

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 Development

Product Description



Product: SENTRI

SENTRI – Scalable Engineering Tools for RF Integration



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



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Antenna Design Capability Requirements CREATE RF

- **Need to design new antennas**
 - Benefit from new materials such as non-linear and meta materials to increase performance of antennas

Metallic inclusions $d \ll \lambda$

Loop Antenna over a Magnetic Ground Plane

- MetaMaterial magnetic ground planes to reduce planar antenna sizes
- MetaMaterials to match embedded antennas improving bandwidth
- MetaMaterials to reduce mutual coupling between antennas

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New antenna design

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Antenna Design Capability Requirements CREATE RF

- **Need to integrate antenna with platform**
 - Dynamic motion of antenna and/or host affects performance
 - e.g., Rotating blades, human movement, structure flexing

Huey Helicopter

Body Worn Antenna

Predator

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Dynamic geometry

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Antenna Design Capability Requirements CREATE RF

- **Need to integrate antenna with platform**
 - Design antenna in-situ of operating environment (sea, ground)

Stryker Reconnaissance Vehicle

Antenna Model of Stryker

Antenna Pattern

Antenna patterns affected by the ground

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Environmental effects

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Antenna Design Capability Requirements CREATE RF

- **Need to integrate antenna with platform**
 - Mitigate co-site interference

Future Destroyer (DDG 1000)

Tightly integrated system with antennas on limited space

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Co-Site interference

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Antenna Design Capability Requirements CREATE RF

- **Need to integrate antenna with platform**
 - Evaluate EMC/EMI effect
 - Evaluate stores' electromagnetic compatibility with aircraft safety-of-flight systems
 - Set high power microwave radiation level

Airborne electronic attack concept

HERO EMI

Hazards of Electromagnetic Radiation to Ordnance (HERO)

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EMC/EMI assessment

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Antenna Design Capability Requirements CREATE RF

- **Need Multi-Disciplinary Design Integration**
 - DoD Must Better Include Non-RF Aspects Into Design; e.g., Weight, Strength, Drag, space/power/cooling requirements, etc.

DARPA ISIS (Integrated Sensor Is Structure) Program requires integration of sensor and airship

