Border Security and the Energy Grid

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NNSA

Approved for unlimited release as LA-UR-09-05290

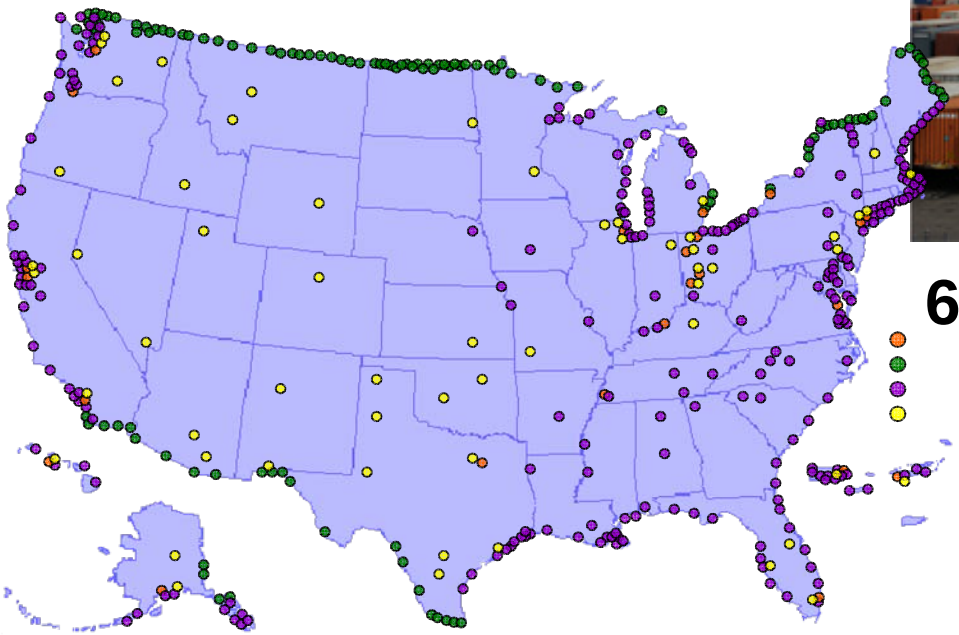
Scale of the problem: Border crossings

Ports of Los Angeles and Long Beach

Annual Container Volume:

~10 million TEUs (twenty-foot equivalent units

Cargo Value: ~$200 billion



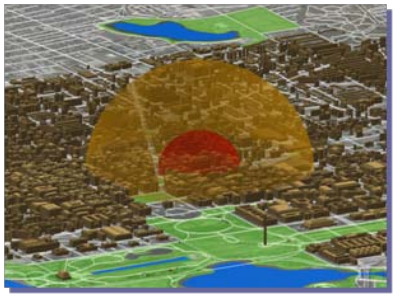
621 US Border Crossings:

- **360,000 vehicles**
- **5,100 trucks/container**
- **2600 aircraft**
- **600 vessels**

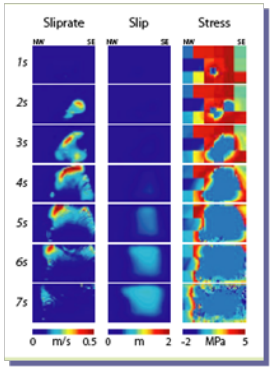
Infrastructure: Against what are we protecting?

- **Natural**
  - Accident
  - Drought
  - Earthquake
  - Flood
  - Heat Wave
  - Hurricane
  - Ice Storm
  - Landslide
  - Pandemic
  - Space Weather
  - Tsunami
  - Volcano
  - Wildfire
- **Terrorist**
  - Biological
  - Chemical
  - Cyber
  - Explosive
    - IED
    - VBIED
    - Aircraft
  - Insider
  - Nuclear
  - Physical Assault
  - Radiological

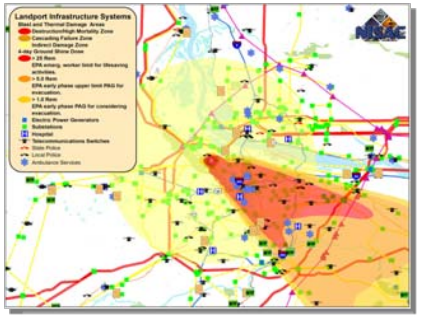
CBR Dispersion Modeling



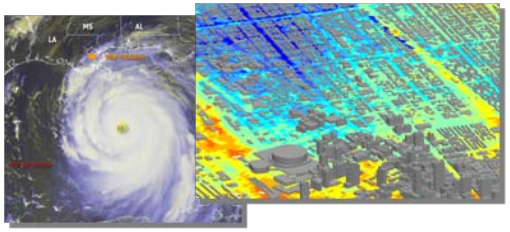
Improvised Nuclear Device



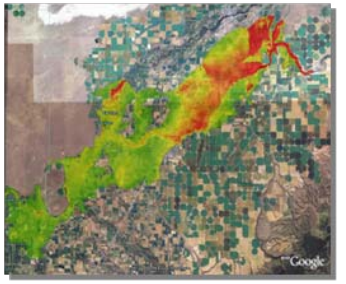
Earthquake



Infrastructure and Population Impacts



Hurricane (flooding)



Dam Break

Infrastructure has many interdependent systems

- Agriculture & Food
- Banking & Finance
- Chemical
- Commercial Facilities
- Dams
- Defense Industrial Base
- Emergency Services
- Energy
- Government Facilities
- Manufacturing
- Nuclear Reactors, Materials & Waste
- Information Technology
- National Monuments & Icons
- Postal & Shipping
- Public Health & Healthcare
- Telecommunications
- Transportation
- Water

5. ENERGY

5.1	**ELECTRICITY**
5.1.1	Electricity Generation
5.1.1.1	Hydroelectric Generation
5.1.1.1.1	*Hydroelectric Dams*
5.1.1.1.2	*Pumped Storage Facilities*
5.1.1.1.3	*Run-of-River Generators*
5.1.1.2	Fossil Fuel Electric Power Generation
5.1.1.2.1	*Coal-fired Generators*
5.1.1.2.2	*Natural-gas-fired Generators*
5.1.1.2.3	*Oil-fired Generators*
5.1.1.3	Nuclear Electric Power Generation
5.1.1.3.1	*Light Water Reactor Power Plants*
5.1.1.3.2	*Other Reactor Power Plants*
5.1.1.4	Other Electric Power Generation
5.1.2	Electricity Transmission
5.1.2.1	Transmission Lines
5.1.2.2	Transmission Substations
5.1.2.3	DC Converter Stations
5.1.2.4	Generation Dispatch and Transmission Control Center
5.1.3	Electricity Distribution
5.1.3.1	Distribution Lines
5.1.3.2	Distribution Substations
5.1.3.3	Distribution Control and Dispatch Centers
5.1.4	Electricity Markets
5.1.4.1	Generation Markets
5.1.4.2	Transmission Markets
5.1.5	Other Electricity Facilities
5.2	**PETROLEUM**
5.2.1	Crude Oil Supply
5.2.1.1	On-shore Wells
5.2.1.2	Off-shore Wells
5.2.1.3	Crude Oil Production from Other Sources
5.2.1.4	Gas-Oil Separation Plants
5.2.2	Crude Oil Storage
5.2.2.1	Strategic Petroleum Reserve
5.2.2.2	Crude Oil Bulk Storage
5.2.2.2.1	*Crude Oil Land-Based Terminals*
5.2.2.2.2	*Crude Oil Marine Terminals*
5.2.3	Crude Oil Transport
5.2.3.1	Crude Oil Pipelines
5.2.3.1.1	*Crude Oil Pipeline Segments*
5.2.3.1.2	*Crude Oil Pipeline Pumping Stations*
5.2.3.1.3	*Crude Oil Pipeline Control Centers*
5.2.3.2	Crude Oil Marine Transport
5.2.3.2.1	*Crude Oil Tankers*
5.2.3.2.2	*Ports Handling Crude Oil*

