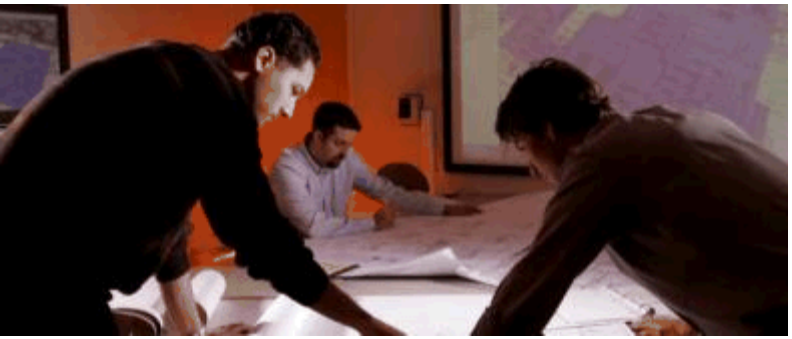
SAND2013-4704C

Exceptional service in the national interest

Sandia National Laboratories



Len Napolitano, Ph.D.

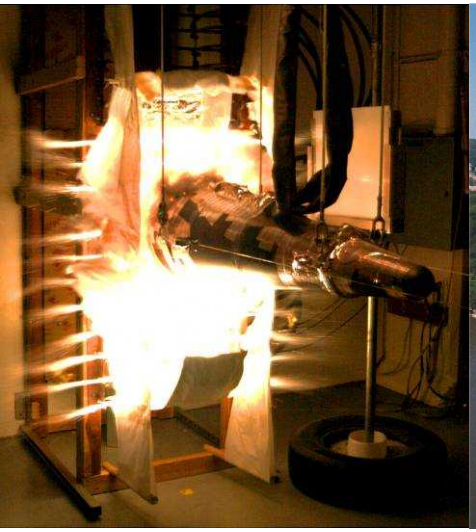
Director
Computer Sciences & Information Systems
Sandia National Laboratories

An Overview

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND No. 2012-5130P

We have four mission areas . . .

- Nuclear Weapons
- Defense Systems and Assessments
- Energy, Resources and Nonproliferation
- Homeland Security and Defense

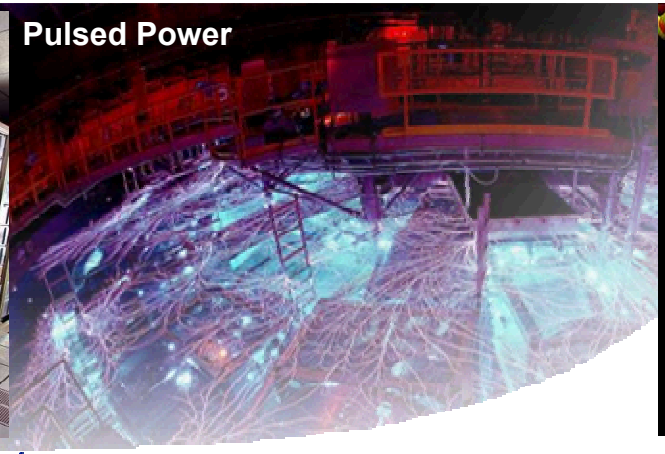


. . . enabled by strong science and engineering.

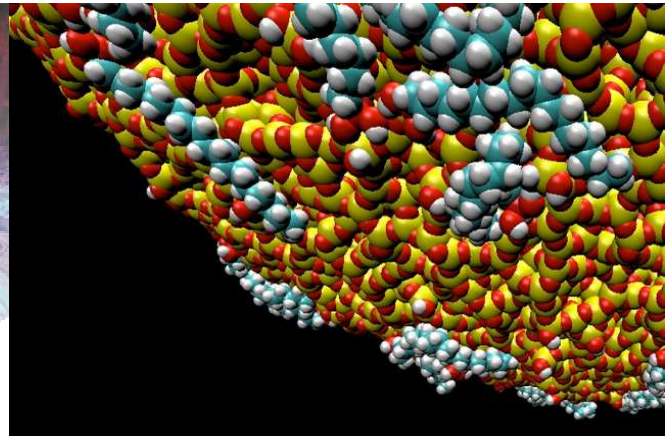
Our Research Disciplines

Computer Science

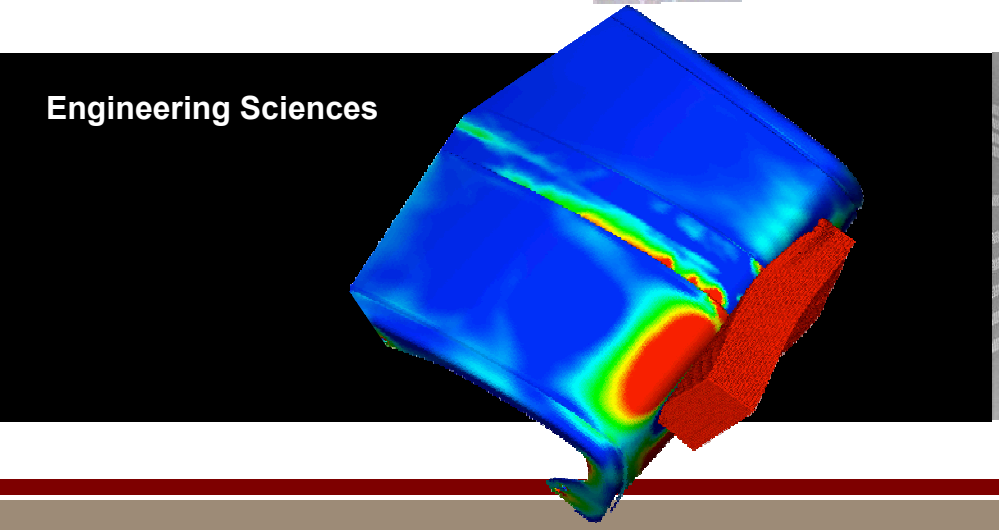
Pulsed Power



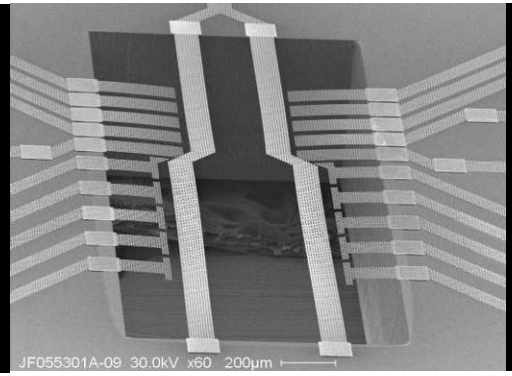
Materials



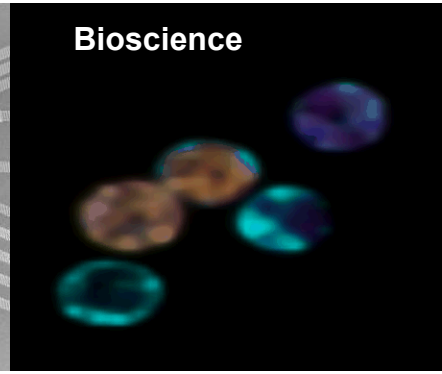
Engineering Sciences



Micro Electronics



Bioscience



Sandia's Impact

Cleanroom invented 1963

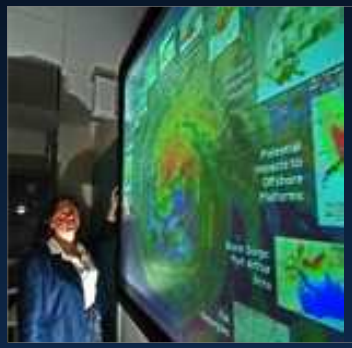
$50 billion worth of cleanrooms built worldwide It's used in hospitals, laboratories and manufacturing plants today.