Future UAV

Future Ship

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Multiple disciplines

Computational Electromagnetics Applies to Almost All DoD Systems



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



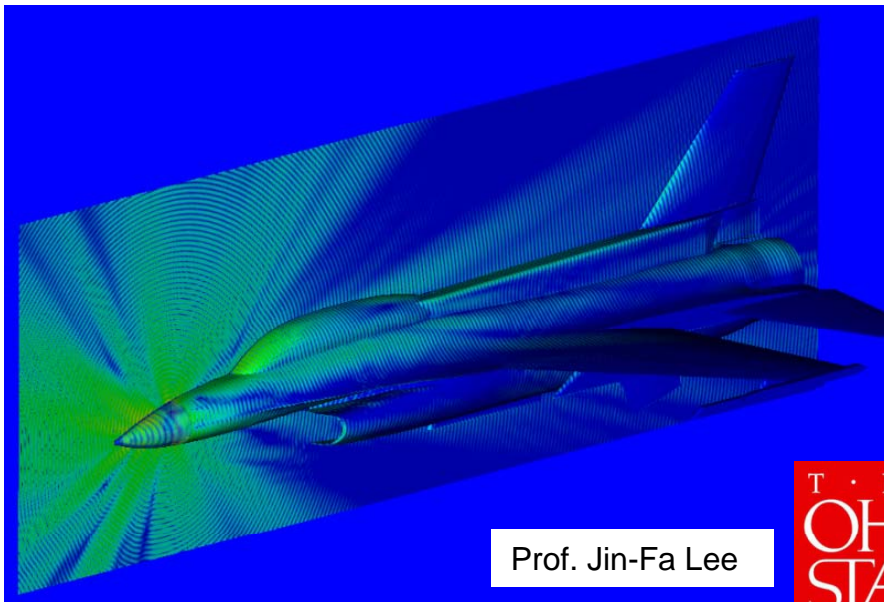
CREATE-RF Development

Product Description

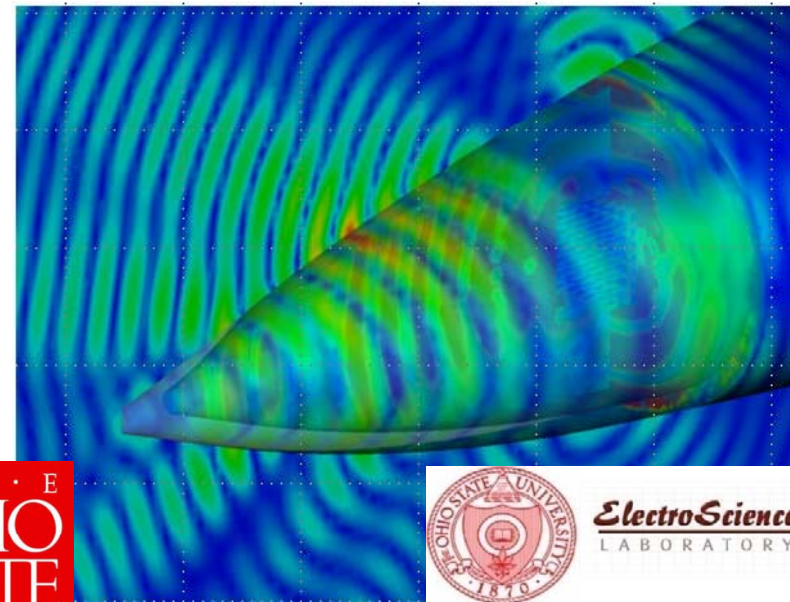


Challenge of Computational Electromagnetics

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



Prof. Jin-Fa Lee



ElectroScience
LABORATORY

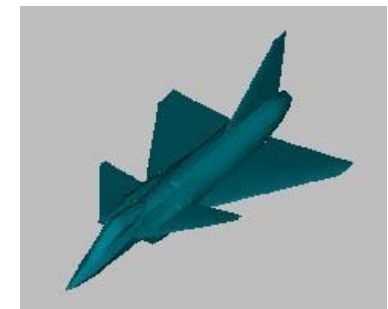
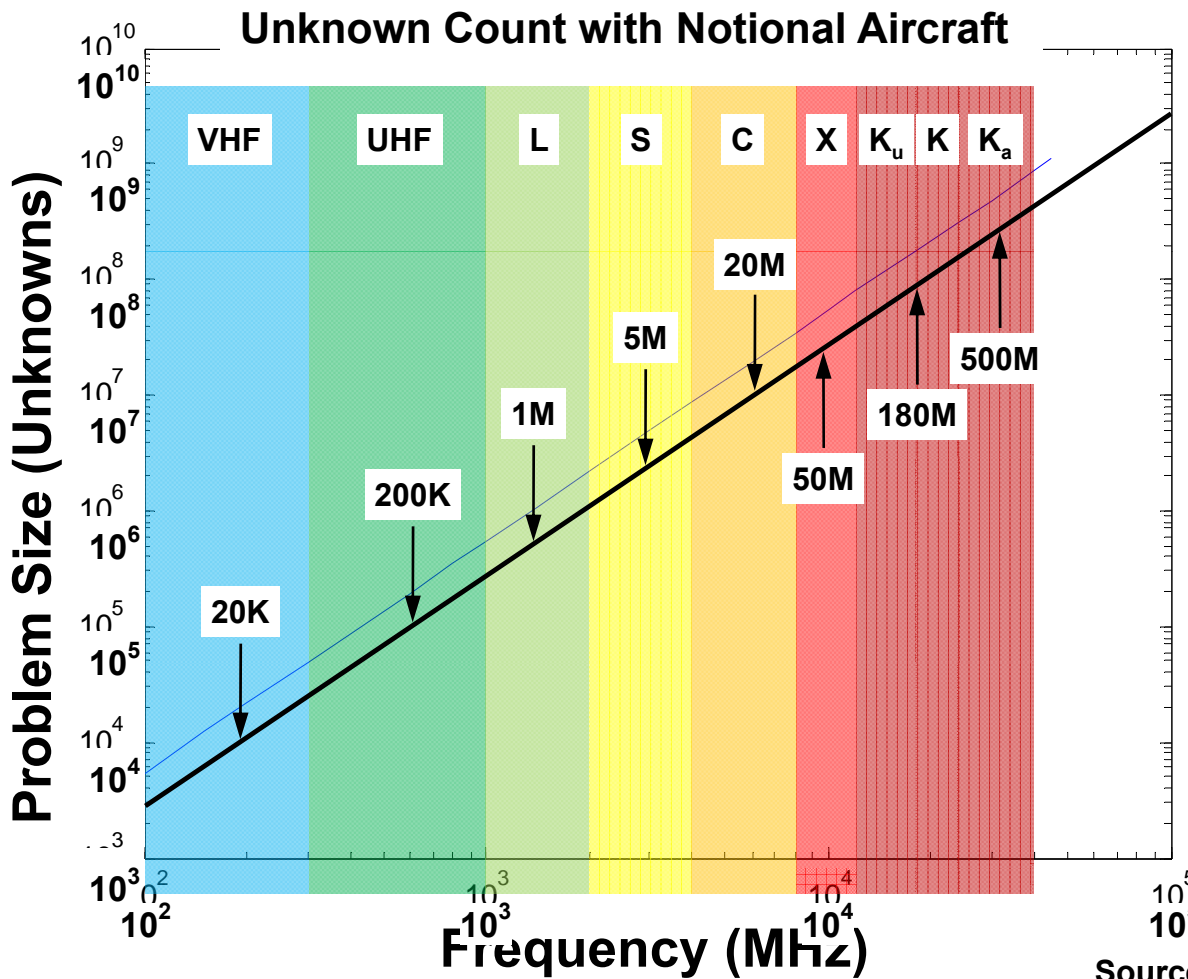


CREATE-RF Development

Product Description



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)

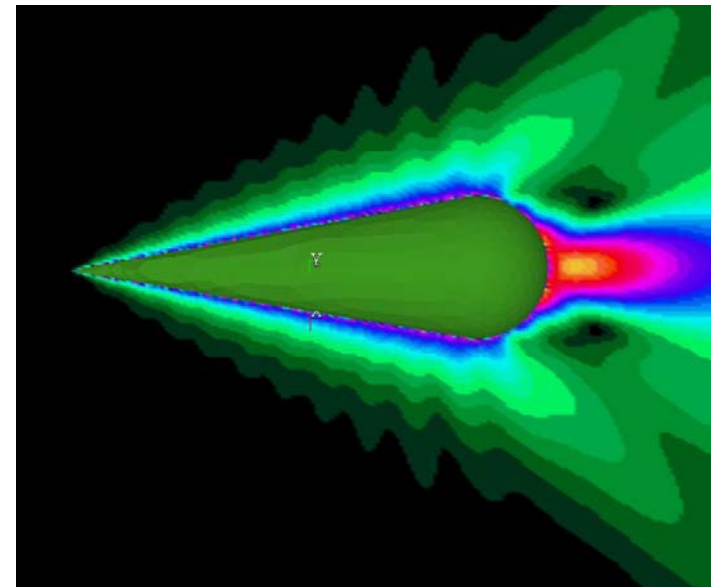
Periodic Structures

- 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



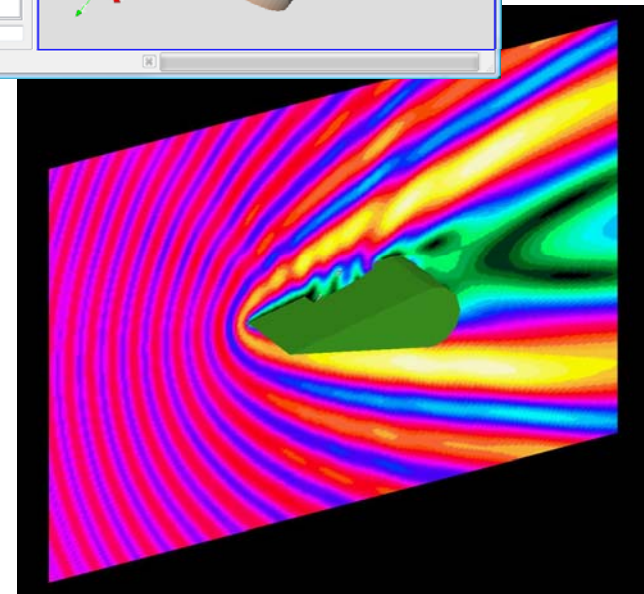
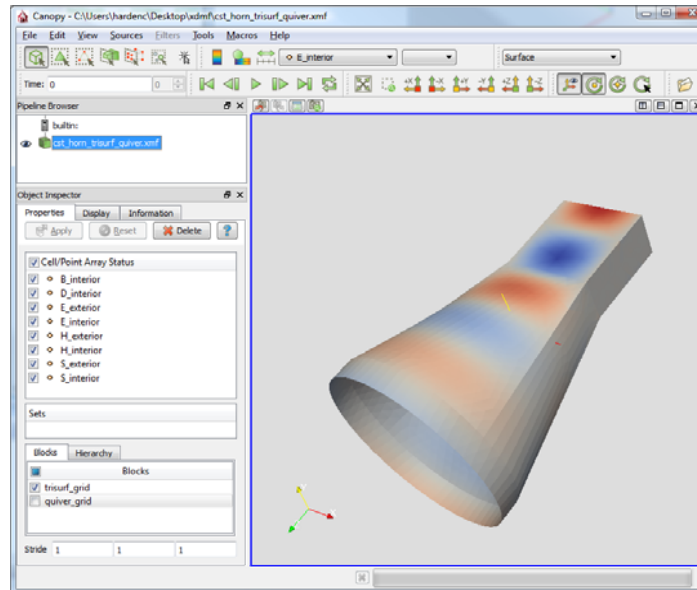
Future Releases of SENTRI