Defined in the National Infrastructure Protection Plan

Capabilities support multiple national security missions

Scientific Credibility

Agility and Innovation

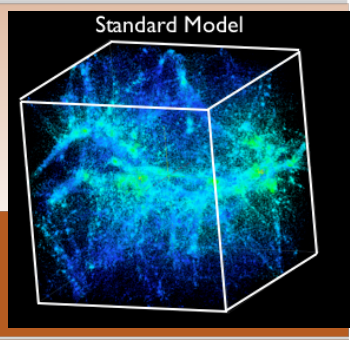
Delivery of Product

FY 2010 Grand Challenges

Beyond the Standard Model

Advances in nuclear and astrophysics at extremes, dynamics and composition of the universe and fundamental symmetries and force

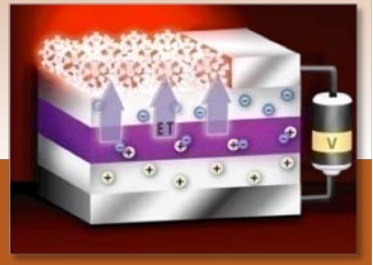
Mission Impact: Sensitive instrumentation and tools to manipulate massive data volumes, in support of national security missions



Materials: Discovery Science to Strategic Applications

Advances in prediction and control of performance, extreme environments and emergent phenomena

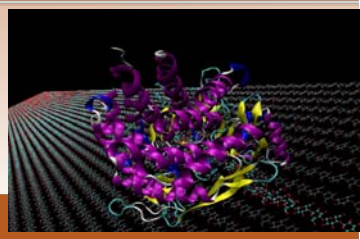
Mission Impact: Energy sources, efficiency and storage; sensing for threat reduction; materials underpinnings of stockpile security



Complex Biological Systems

Advances in protection from pathogens, biology by design, understanding of the human brain and energy and climate impacts

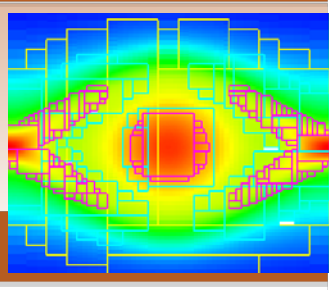
Mission Impact: Energy, national security, health and the environment



Information Science & Technology

Advances in data intensive computing, inference/prediction, quantum information science and computing in extremes

Mission Impact: Overarching capability supporting all Laboratory missions

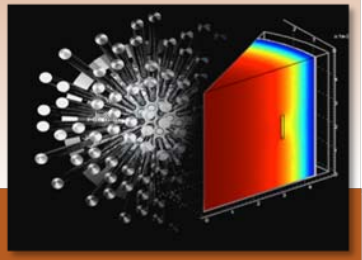


FY 2010 Grand Challenges

Energy & Earth Systems

Advances in energy storage, new fuels, nontraditional sources, sustainable nuclear power and managing energy byproducts

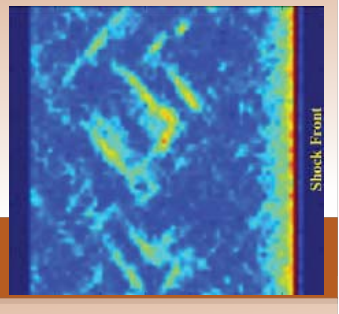
Mission Impact: Energy and climate security



Nuclear Performance

Advances in performance of heterogeneous explosives, degradation of thermonuclear performance, feedback between nuclear and thermonuclear performance and effects of off-normal conditions

Mission Impact: Stockpile safety, surety and reliability



Sensing & Measurement Science for Global Security

Advances in detection, forensics, signatures and movement/network characterization

Mission Impact: Nuclear weapons of mass destruction, space situational awareness, global environmental treaty monitoring and emerging threats

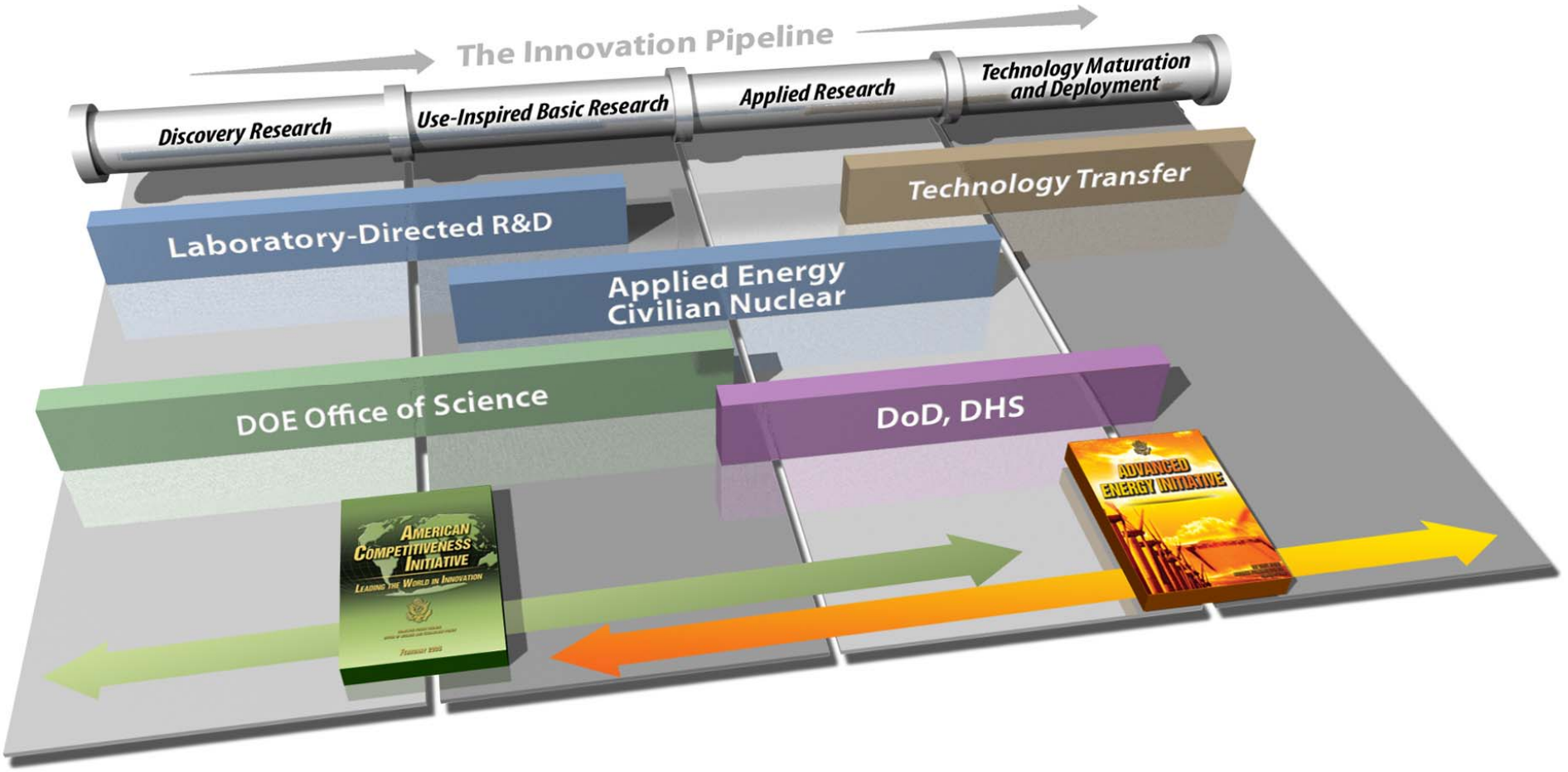
Intelligent, Adaptive Engineered Systems

