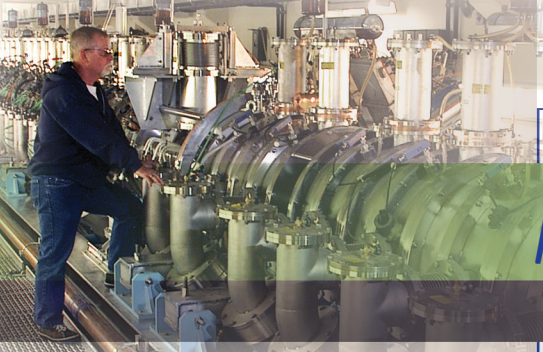
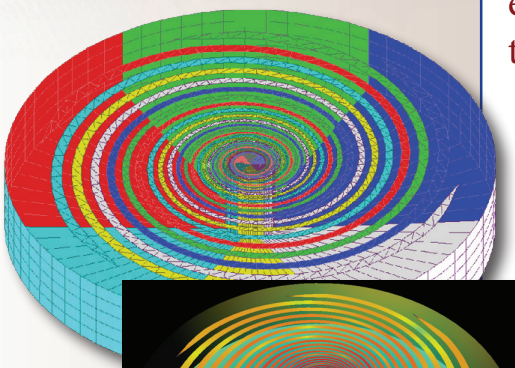
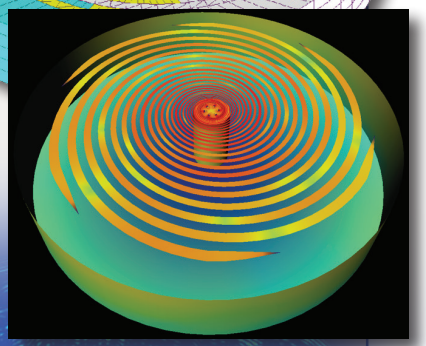


Applied Electromagnetics

Lawrence Livermore National Laboratory

At Lawrence Livermore, novel uses of applied EM abound. We pioneered the use of time-domain finite difference, finite element, and boundary element methods for analysis of fast transient electromagnetics.





Broadband cavity-backed spiral antenna.

Our broad experience supports the full range of electromagnetic phenomena that are ubiquitous throughout the Laboratory's mission, spanning problems from optical regimes to classic microwave and radio-frequency research to the static fields associated with fixed magnets.

Example Projects

Space Situational Awareness
- Fast, accurate radar cross-section estimates of space debris for analysis of next-generation collision-avoidance radar systems

Antenna
- Simulated rotational symmetry, analytical treatment for layered media, and detailed feed model using EIGER code

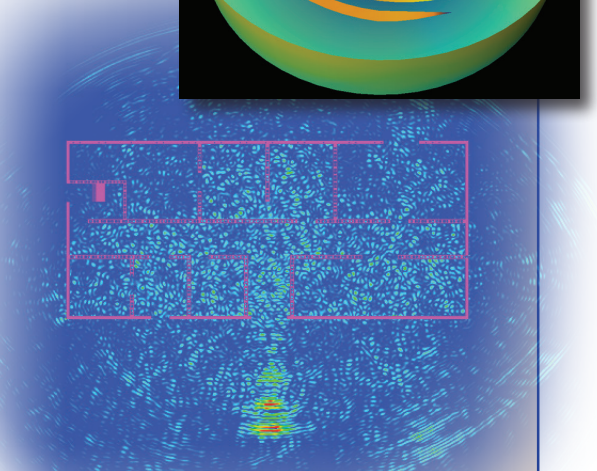
Wall-Penetrating Radar
- Mobile radar revealed internal structure of buildings
- First-principle simulations contain details not found in traditional ray-tracing simulations

Signatures from Explosions
- Characterizing conventional explosions using active and passive electromagnetic sensing

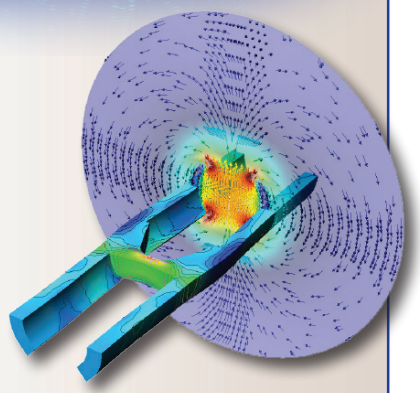
Electromagnetic Launchers
- Simulated sliding electrical contacts for the Navy's railgun program using ALE3D code

EM Effects on Circuits
- Discovered with EMSolve that weak electric fields can temporarily disrupt the operation of off-the-shelf industrial electronics when the frequency is chosen properly