Full End-to-End Analysis System

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

Programmable System

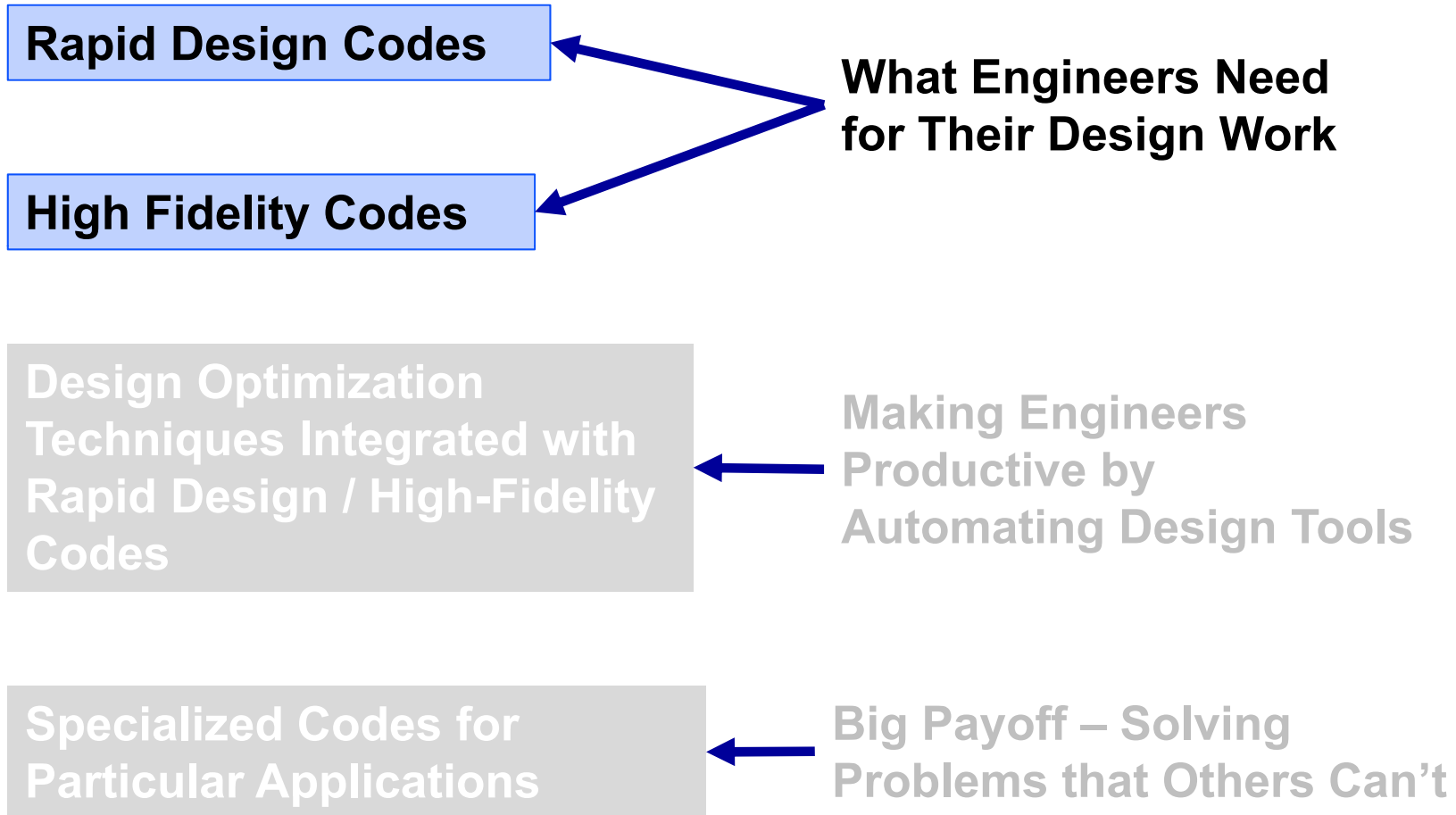
- Software Release as a Application Programming Interface for Further Tailoring by End User