Advances in validated models and simulations, intelligent sensor systems and information collection

Mission Impact: Overarching capability supporting all Laboratory missions

National Labs bridge from discovery to deployment

Strategic investments targeted to accelerate innovation



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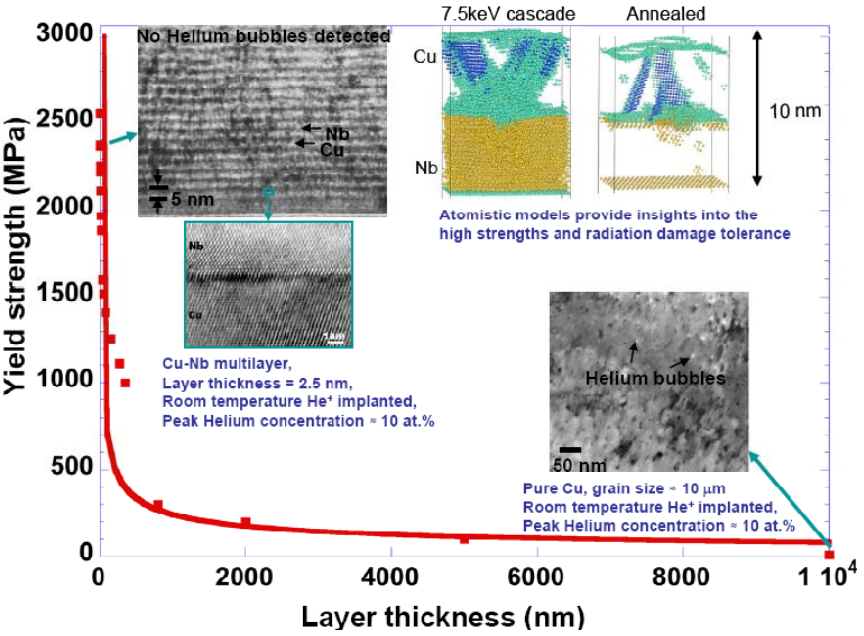
Program development partnership with LDRD PIs leads to new programs.

J. Sarrao (mentor)
Program Director, Office of Science Programs



DOE Energy Frontier Research Center

"Extreme Environment Tolerant Materials via Atomic Scale Design of Interfaces"

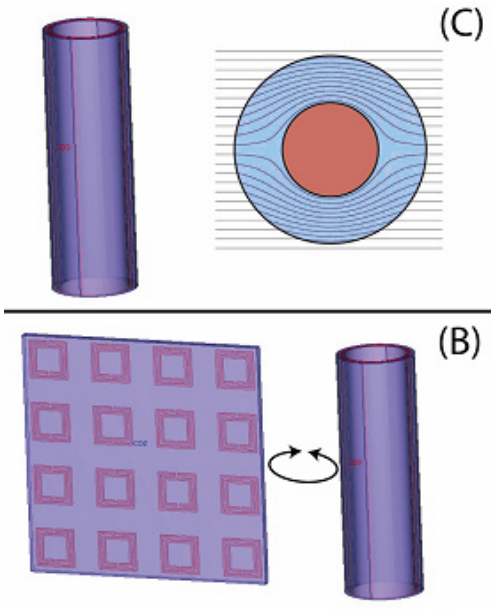
M. Nastasi, PI

Nanolayered composites provide orders of magnitude increase in strength and enhanced radiation damage tolerance compared to bulk materials.

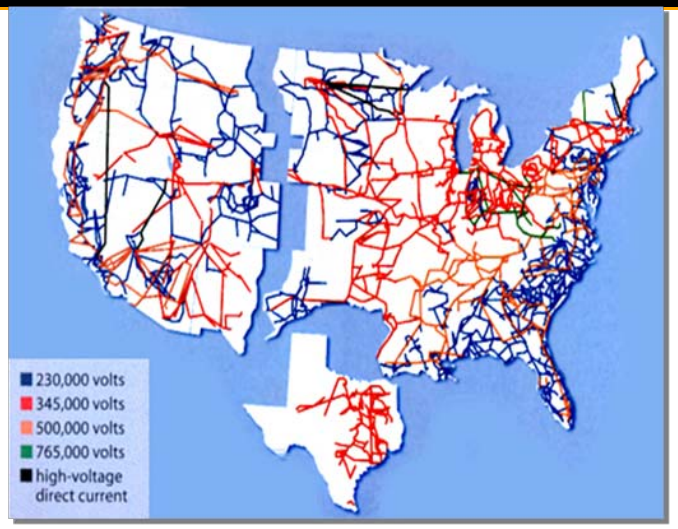
Potential applications as structural materials and coatings in nuclear power reactors.