9/11

Sandia sets contingency plans for release of materials and aircraft attacks on critical facilities. Search dogs equipped with cameras for search and rescue K-9 handlers

2008 Satellite Takedown

Red Storm computing helps shoot down rogue satellite



Hurricane Katrina

Sandia is called to assess flooding & infrastructure failures

Fukushima

Sandia helps cleanup radioactive wastewater

Columbia Tragedy

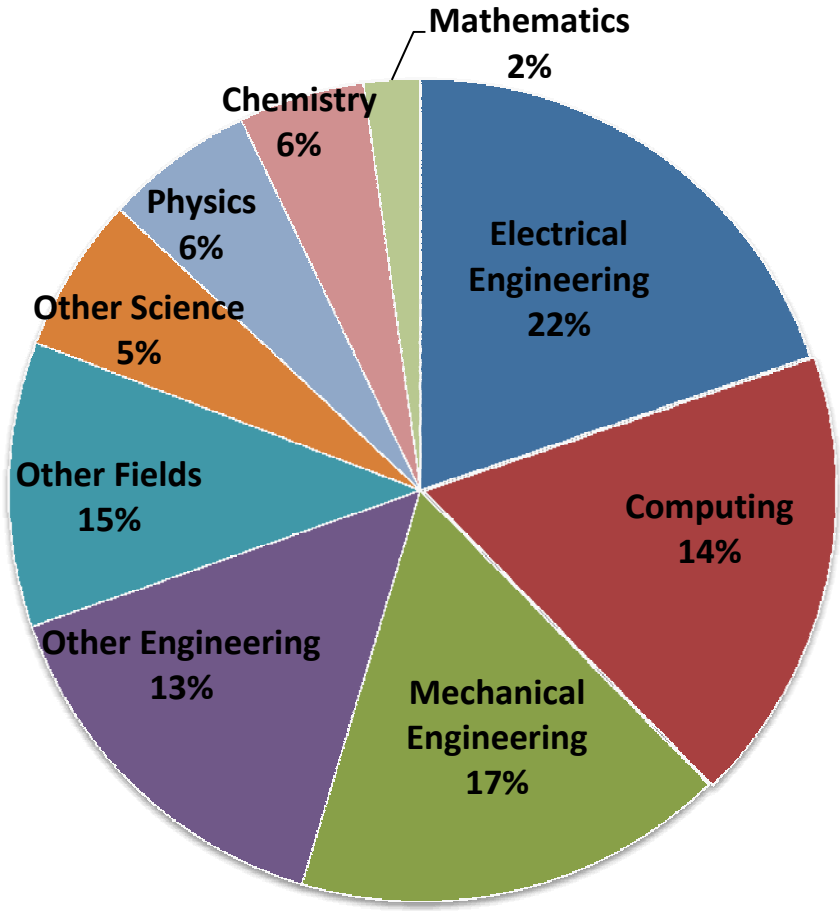
Sandia scientists and engineers are called to investigate the disaster and how to prevent it from happening again.

Our Workforce

- On-site workforce: 11,711
- Regular employees: 9,494
- Gross payroll: ~$1.046 billion

Data as of April 12, 2013

R&D staff (4,799) by discipline



Computational Science in action: Assuring the nation's nuclear stockpile safety

System Engineers

- Do our systems meet safety requirements in an accident?
- Can we adjust system design or operational procedures to improve safety?

Analysts

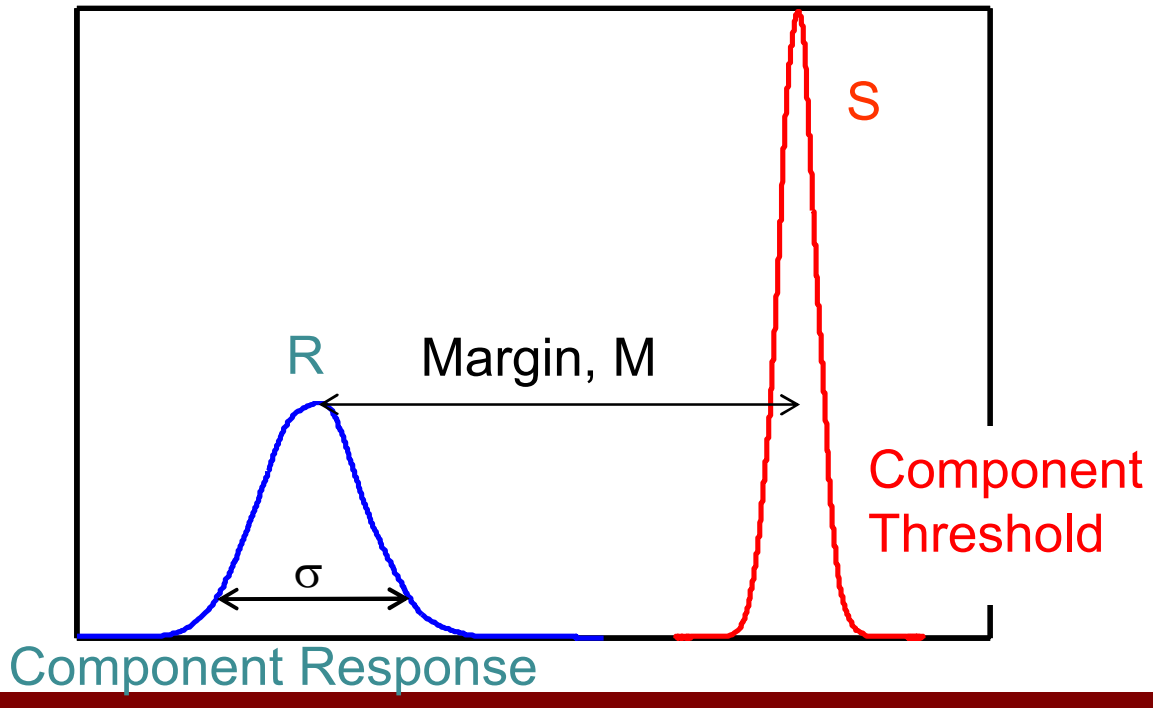
- How do we use M&S to answer safety questions in the absence of testing?
- How can we address uncertainties given computationally expensive simulations?