Development Approach

Development Strategy



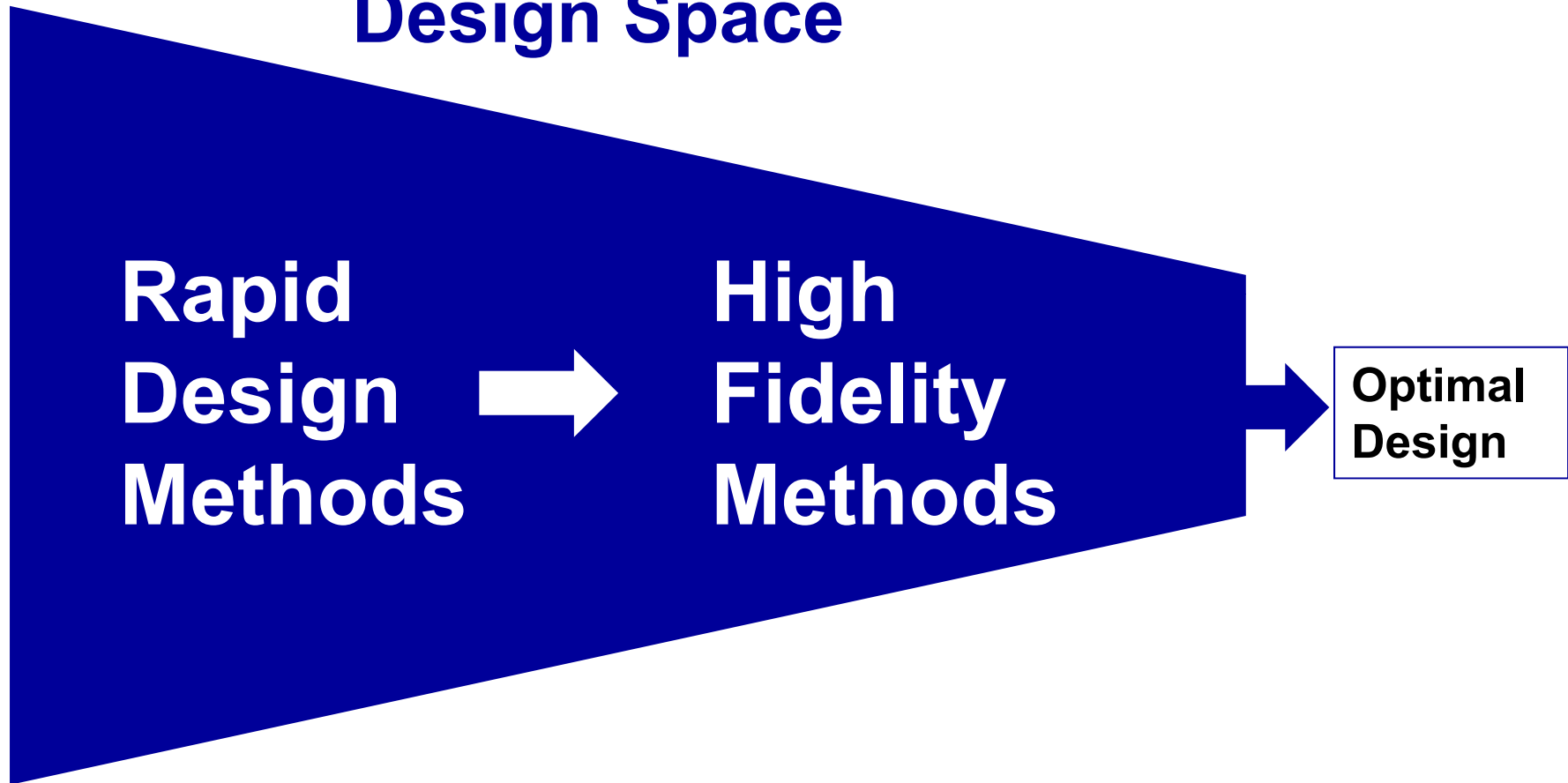


Development Approach

Development Strategy



Design Space

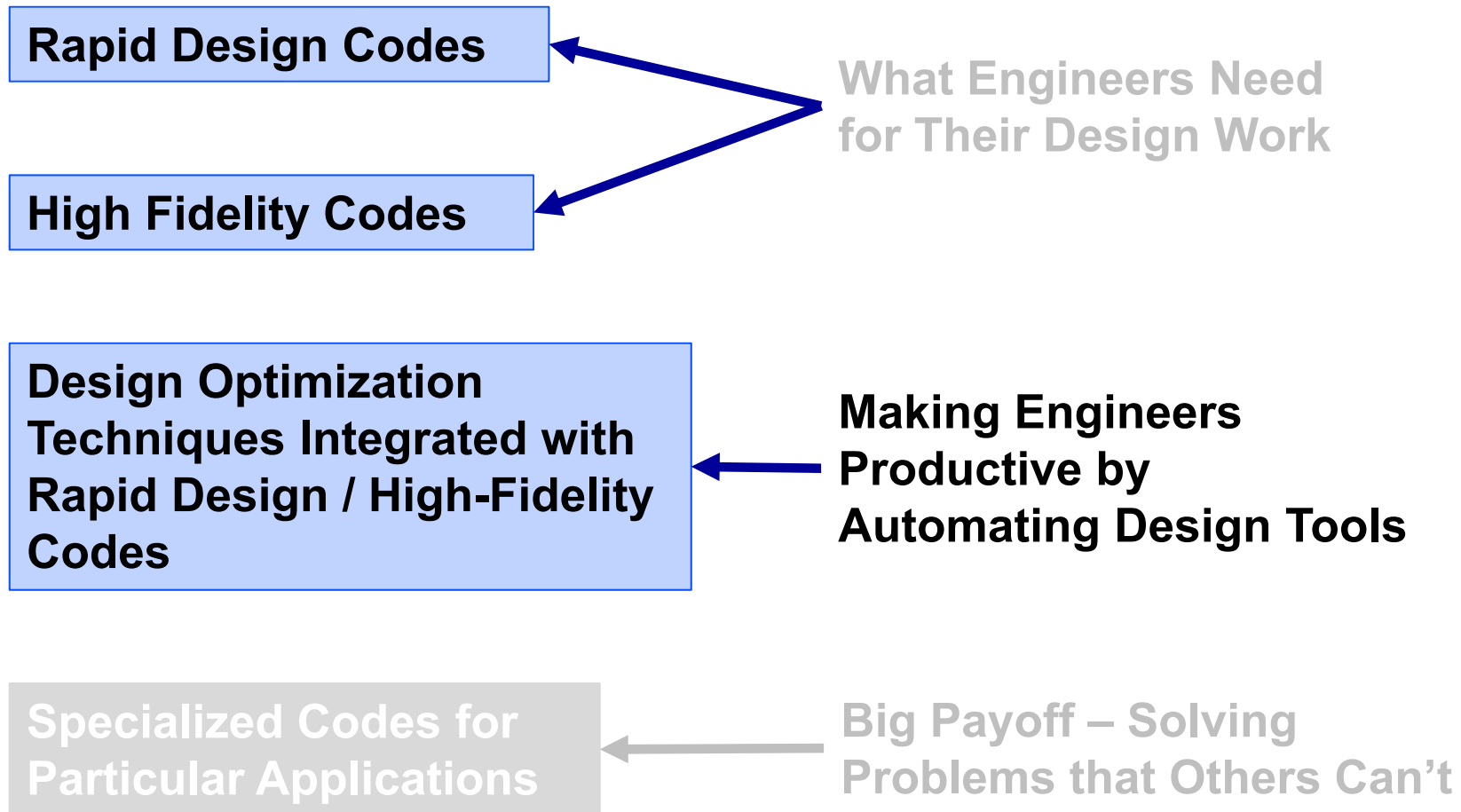


Rapid Design Methods → Narrow Design Space
High Fidelity Methods → Model All Variables, Optimal Design



