CREATE-RF Status

National Defense Industrial Association
June 21, 2011
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

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CREATE-RF Requirement Summary

Antenna Design Capability Requirements

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

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

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

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

- Need to integrate antenna with platform
  - Evaluate EMC/EMI effect

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

Co-Site interference
EMC/EMI assessment
Multiple disciplines

Computational Electromagnetics Applies to Almost All DoD Systems

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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

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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)
CREATE-RF Development
Product Description

Challenge of Computational Electromagnetics

- VHF
- UHF
- L
- S
- C
- X
- K
- Ku
- Ka

- Length = 15.5 m
- Width = 8.9 m
- Height = 4.1 m
- 100 MHz to 40 GHz
- 10 samples/λ

Source: Riverside Research Institute

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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
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

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

Design Space

Rapid Design Methods → High Fidelity Methods → Optimal Design

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

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Development Approach

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Development Approach

Development Strategy

- **Rapid Design Codes**
- **High Fidelity Codes**

What Engineers Need for Their Design Work

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Making Engineers Productive by Automating Design Tools

- **Specialized Codes for Particular Applications**

Big Payoff → Solving Problems that Others Can’t

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Application Examples

Microwave Circuit Analysis

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

High Dielectric Coupled-Ring Filter

\[ \varepsilon = 38 \] (both)

Air

Dielectric

Coax \[ \varepsilon = 2.4 \]

Normal H on symmetry plane.

Successfully Benchmarked w/ Independent Software Vendor Tools

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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 cell. (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

Frequency, GHz

Legend

Return Loss ($S_{11}$, dB)

- 40 - 30 - 20 - 10 0 10

- 40 - 30 - 20 - 10 0 10

Near field is post-processed, could be used as illumination for other problems.

Solution domain.

Successfully Benchmarked w/ Independent Software Vendor Tools

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Application Examples

Antenna Patch Array

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

Gain (left) & field structure (right).

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Application Examples

In-Situ Antenna Analysis

Lofted horn on notional missile.

$\varepsilon = 1.8$ (radome)

$\varepsilon = 1$ (air)

Metal

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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