Computational Scientists

- What new mathematical models and numerical/statistical methods are needed?
- How do we implement these efficiently in software on advanced architectures?

Quantification of Margins and Uncertainty (QMU) is the framework for addressing safety questions

- Quantifies the performance thresholds and associated margins for systems made under conditions of uncertainty
- Margin - Difference between system's nominal/median performance vs. a do-not-exceed threshold.



Verification and validation (V&V) and QMU provide a rigorous basis for credible computational simulation supporting risk-informed decision making

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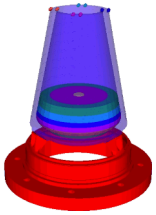
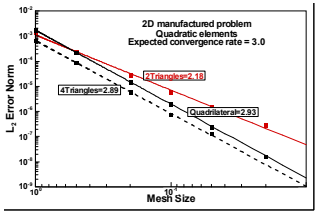
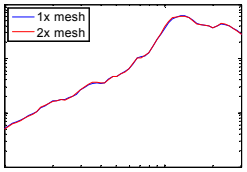
Representation and Geometric Fidelity



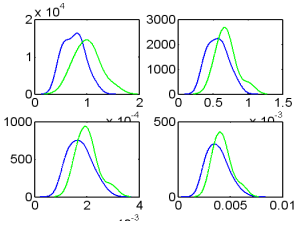
Code Verification



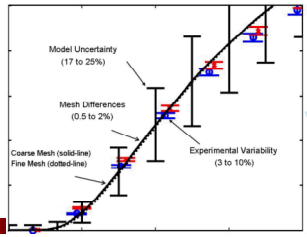
Solution Verification



Model Validation



Uncertainty Quantification

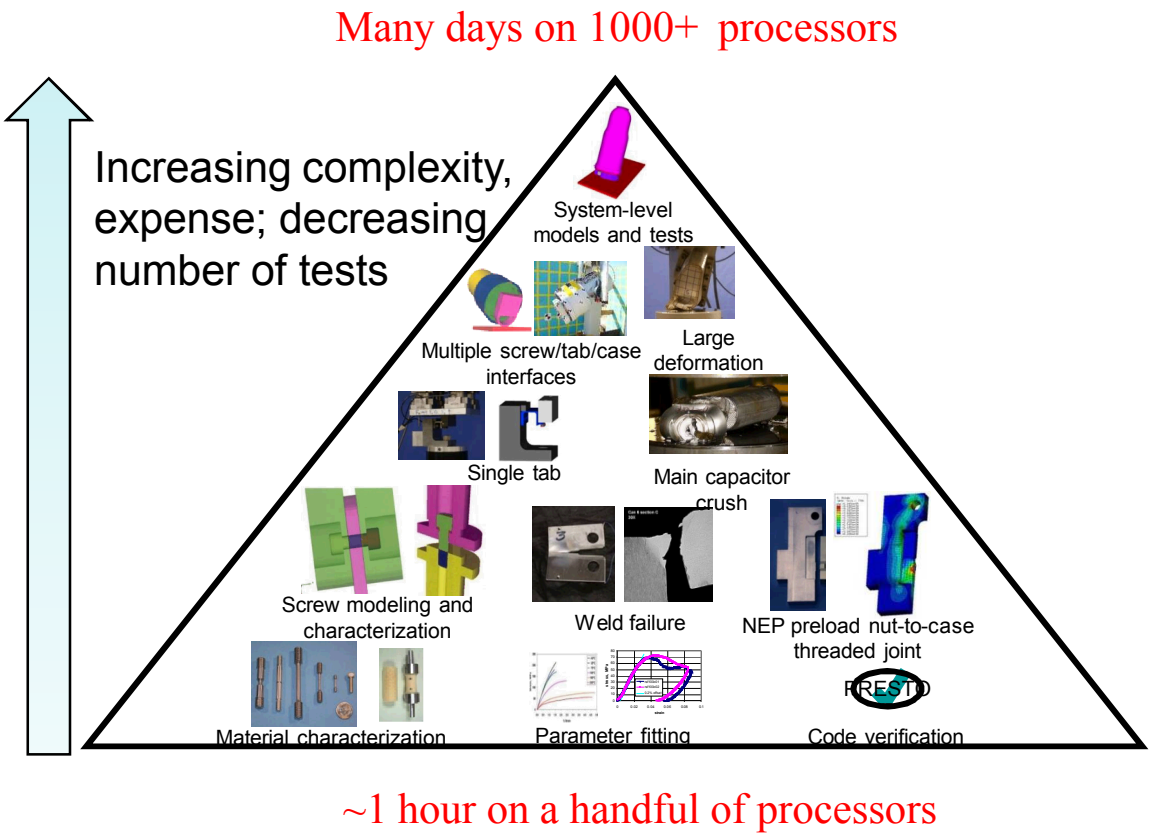


Credibility Assessment

Uncertainty Quantification and QMU

Risk-Informed Decision Making w/Computational Simulation

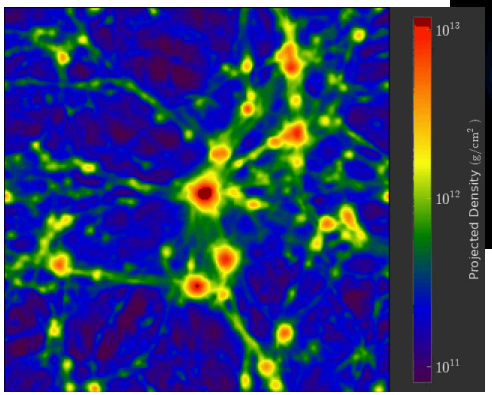
Complicated system hierarchy and high computational demands motivate new research to enable V&V and QMU

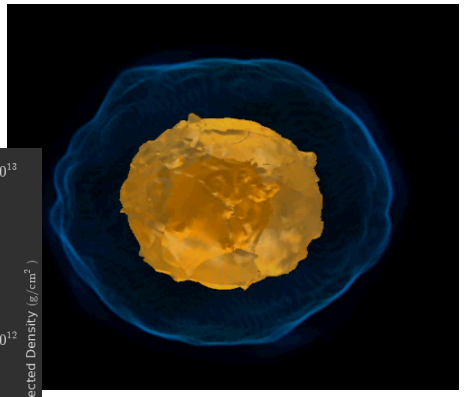


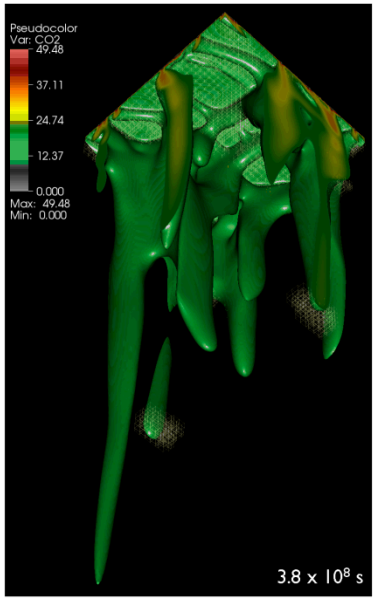
- **(Non-exhaustive) list of research areas**
  - Scalable uncertainty quantification methods
  - Methods for combining and propagating errors and uncertainties through multiple system levels
  - Hybrid optimization and uncertainty quantification methods
  - Reduced-order and surrogate modeling
  - Scalable pre-conditioners
  - Solution and code verification tools
  - Workflow tools