Development Approach

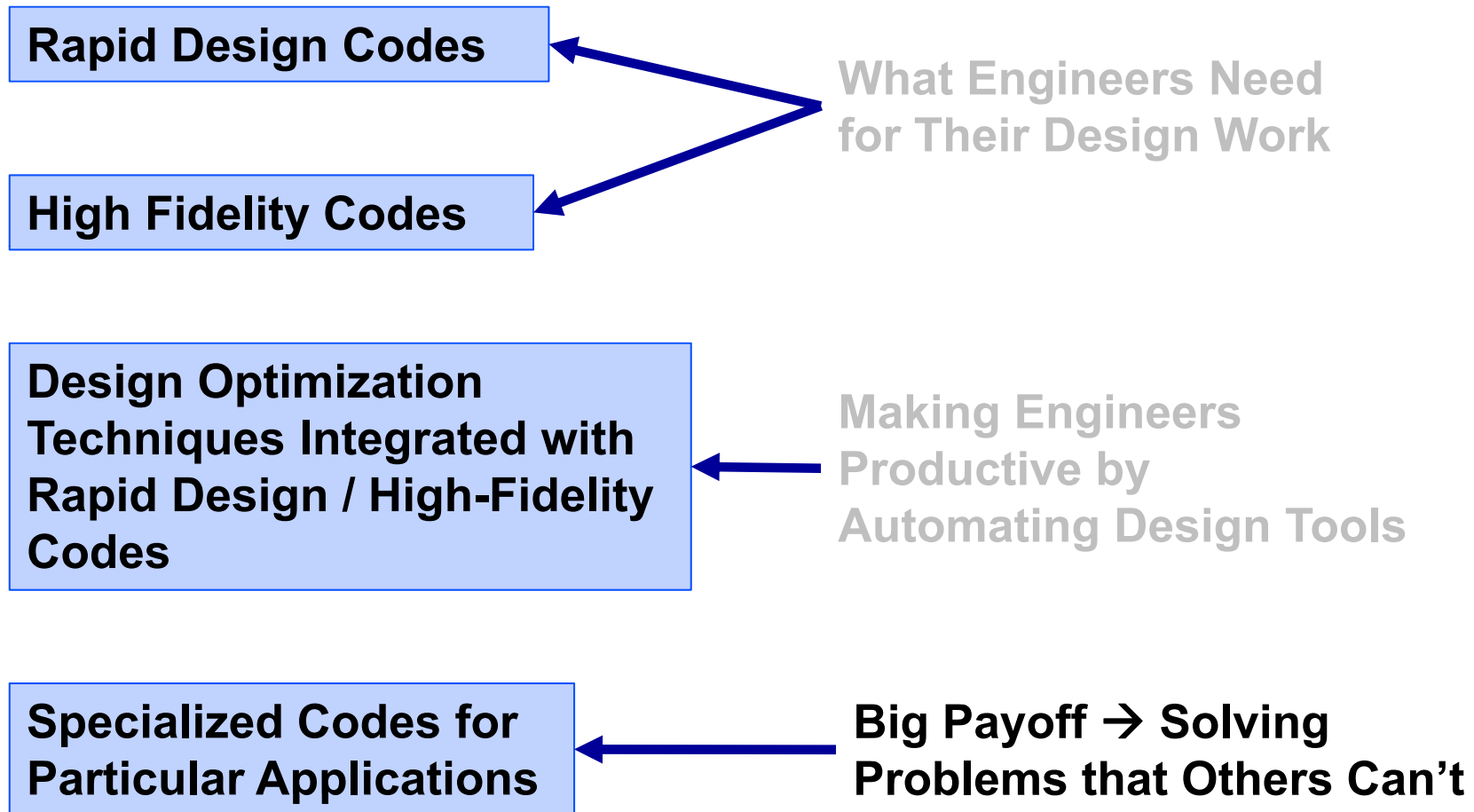
Development Strategy





Development Approach

Development Strategy





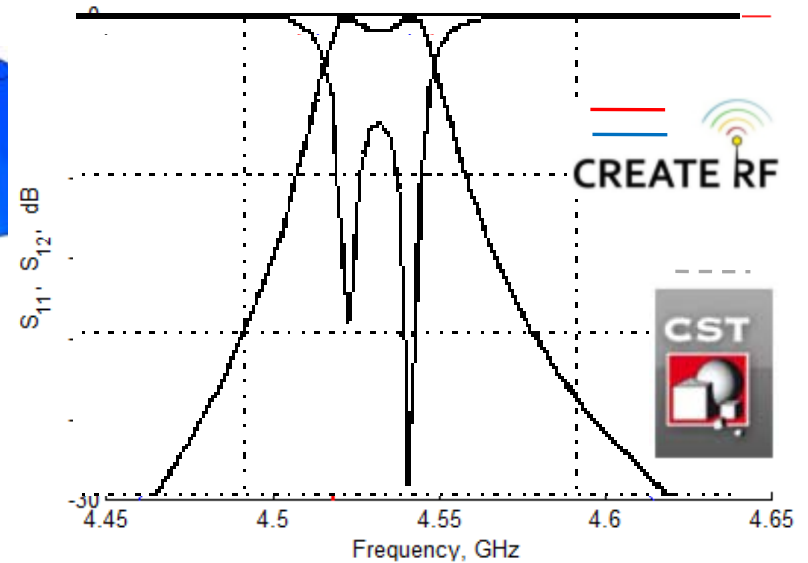
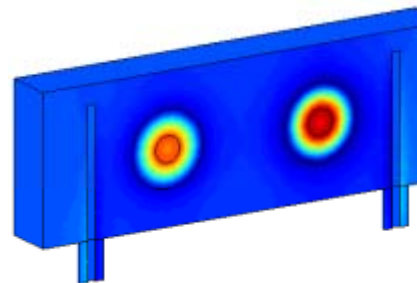
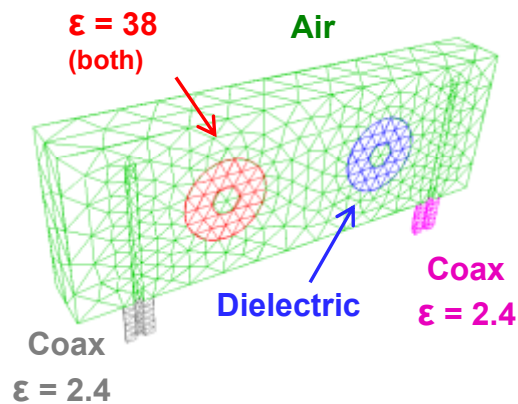
Application Examples

Microwave Circuit Analysis



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

High Dielectric Coupled-Ring Filter



Successfully Benchmarked w/ Independent Software Vendor Tools



Application Examples

Metamaterials



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*

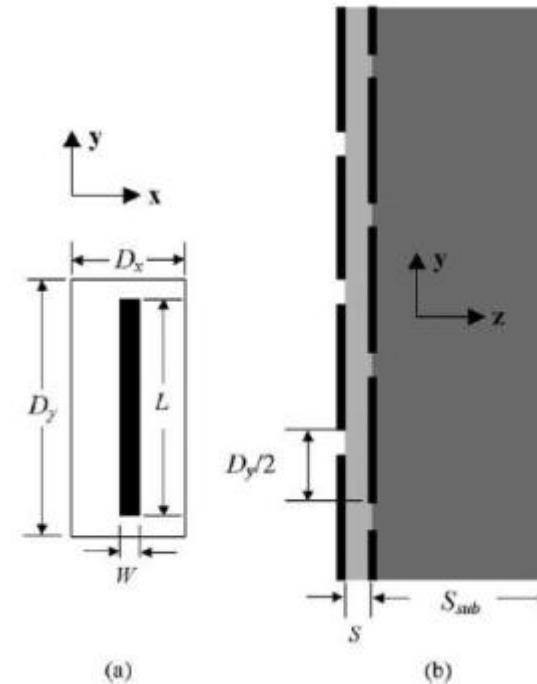
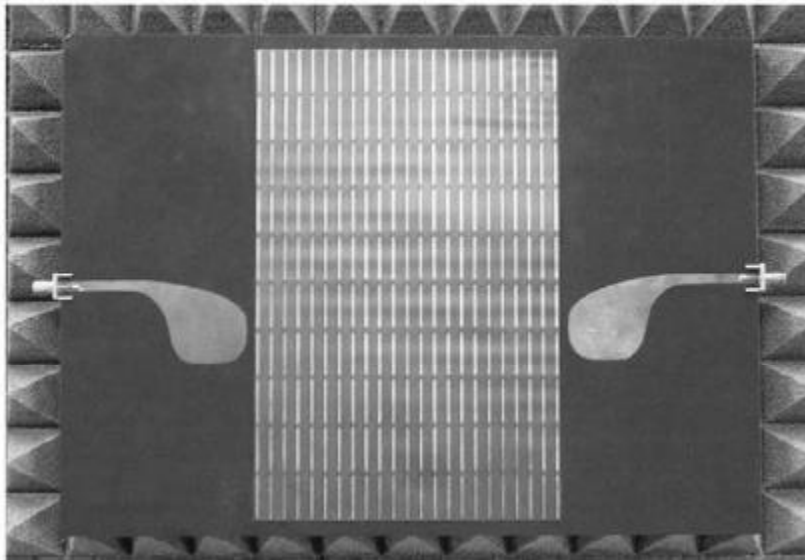


Fig. 2. (a) Geometry of dipole array unit cel. (b) Cross section of dipole CCMEBG.