LDRD: *Enhanced Radiation Damage Resistance via Manipulation of the Properties of Nanoscale Materials*

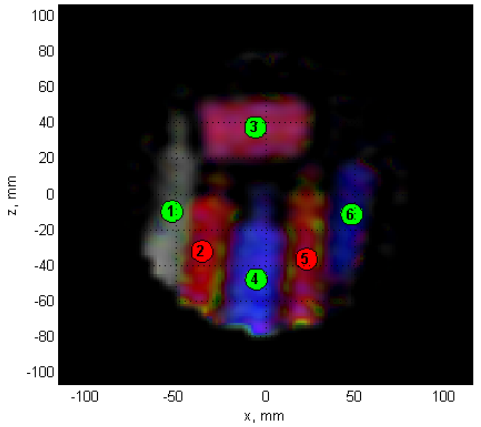
Border security requires multiple scientific advances



Materials Science



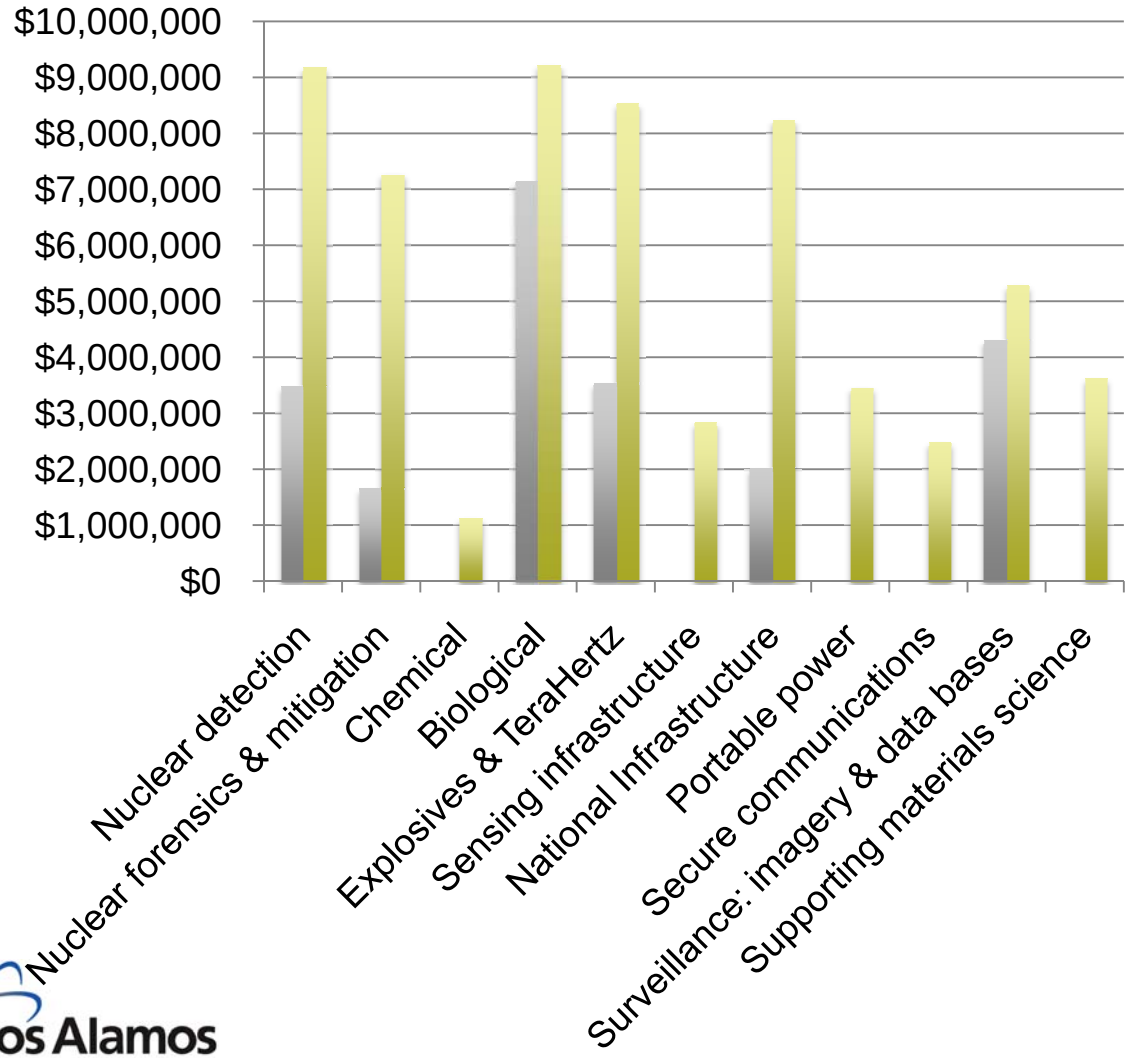
Network Science



Sensing Science

Image recognition

LDRD Investment in Homeland Security Research Areas

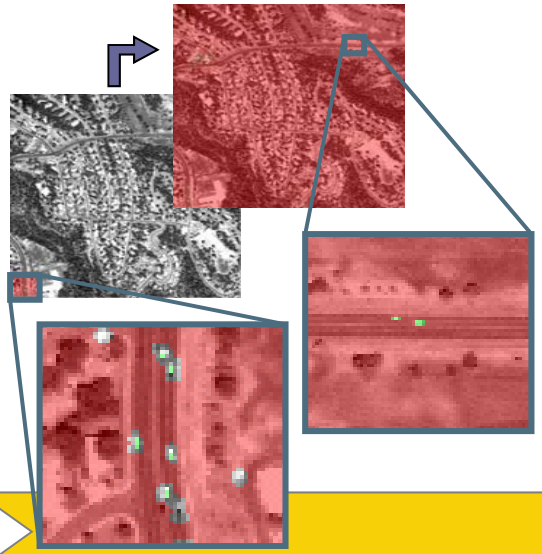


Total = $83M

- Project addresses identified mission challenge
- Project builds underlying science & technology

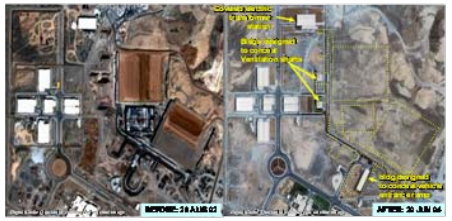
Capability for Border Security - Image Recognition

Real World Machine Learning
LDRD 20020054DR

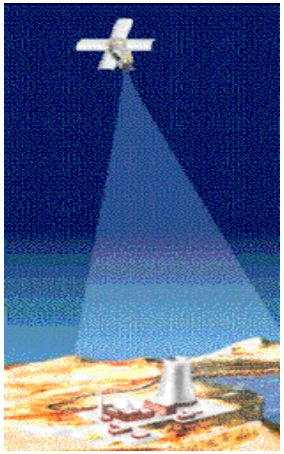


Automated Change Detection
LDRD 20080040DR

Foundations for Practical Pattern Recognition Systems
LDRD 20080182ER



Initial idea:



Automate analysis of remote sensing imagery

Enhanced analysis of remote sensing imagery

NGA/DTRA
Persistent Surveillance
(new start 2008)

NA-22
Content Based Search
LA06-VV-CBS-PD06

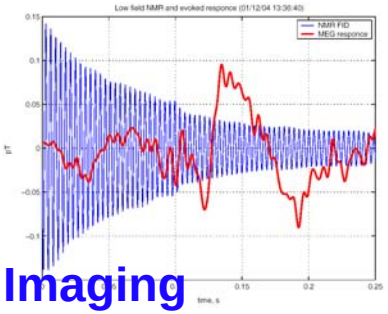
Synthetic Cognition through Petascale Models
(LDRD 20090004DR)