Combustion as a Surrogate for Broader Class of Problems

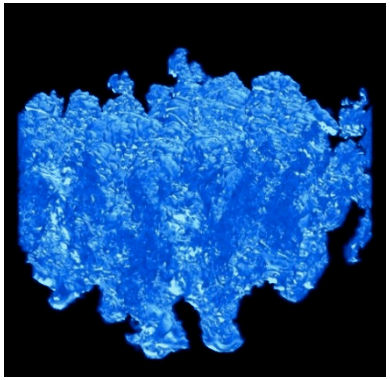
- **Combustion is surrogate for a broader class of PDE problems:**
  - Cosmology
  - Subsurface Flow
  - Astrophysics
  - Defense Science

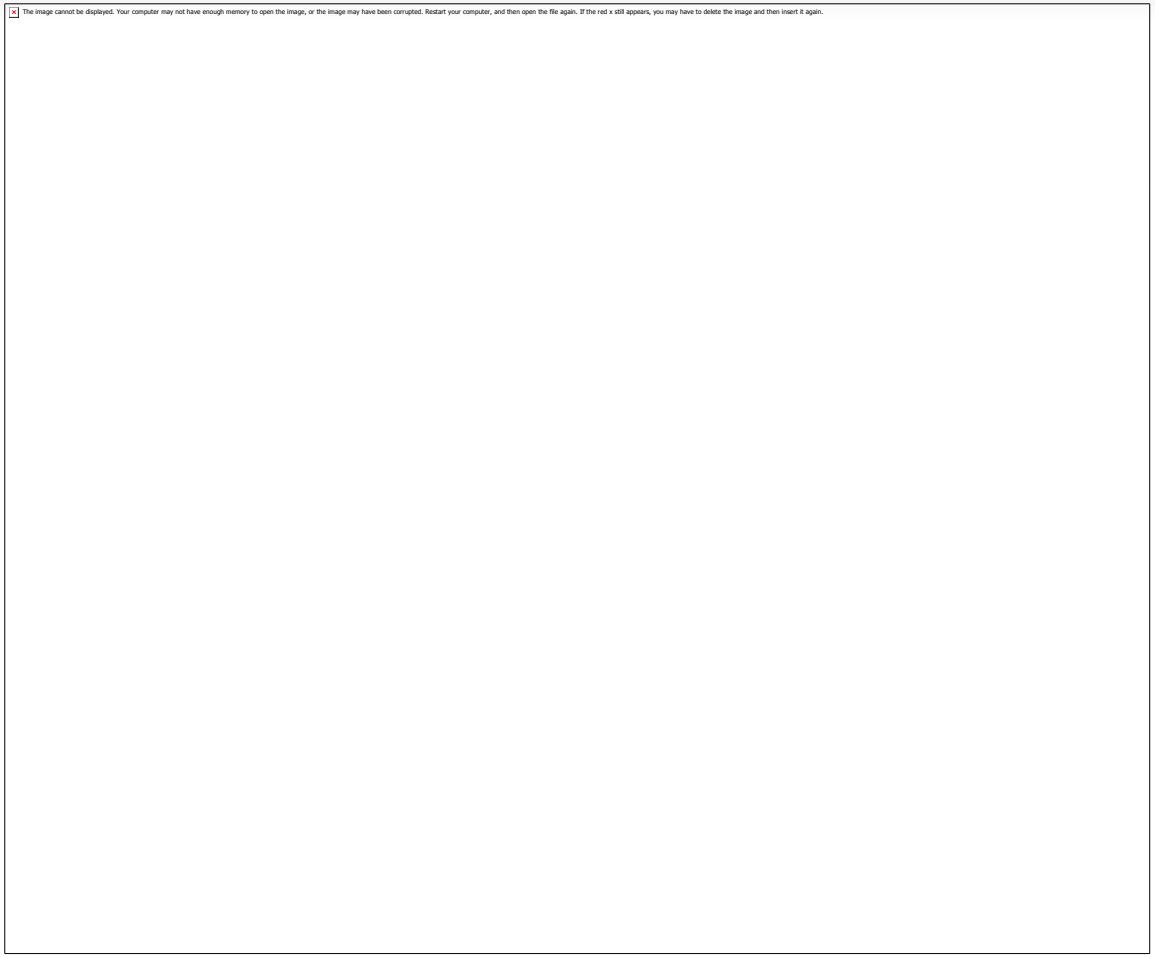






- **In situ analytics/viz/UQ also applies to broad range of domain science:**
  - Fusion
  - Climate
  - Combustion
  - Astrophysics
  - Shock/Turbulence

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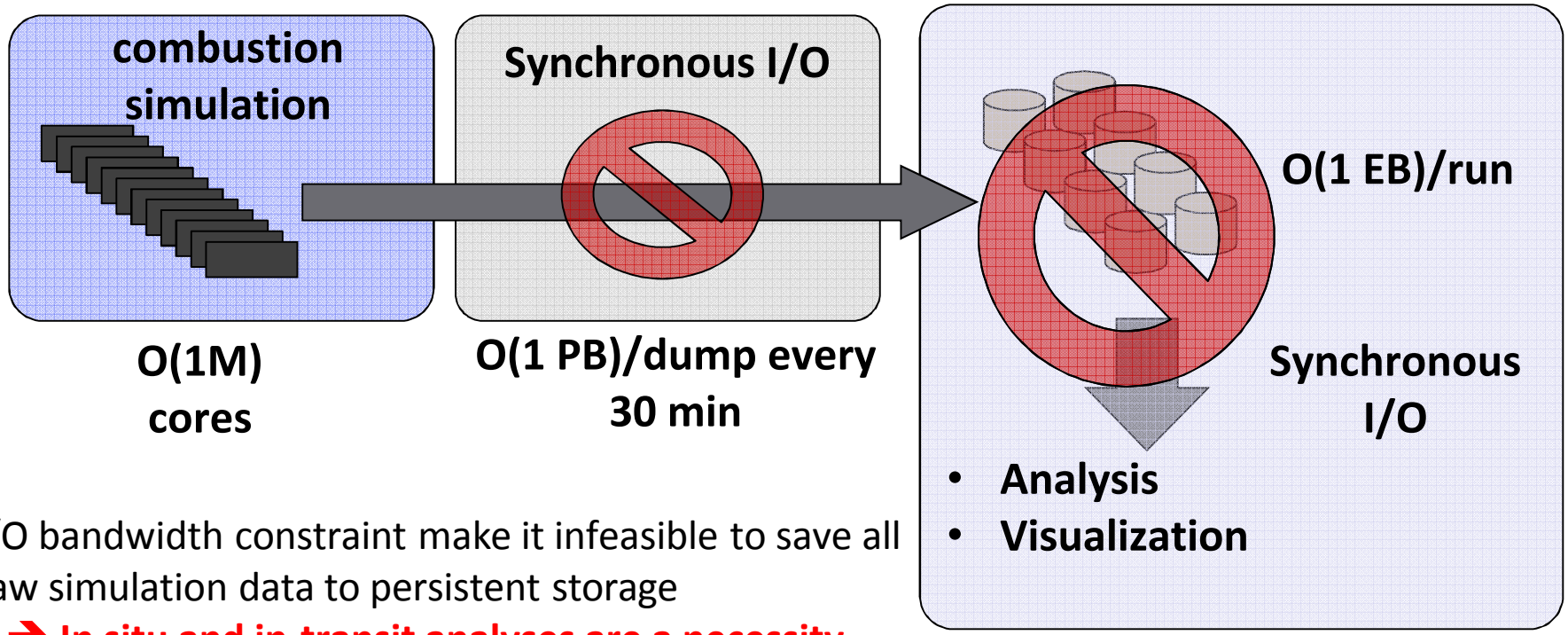
Petascale Computing Workflow Model Will Not Work at Exascale