Application Examples

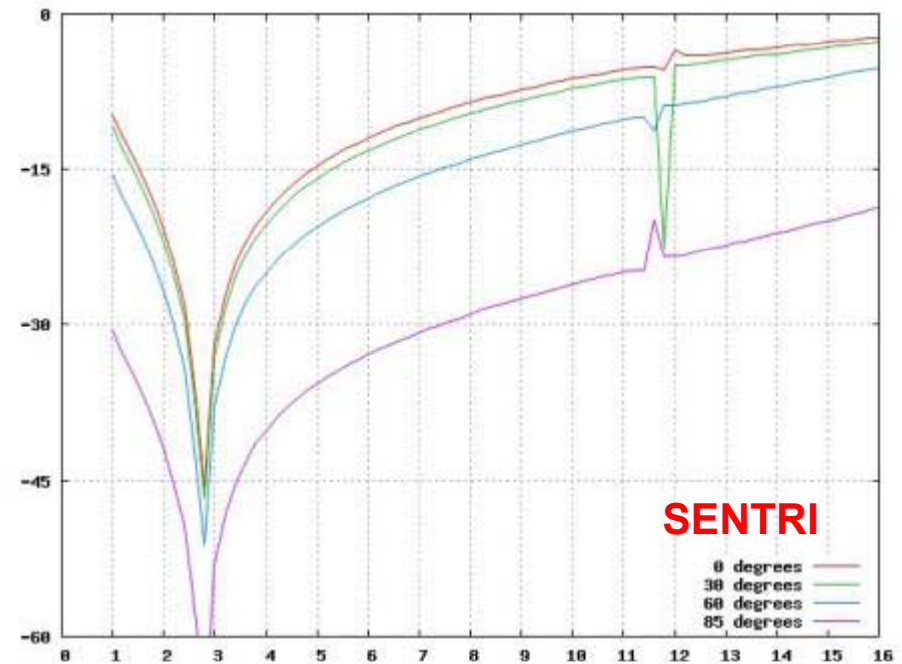
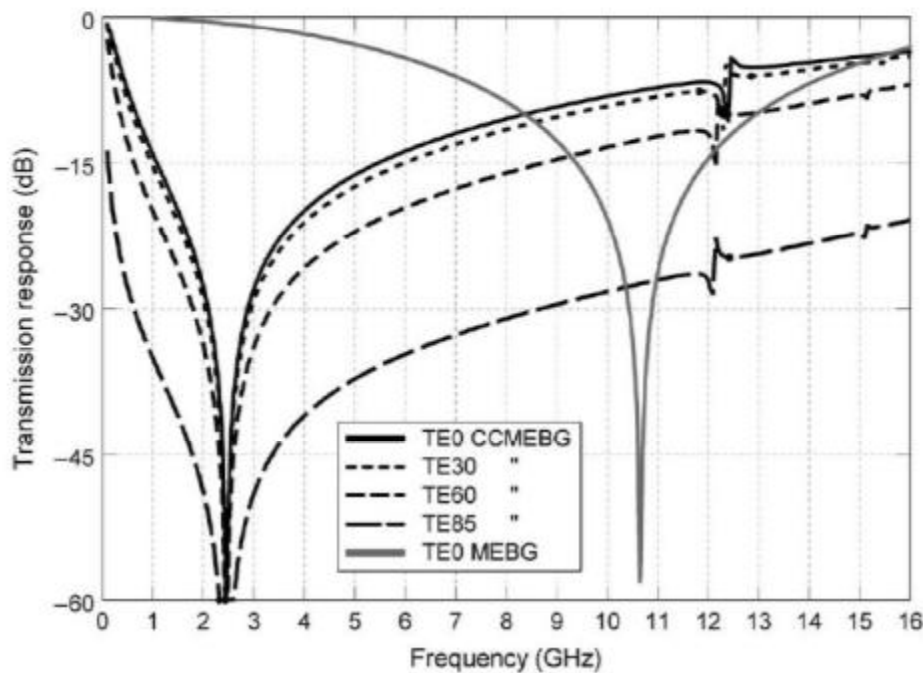
Metamaterials