Spinoffs:
Genie/
Genie Pro
Vista
RaveGrid

Path to Mission Solutions: ULF-MRI Technology

Simultaneous MEG/MRI

LDRD Project 20060312ER



Resonant Neural Current Imaging

LDRD Project 20070349ER

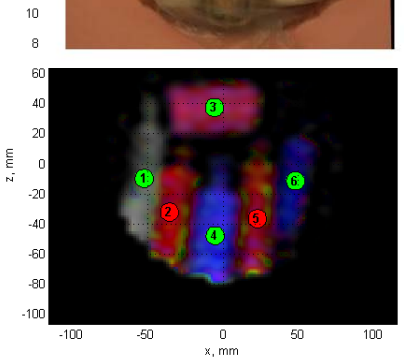
Homeland Security: Threat Material Detection

Brain Imaging

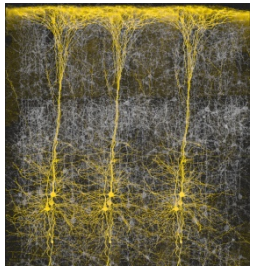
Tissue & Material Discrimination

Function & Structure

New Physics: Resonant Detection



DOE/BER Investment



NIH Neural Current Modeling

ULF-NMR Detection of SNM (^{235}U)

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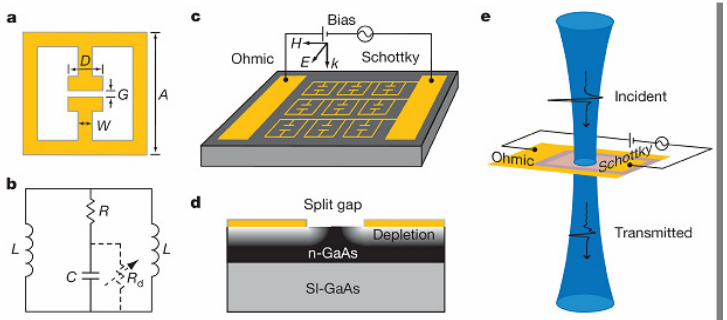
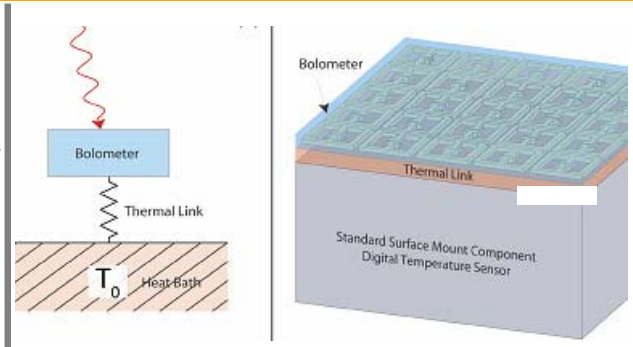
Metamaterials: Enabling Advanced Imaging, Signal Processing, and Cloaking

Signal Processing



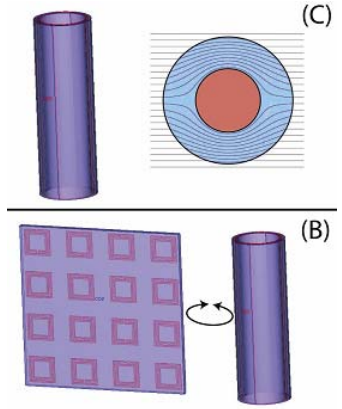
- Introduced the concept of *active* THz metamaterials
- Photonic/electronic control of material properties (e.g. index of refraction) on an ultrafast time scale
- Basis for coherent wave control over entire EM spectrum
- Applications: high-speed communications, THz radar

Imaging



- Metamaterials enable perfect absorption of electromagnetic waves.
- Demonstrated metamaterials with nearly perfect absorption and transmission
- Enables high-frequency imaging (bolometric) arrays
- Applications: microwave/far-IR imaging, non-invasive spectroscopy and sensing.

Cloaking



- Cloaking requires 3D, conformable materials with custom EM properties
- Demonstrated flexible, multi-layer THz metamaterials, the first steps in cloaking
- Applications: antenna shielding, basis for complex wave control devices (e.g. lenses).

Led to DARPA funding on metamaterials for MEMS technology and IC projects on faster modulators and lightweight lenses.