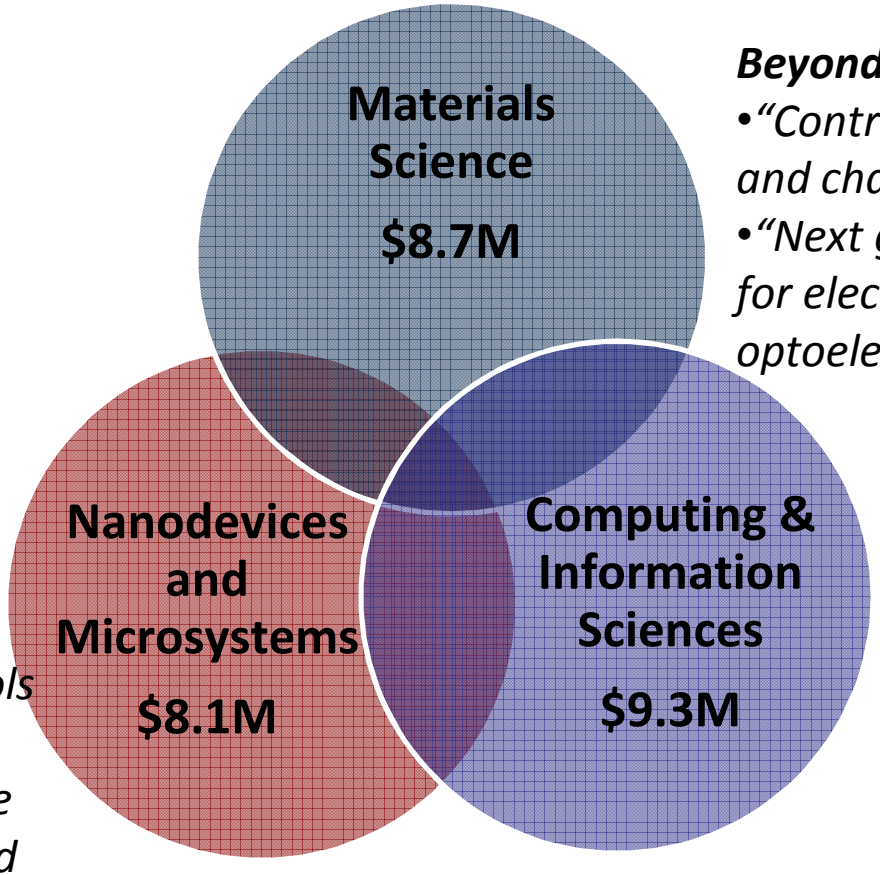
Sandia National Laboratories

Performing the simulation is not enough – need to analyze results



- I/O bandwidth constraint make it infeasible to save all raw simulation data to persistent storage
  - ➔ **In situ and in-transit analyses are a necessity**
- Challenge: co-design a workflow that supports smart placement of analyses, visualization and UQ, tracking large graphs, reducing checkpointing size with in-situ analytics

Sandia's Beyond Moore's Computing Research Challenge



Beyond Moore Materials:
- *"Control of energy, mass, and charge transfer"*
- *"Next generation materials for electronics and optoelectronics"*

"Beyond Moore Technologies: *The development of concepts, devices, tools and systems that continue performance improvements beyond Moore's Law."*

"Beyond Moore Computing: *The development of a new device family and architecture with vastly superior properties and exponential improvement curve."*

The Structural Simulation Toolkit: a community simulation framework for HPC

Sandia National Laboratories

- **Goal**
  - Make SST the standard architectural simulation framework for HPC
  - Be able to evaluate future systems on relevant workloads
  - Use supercomputers to design supercomputers
- **Approach**
  - Parallel Discrete Event core with conservative optimization over MPI
  - Simple & detailed models for processor, network, memory & power
  - Open Core, non viral, modular
  - Current Release (2.1) at code.google.com/p/sst-simulator/
- **Partnering**
  - "Best of Breed" simulation suite combining Labs, academia, & industry