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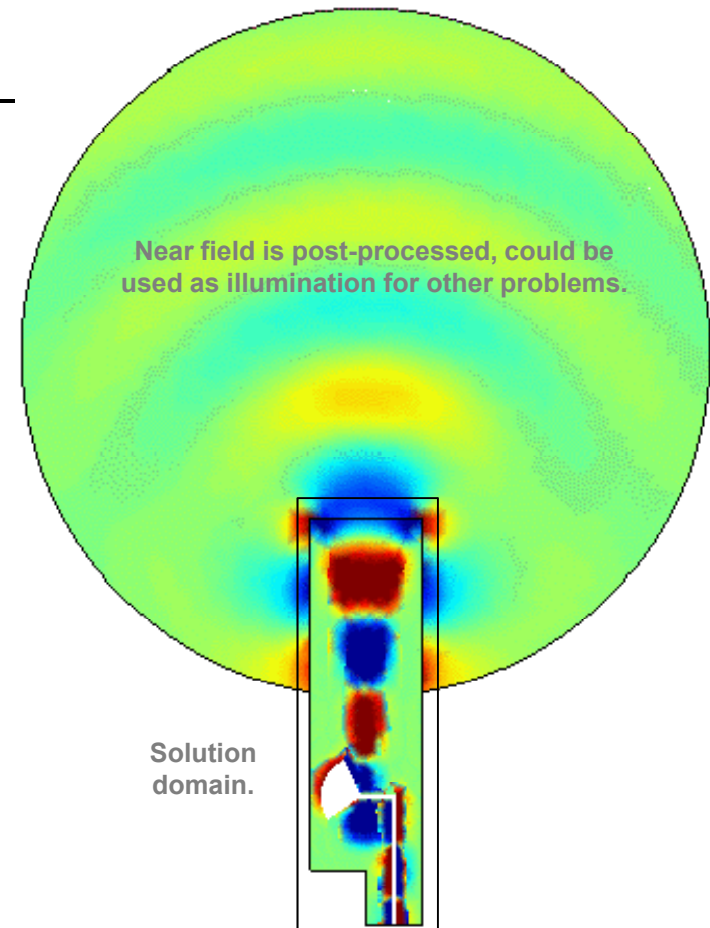
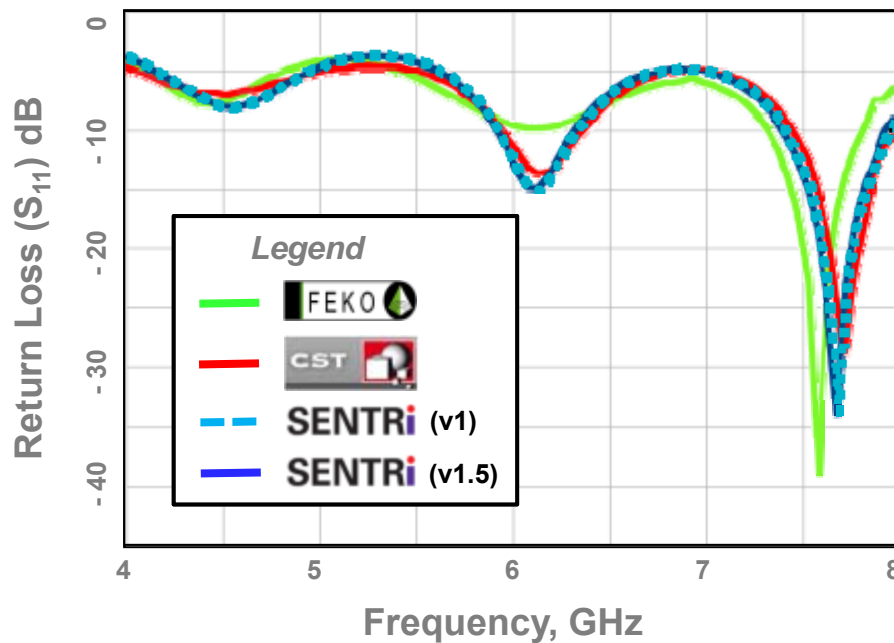
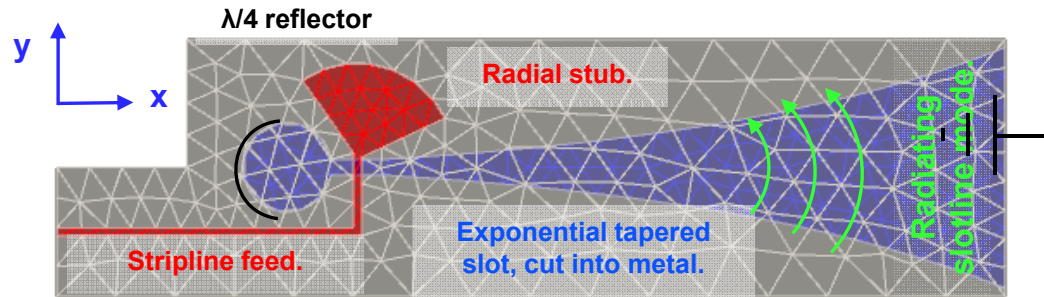


Application Examples

Printed Circuit Antennas



SENTRI vs. Commercial Codes



Successfully Benchmarked w/ Independent Software Vendor Tools

Distribution A: Approved for public release; distribution is unlimited

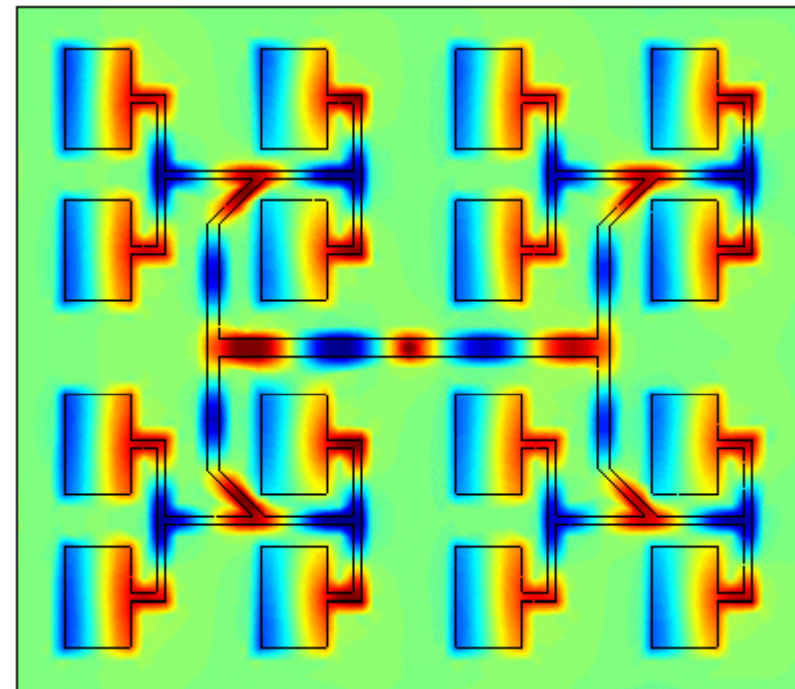
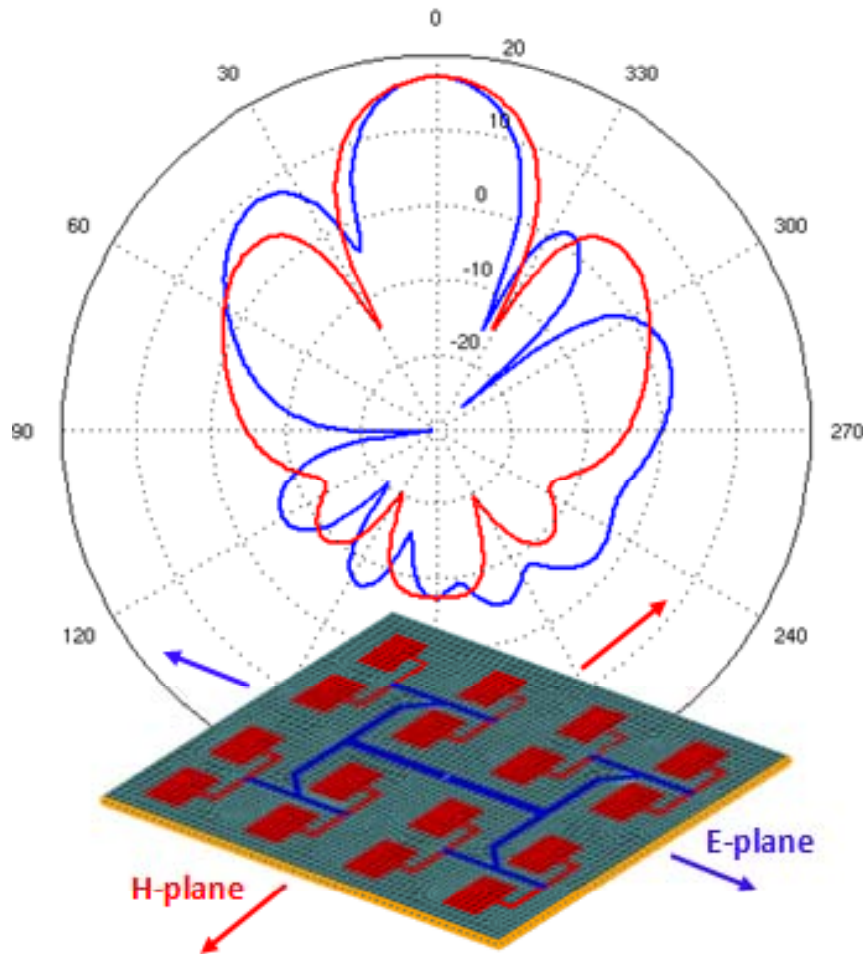


Application Examples

Antenna Patch Array



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



Gain (left) & field structure (right).