Space Situational Awareness: Global Monitoring of the Sky

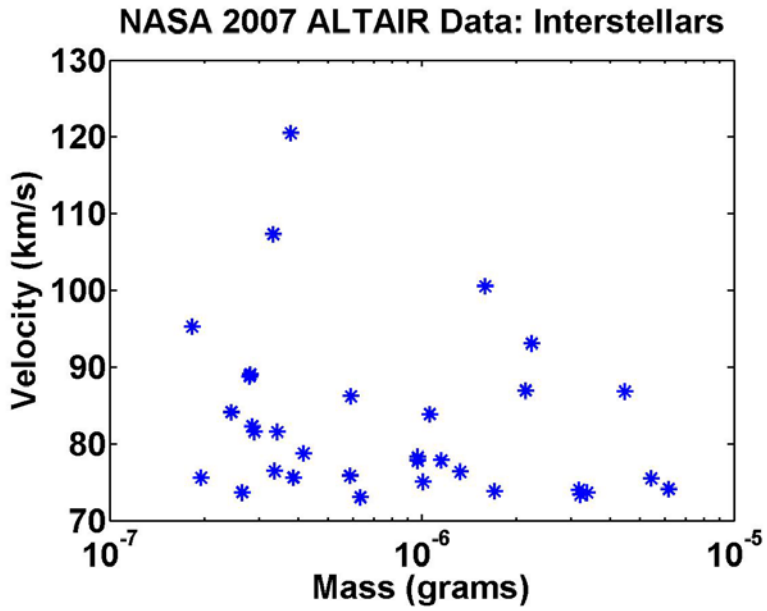
RAPTOR telescope

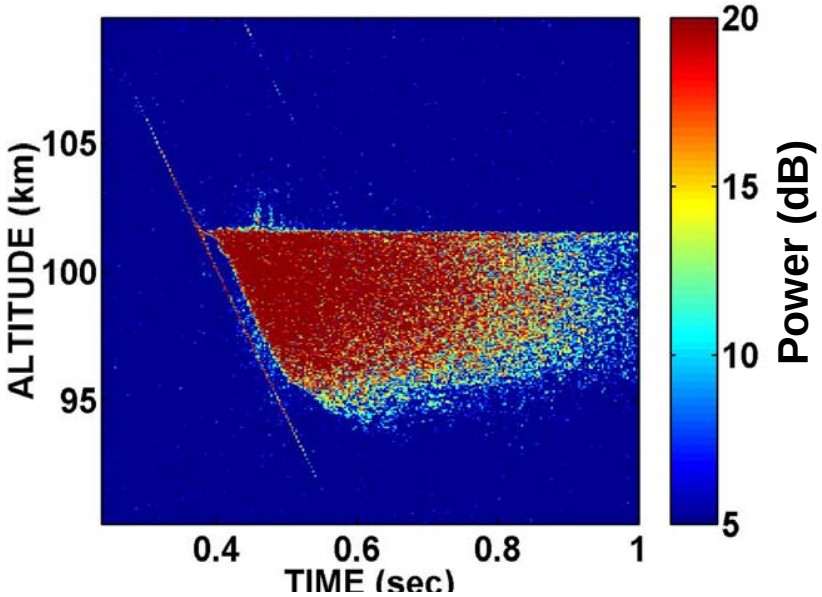
Gamma-ray burst

- LDRD investment to understand gamma-ray bursts demonstrates new mission solutions to detect and track objects in space.
- World's most advanced network of robotic instruments can image transient events within 10 seconds.
- "Thinking telescopes" help protect the national space infrastructure.

New approach using automated, networked instrumentation for dynamic monitoring for Space Situational Awareness and ubiquitous sensing.

Space situational awareness: The First Characterization of Large Interstellar Dust





Mission relevance

- RF detection of dense plasma structures
- Modeling of ablation and plasma physics for atmospheric explosive events
- Dust detection for spacecraft and satellite safety and Space Situational Awareness
- Protects information infrastructure.

National Convergence on Energy Security

"The challenge is so immense that existing energy approaches – even with improvements from advanced engineering and improved technology based on known concepts – will not be enough to secure our energy future. Instead, meeting the challenge will require new technologies for producing, storing, and using energy with performance levels far beyond what is now possible."

DOE Basic Energy Sciences Advisory Committee, December 2008

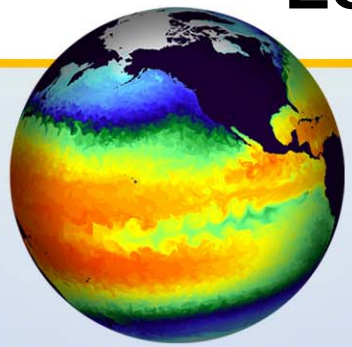
"Just like the nation, to reduce its energy risks the DoD must significantly improve its energy productivity and use renewable sources where possible. Technologies that extract more capability from the energy we use improve our military capability and make our industries…increasingly more competitive in a global market that increasingly values efficiency."

Defense Science Board Task Force on DoD Energy Strategy, February 2008

"Global climate change will have wide-ranging implications for US national security interests over the next 20 years…. The most significant impact for the United States will be indirect and result from climate-driven effects on many other countries and their potential to seriously affect US national security interests."

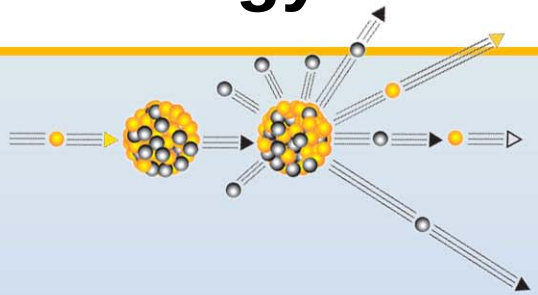
Thomas Fingar, Chairman, National Intelligence Council, June 2008

Los Alamos Energy Security Focus Areas



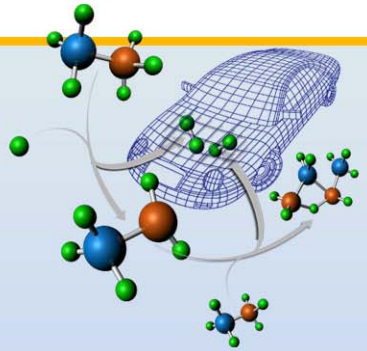
Impacts of Energy Demand Growth

- Coupled predictive models for climate, infrastructure impact analysis
- Prediction of abrupt change at multiple scales (regional to global)
- Global security and policy implications



Sustainable Nuclear Energy

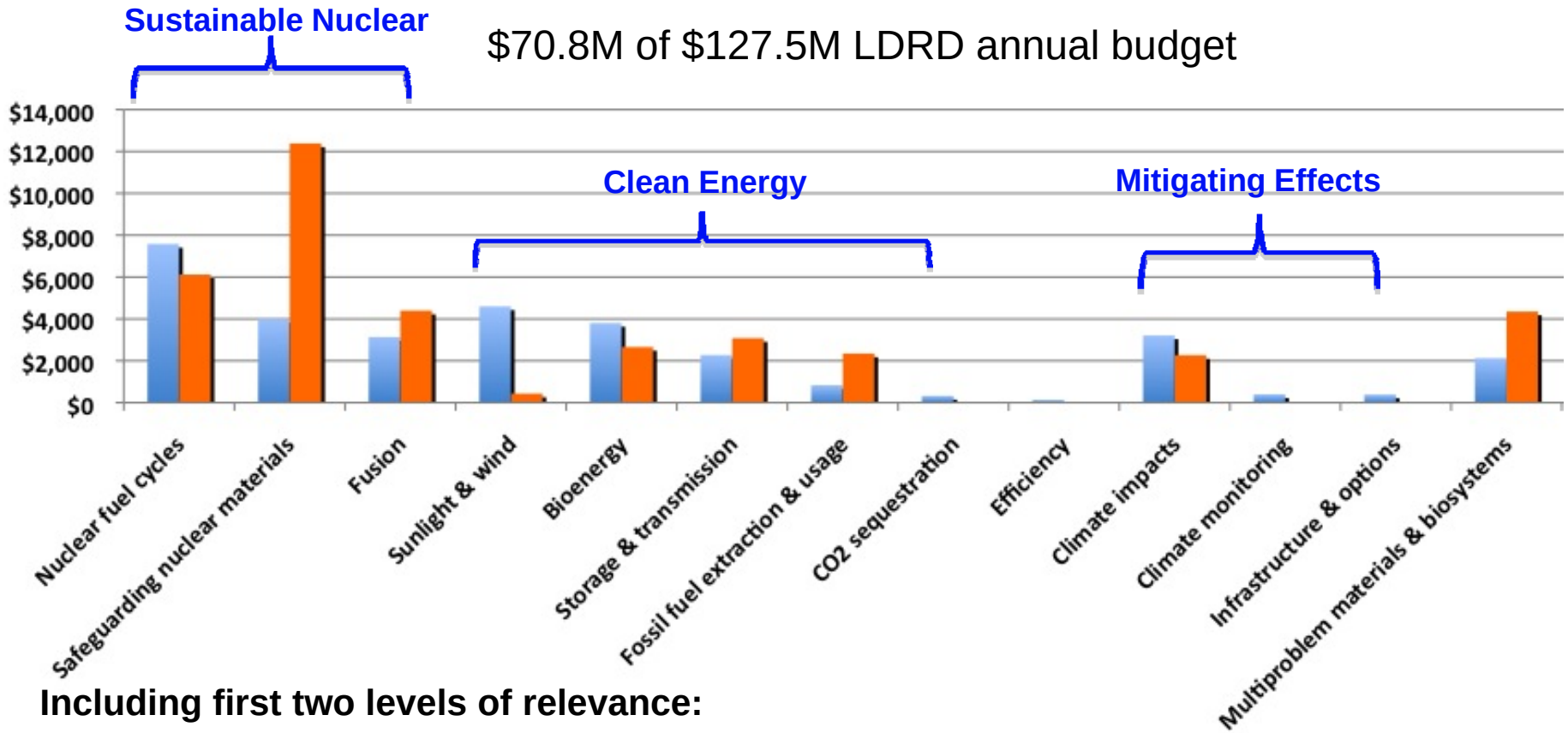
- Efficient extraction of energy content from fuel
- Nonproliferation & safeguards
- Effective waste management