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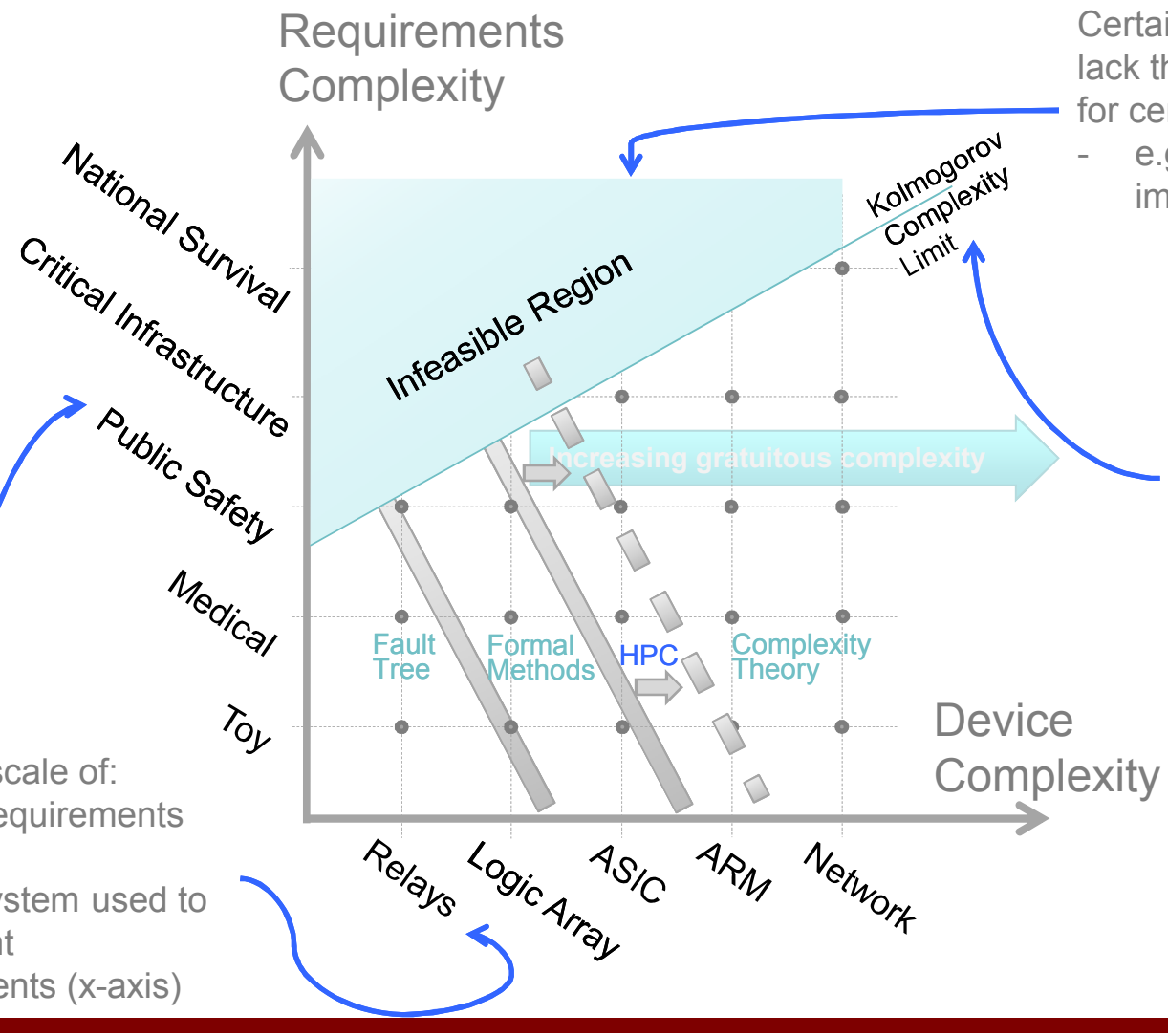
Cyber 1 & 2 from Bob

Mapping the Complexity Space of Components and Systems for Determining Trust



Certain devices inherently lack the complexity needed for certain tasks

- e.g., a relay cannot implement a power grid

A device needs only a given amount of design complexity to implement a set of requirements

Logarithmic scale of:

- System requirements (y-axis)
- Device/system used to implement requirements (x-axis)

Slide 16

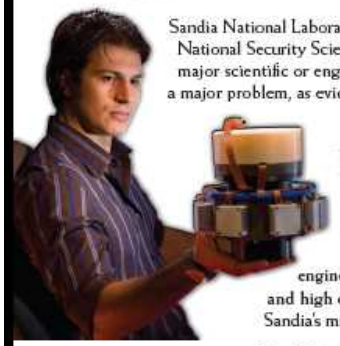
LAM1 make this the "theory of trust" slide? and move up in the deck
LeAnn, 5/12/2013

Sandia has an active hiring program in HPC

- **Student Internships**
  - Undergraduate and graduate
  - Typically summers, but not exclusively
- **Hire at all levels**
  - BS, MS, PhD
  - CS and Engineering concentrations
  - Full time, Limited term, Postdocs
- **In addition to scalable computing, we are very active in cyber security.**

SANDIA NATIONAL LABORATORIES

President Harry S. Truman Fellowship in National Security Science and Engineering



Sandia National Laboratories is seeking applicants for the President Harry S. Truman Fellowship (in National Security Science and Engineering). Candidates for this position are expected to have solved a major scientific or engineering problem in their thesis work or have provided a new approach or insight to a major problem, as evidenced by a recognized impact in their field.

The Fellowship provides the opportunity for new Ph.D. scientists and engineers to pursue independent research of their own choosing that supports Sandia's national security mission. The appointee is expected to foster creativity and to stimulate exploration of forefront science and technology and high-risk, potentially high-value research and development.

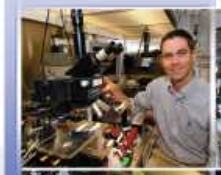
Sandia's research focus areas are: bioscience, computing and information science, engineering science, materials science, nanodevices and microsystems, radiation effects and high energy density physics, and geosciences. Additional R&D programs in support of Sandia's mission areas can be found here.

Candidates must meet the following requirements: the ability to obtain a DOE "Q" clearance; and a Ph.D. (3.5 undergraduate and 3.7 graduate GPA preferred), awarded within the past three years at the time of application, or completed Ph.D. requirements by commencement of appointment. Candidates must be seeking their first national laboratory appointment (no previous postdoctoral appointments at a national laboratory).

The Truman Fellowship is a three-year appointment normally beginning on October 1. The salary is $111,200 plus benefits and additional funding for the chosen proposal. The deadline is November 1 of each year. For more information on the Fellowship and how to apply, see:

http://sandia.gov/careers/students_postdocs/fellowships/truman_fellowship.html

Sandia works in close partnership with federal agencies, universities, and industries to remain at the leading edge in accomplishing our mission.



Sandia National Laboratories is one of the country's largest research facilities employing nearly 8,500 people at major facilities in Albuquerque, New Mexico and Livermore, California. Please visit our website at www.sandia.gov.

Sandia is an equal opportunity employer.
We maintain a drug-free workplace.

LOCKHEED MARTIN

Sandia National Laboratories

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Sandia - *Today*

Our expanded role today as a multi-program national security laboratory, Sandia has played a vital role in ensuring that our country maintains science and engineering superiority.

We invite you to be a part of something more – a quest for rendering an exceptional service in the national interest.

