmarked w/ Independent Software Vendor Tools

Application Examples

Antenna Patch Array

A large printed array is an antenna-type problem that also benefits.



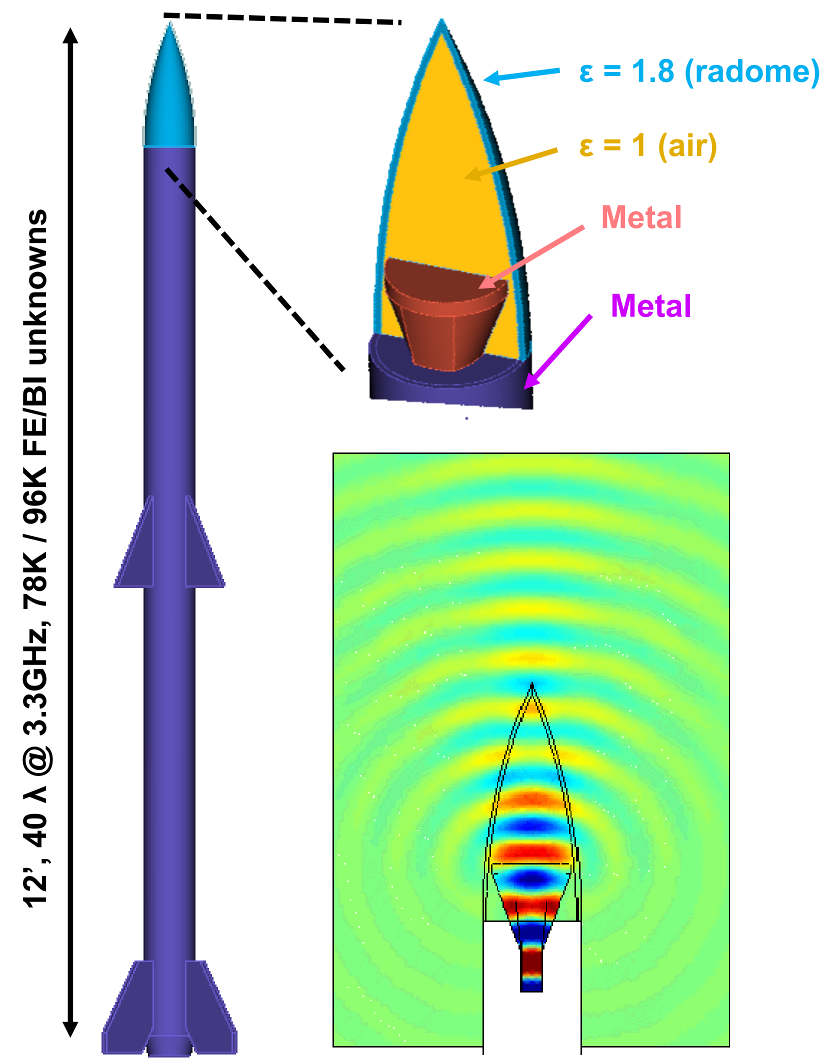


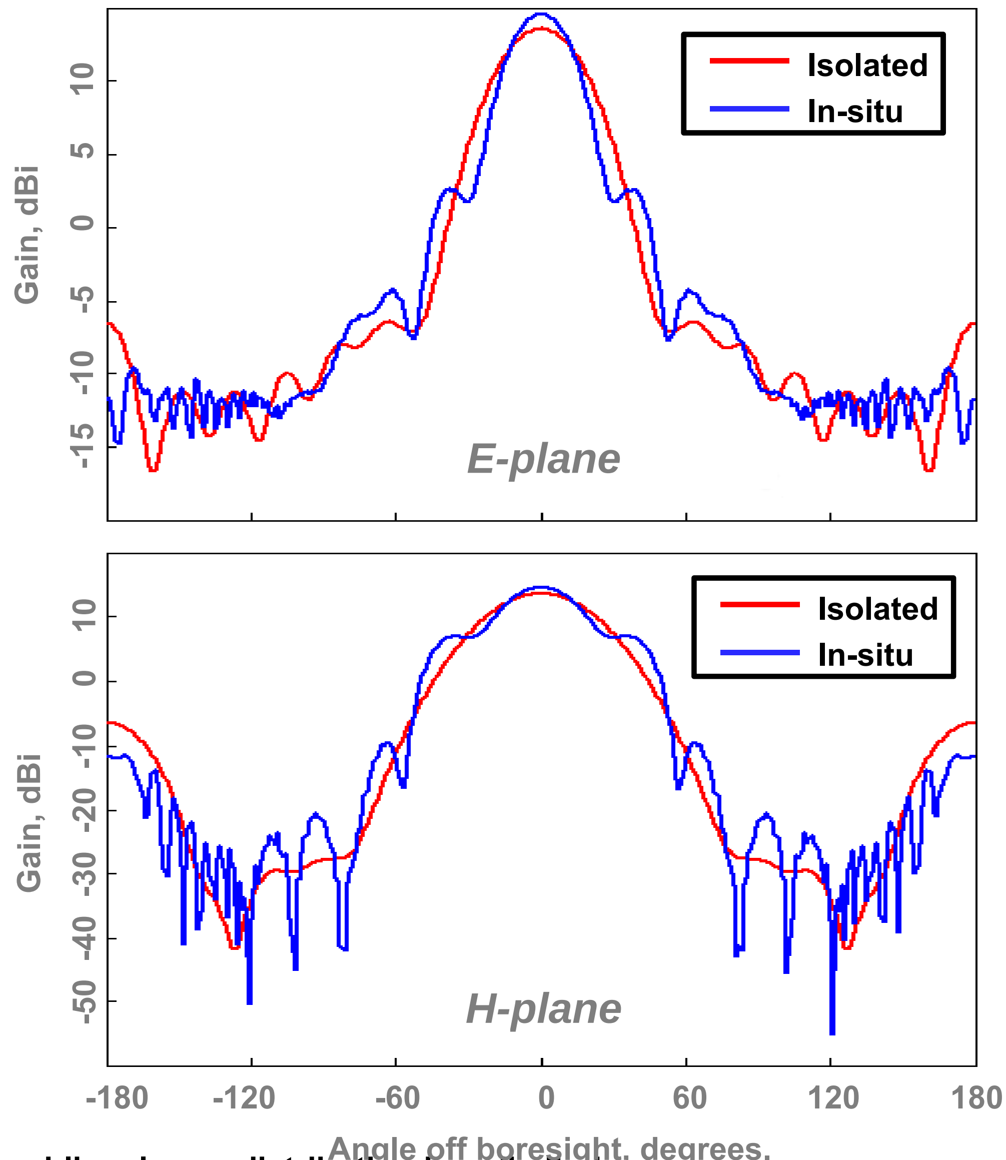
Gain (left) & field structure (right).

Application Examples

In-Situ Antenna Analysis

Lofted horn on notional missile.





Conclusion

- **Computational Electromagnetic Applications are Challenging but with High Performance Computers and Advanced Numerical Methods they can be Solved**
- **CREATE-RF Software Development**
  - For Use by DoD Government and Contractor Engineers
  - Allows for Specific Tailoring for Special Applications
  - Tech-Transfer Mechanism for Next-Gen of Gov't Engineers
- **CREATE-RF Transfer to Military Industry**
  - Complete Analysis Package
  - Runs on Workstations and High Performance Computers
  - Programmable System for End User Extensibility