Concepts and Materials for Clean Energy

- Energy storage, generation, and transmission
- Revolutionary alternatives to petroleum
- Clean fossil energy

LDRD projects support Energy Security



$70.8M of $127.5M LDRD annual budget

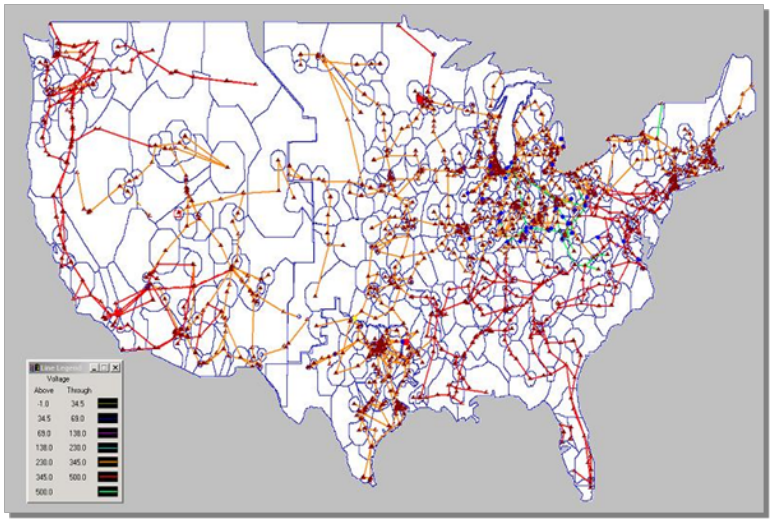
Including first two levels of relevance:

- Project directly addresses a well-defined, long-term concern
- Project performs fundamental research and development that underlies the science and technology

Energy Grid Challenges of the Future

Future electric grid requires integrating renewables and anticipating change.

- Requires predictive simulation and rapid integration of new technologies for renewable generation, transmission, and storage.
- Integration is needed to maintain grid stability.
- Cost-effective investment requires predictive simulation.

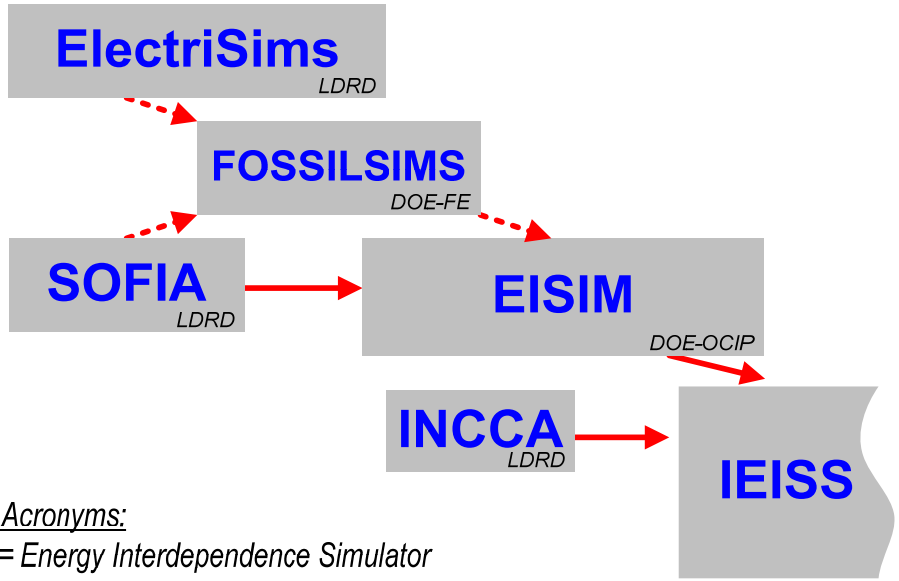


Constraints:

- Utilities manage centralized, slowly-variable resources.
- Transmission grids are not designed for unpredictable flow patterns.
- Utility-scale storage capacity currently are very low.
- Future technologies need an integrated plan today.

LDRD investments fostered our infrastructure modeling capability

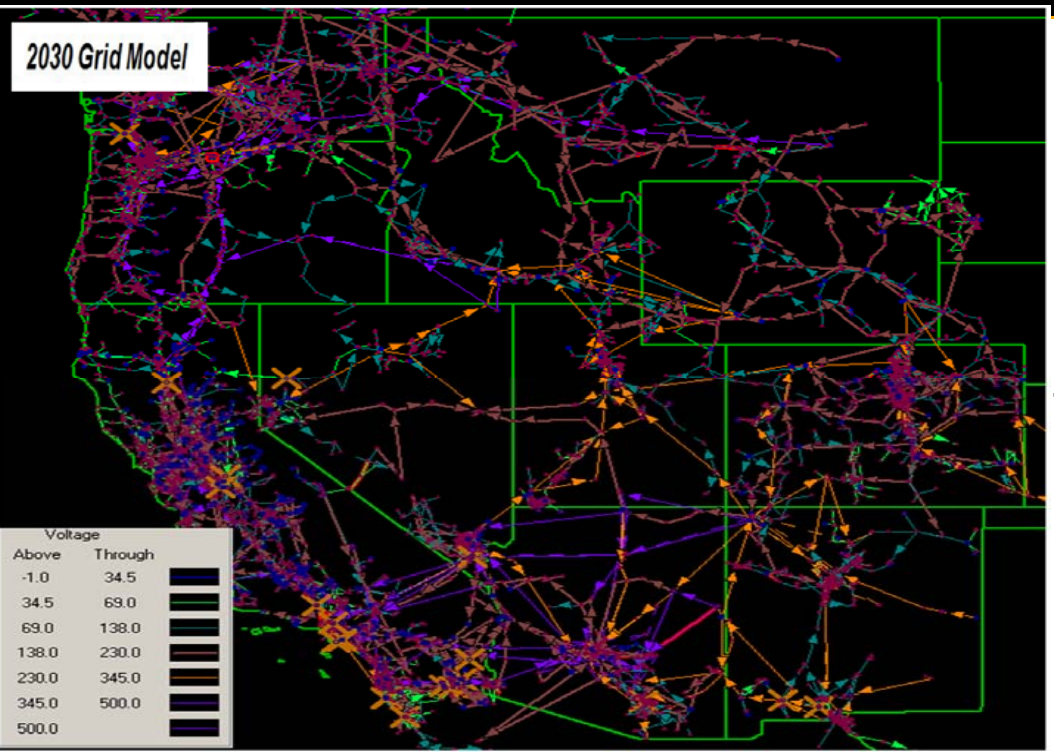
Analyze scenarios affecting multiple networks and cascading interdependencies.