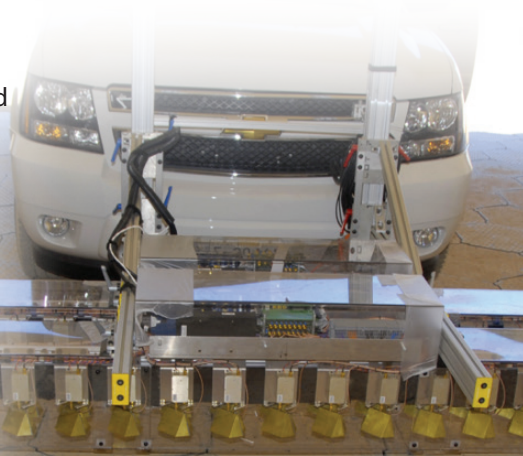
Ground-Penetrating Radar
- Developed mobile bistatic ultrawideband radar for detecting and classifying buried metallic objects
- Designed for detecting unexploded ordnance and recently commercialized for underground gas and power lines

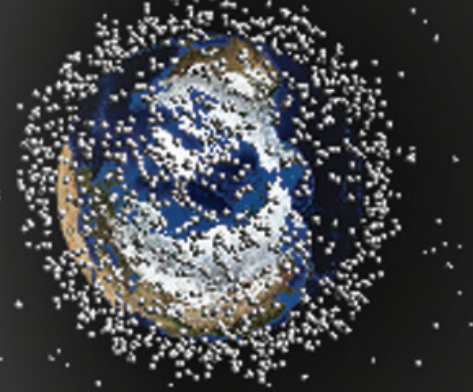


High resolution simulation of wall penetrating radar using EMSolve.



Fields and stresses in an electromagnetic launcher.



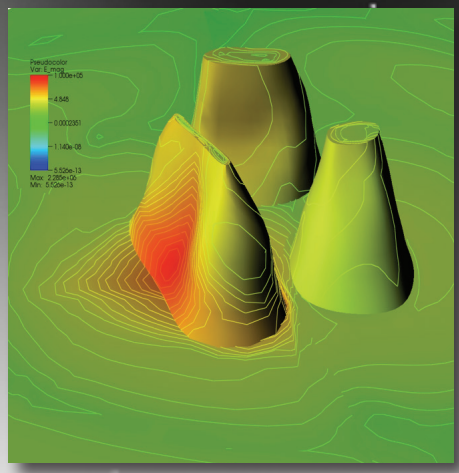


Unique Modeling and Simulation Capabilities

- Pioneered the use of time-domain finite difference, finite element, and boundary element methods for analysis of fast transient electromagnetics
- Developed the massively parallel EMSolve, for modeling microwaves and RF, circuit board interference, and more
- Co-developed EIGER for linear steady-state problems where high fidelity is required, e.g., modeling MEMs devices, the human neck (for speech recognition), antennas, microwave circuits, full-scale missiles and ships, and phased arrays

Facilities

- Anechoic chambers, shielded rooms, outdoor test ranges, and RF sources and instrumentation from "DC to daylight"
- Microfabrication, CNC machining, and 3D printing for prototype RF devices and systems
- High-voltage, high-current, and destructive testing capability



Low frequency EM fields surrounding hypothetical underground power lines.

Sponsors

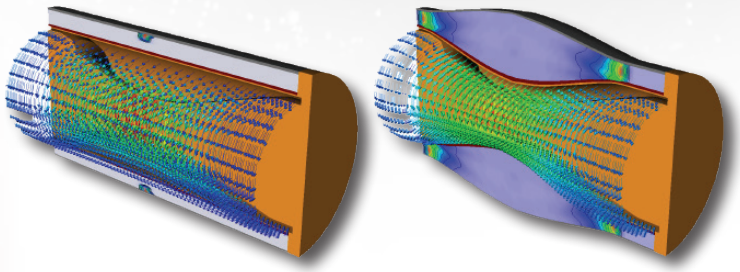
- National Nuclear Security Administration
- Defense Advanced Research Programs Agency
- Defense Threat Research Agency
- Department of Homeland Security
- Joint Improvised Explosive Device Defeat Organization

Academic Alliances

- University of Illinois, for Z pinch modeling, experimentation
- The Ohio State University, for model order reduction
- University of Bath, for computational optimization

Staff

More than 30 members specializing in theory and numerical methods, system design and analysis, measurements, and grounding, shielding and safety.



Explosive pulse power is used to generate million-amp current pulses.

Capability Leader

Dr. Daniel White **925-422-9870** **white37@llnl.gov**

Dan is the Deputy Division Leader of the Computational Engineering Division at LLNL. He obtained BS and MS degrees in Electrical Engineering, and Ph.D. degree in Applied Science, from UC Davis. His expertise is in numerical methods for electromagnetics, parallel computing, electrical system modeling and simulation.

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