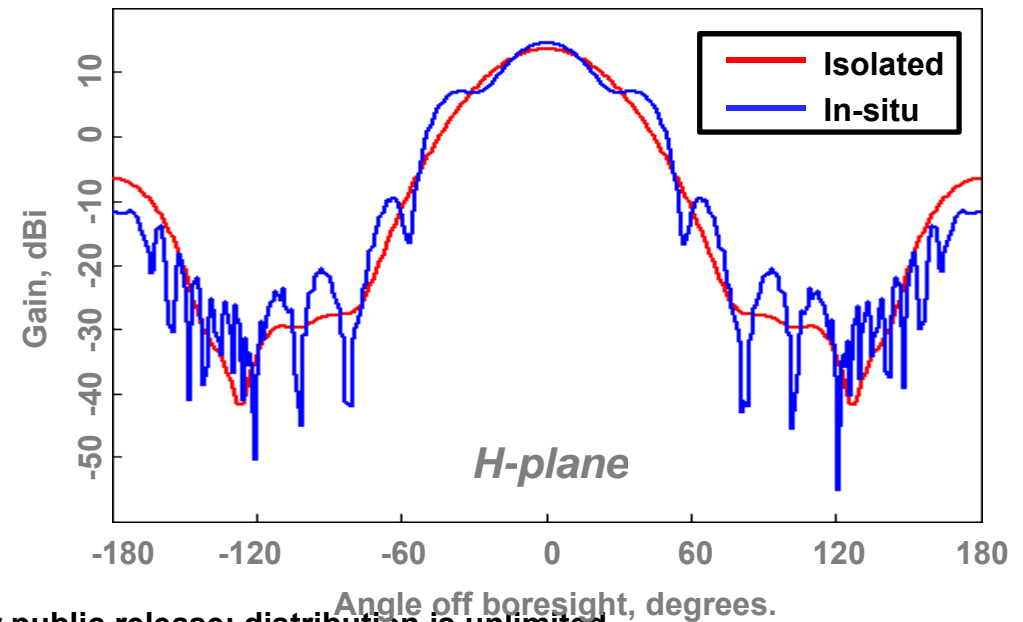
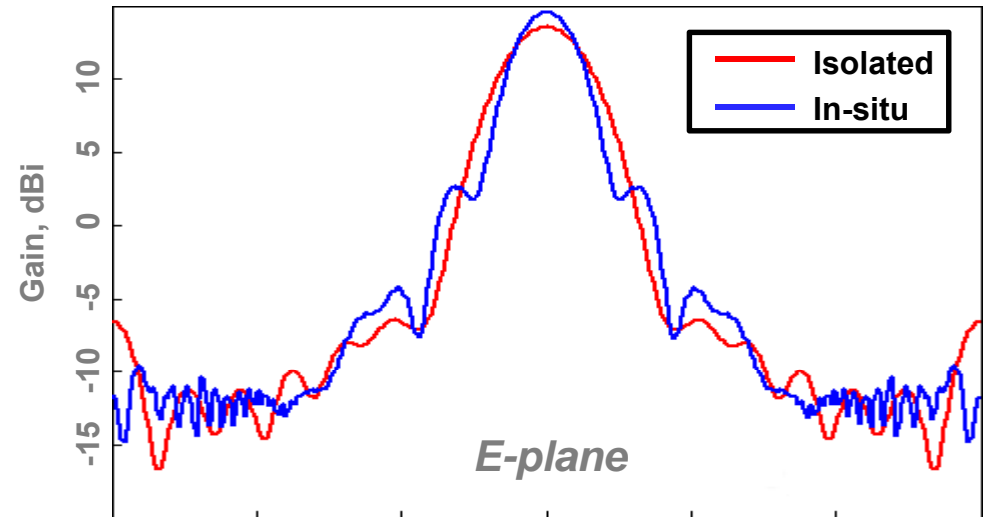
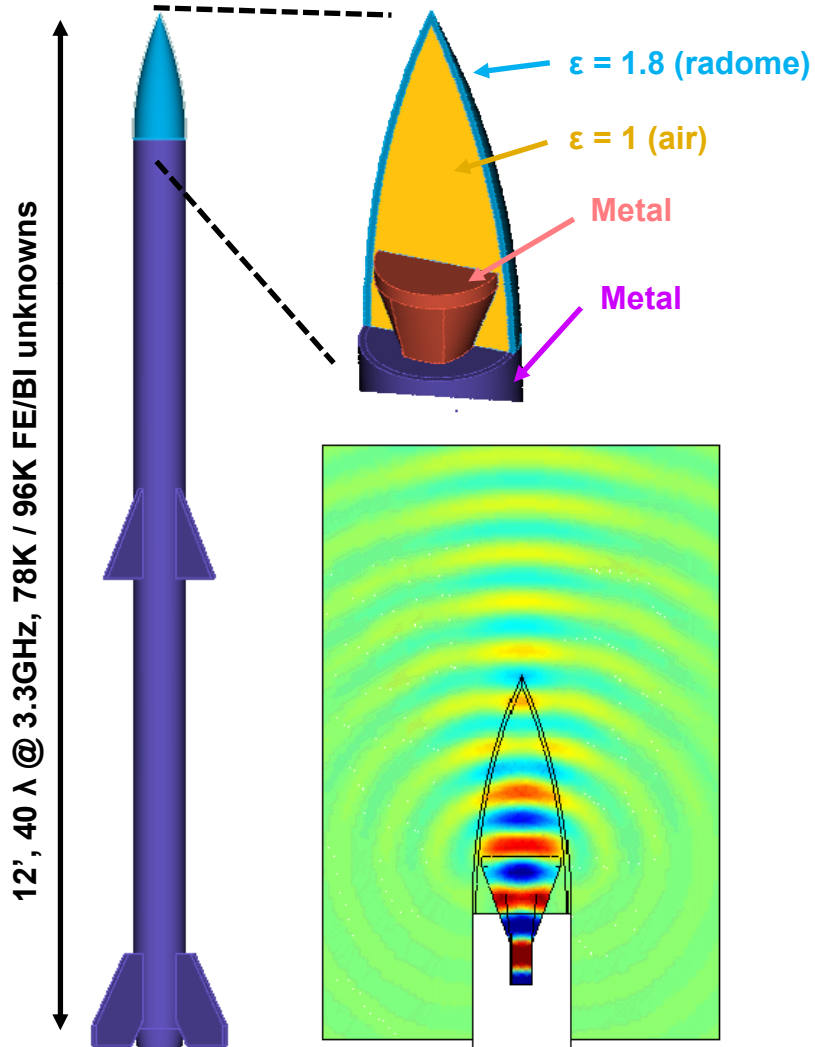


Application Examples

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