Key to Acronyms:

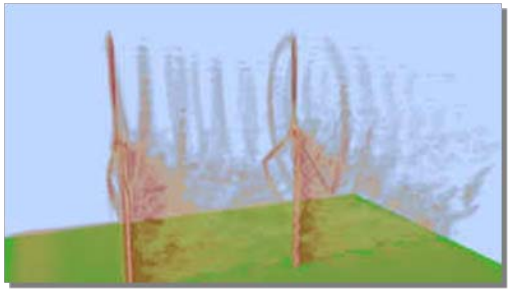
EISIM = Energy Interdependence Simulator
ElectriSims = EliSims = Electric Industry Simulation System
FOSSILSIMS = Fossil Energy Simulation System
IEISS = Interdependency Environment for Infrastructure System Simulation
INCCA = Infrastructure Network Criticality and Causality Analysis
SOFIA = Simulation Object Framework for Infrastructure Analysis

Challenge: 20% wind energy integration



LDRD Projects

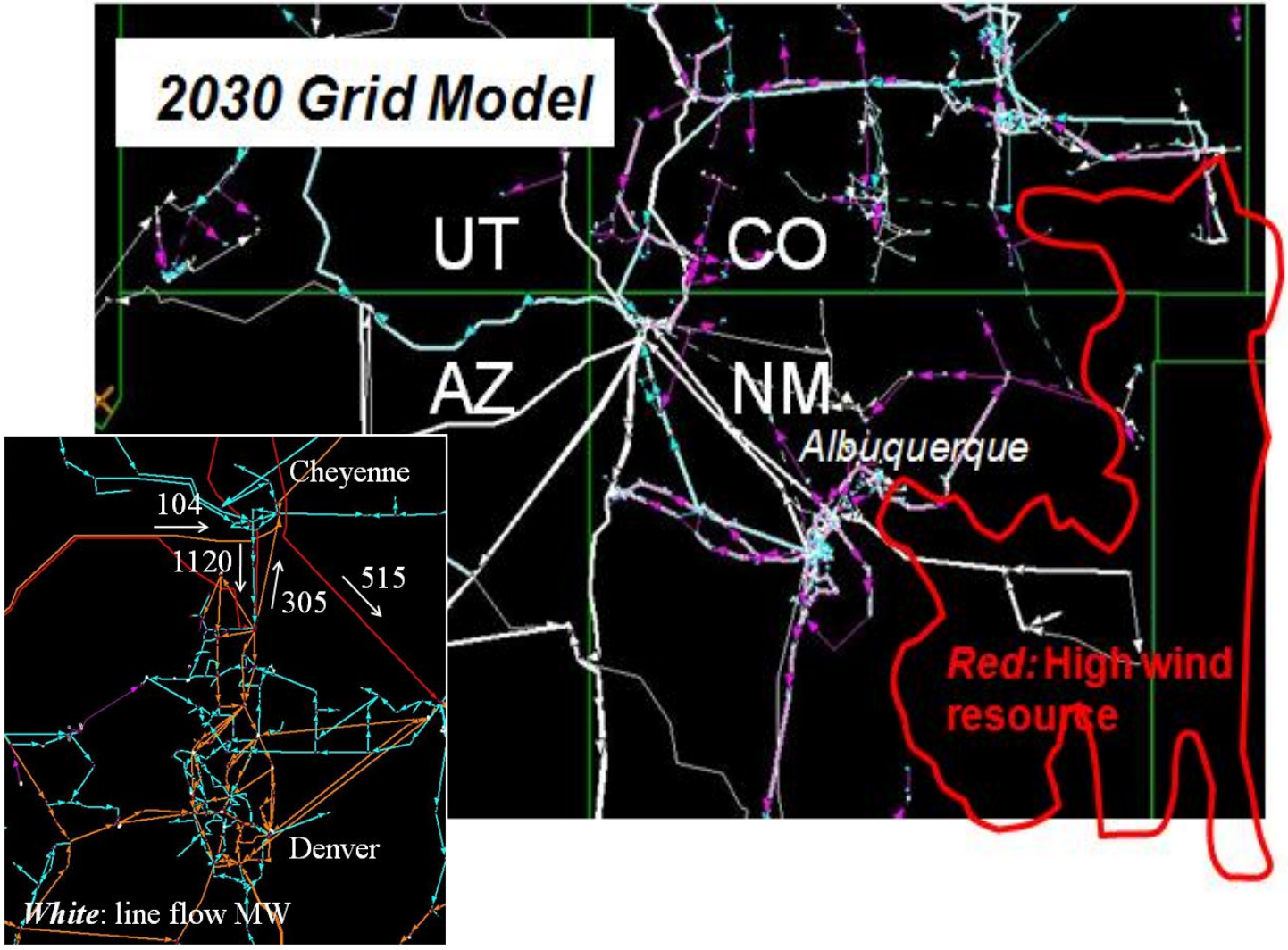
- Designing Intelligence into the Next Generation Wind Turbine
- Lagrangian Approach to Capturing Interactions between Wind-Energy Turbines and Atmosphere
- Intelligent Wind Turbines
- Science for a Robust Electrical Grid: Optimization and Control



Institutional Computing Project

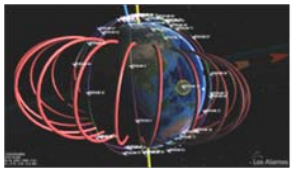
- Atmospheric Modeling for Wind Energy

Complex flows in actual grid

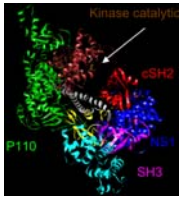


LANL Posters

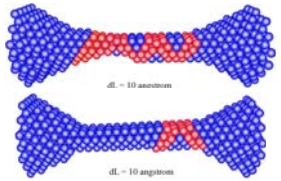
- **Protecting Our Space Enterprise**



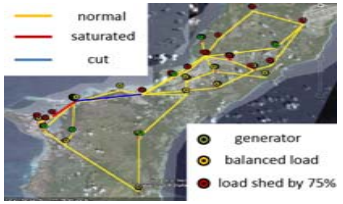
- **Defense Against Pandemics**



- **Stronger Materials for the Infrastructure**



- **Science for a Robust Electrical Grid**



- **Magnetic Resonance Imaging to Understand the Brain and Protect our Borders**