Sandia National Laboratories

Backup stuff

Sandia's History

THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

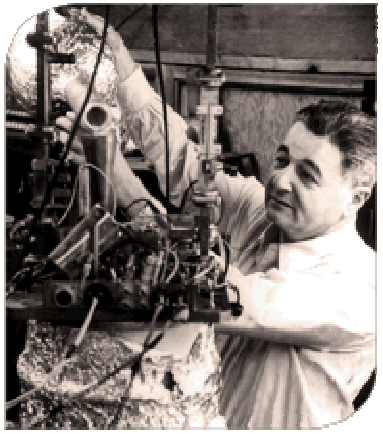
I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

Sandia National Laboratories



National Security Challenges

1950s	1960s	1970s	1980s	1990s	2000s	2010s
Nuclear weapons	Development engineering	Multiprogram laboratory	Missile defense work	Post–Cold War transition	Post 9/11	Life Extension Programs START
Production and manufacturing engineering	Vietnam conflict	Energy crisis	Cold War	Stockpile stewardship	National security	National security challenges

Sandia's Sites

Sandia National Laboratories

Albuquerque, New Mexico

Livermore, California

Kauai, Hawaii

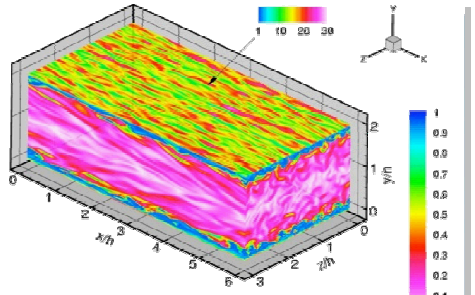
Waste Isolation Pilot Plant, Carlsbad, New Mexico

Pantex Plant, Amarillo, Texas

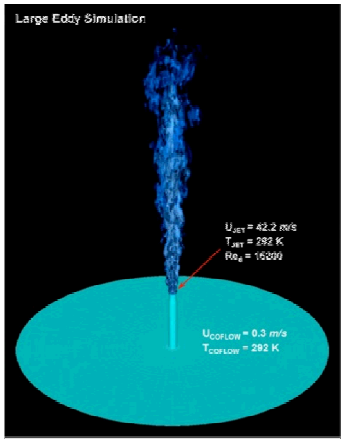
Tonopah, Nevada

Large Eddy Simulation of Turbulent Multiphase Combustion Processes

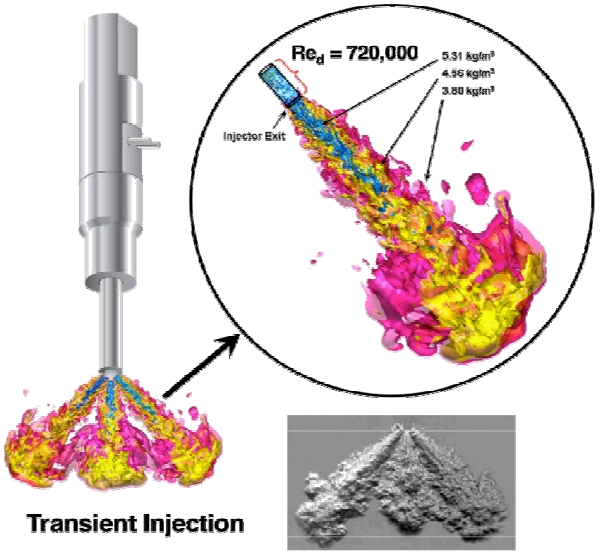
Sandia National Laboratories



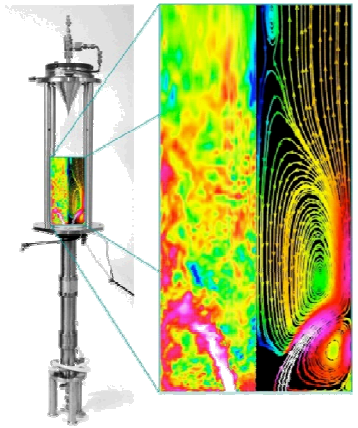
High-Re Wall-Bounded Flows



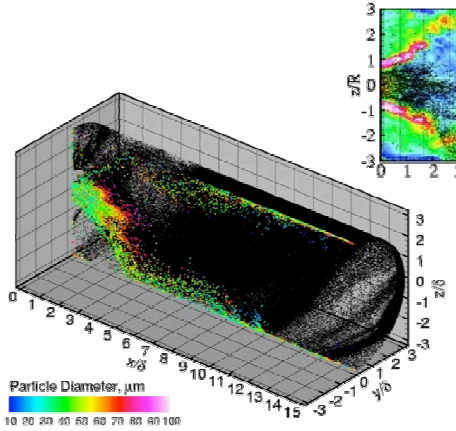
Nonpremixed Flames

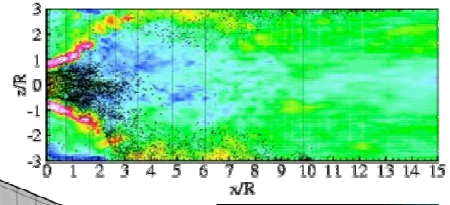


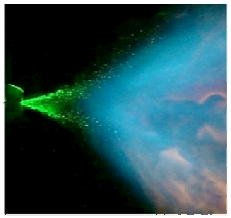
Transient Injection



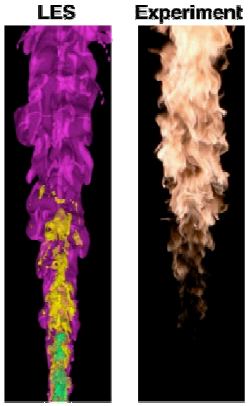
Premixed Flames







High-Pressure Multiphase Flows

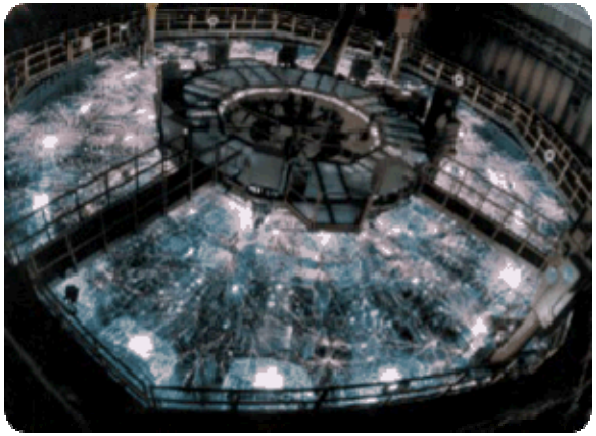


Soot and Emissions

Nuclear Weapons

Sandia National Laboratories

Pulsed power and radiation effects sciences

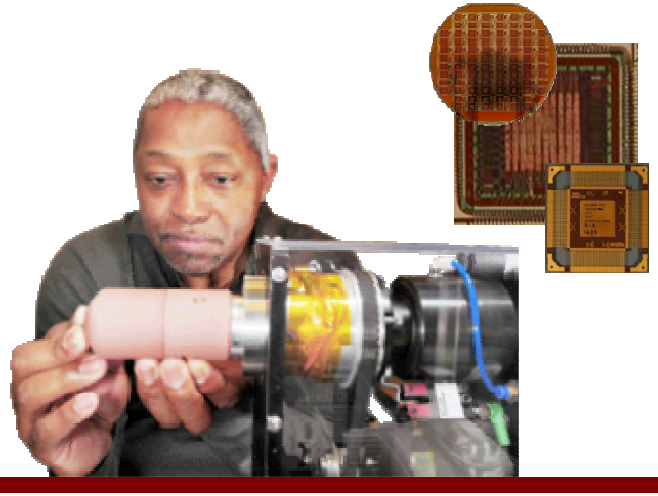


Design agency for nonnuclear components

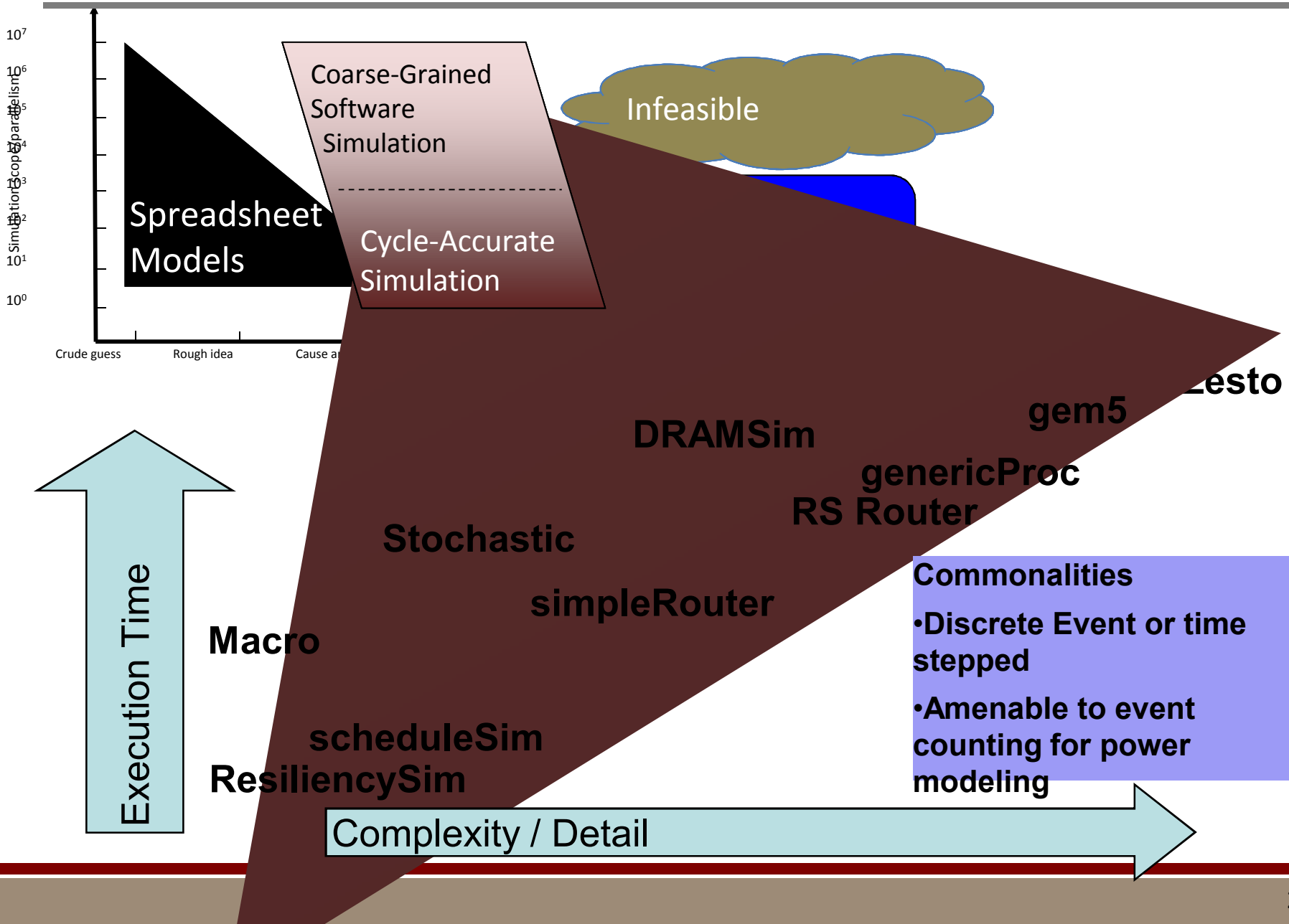
- Neutron generators
- Arming, fuzing and firing systems
- Safety systems
- Gas transfer systems

Warhead systems engineering and integration

Production agency



Range of SST Component Models



Defense Systems and Assessments

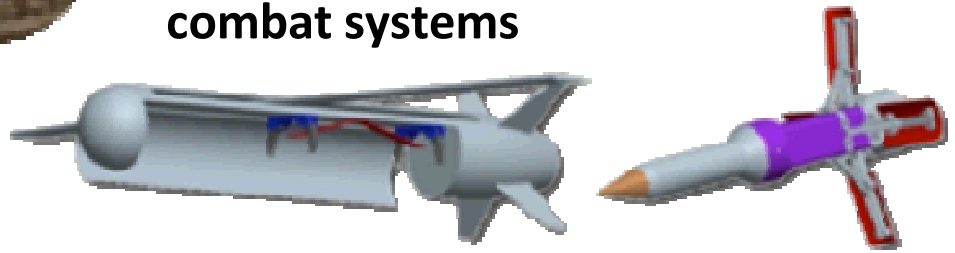
Sandia National Laboratories

Synthetic aperture radar

Support for NASA

Support for ballistic missile defense

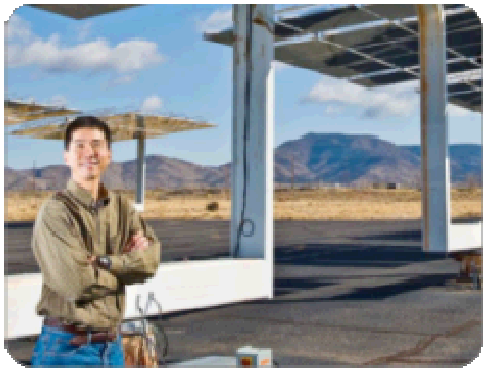
Ground sensors for future combat systems



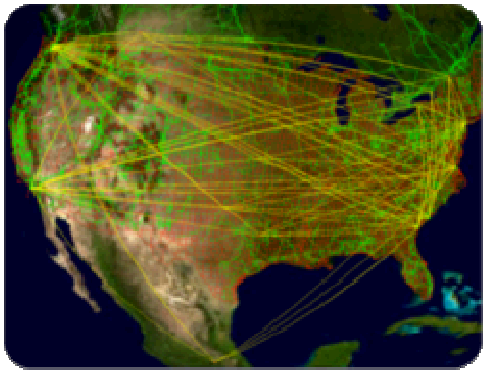
Energy, Climate, and Infrastructure Security

Sandia National Laboratories

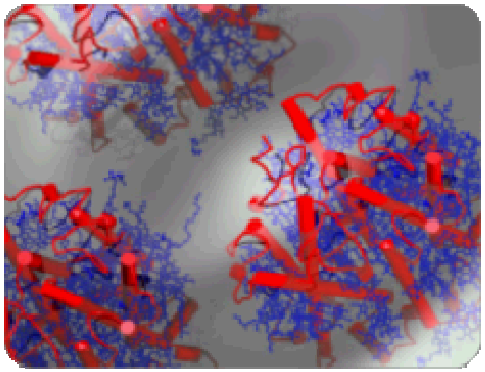
Energy



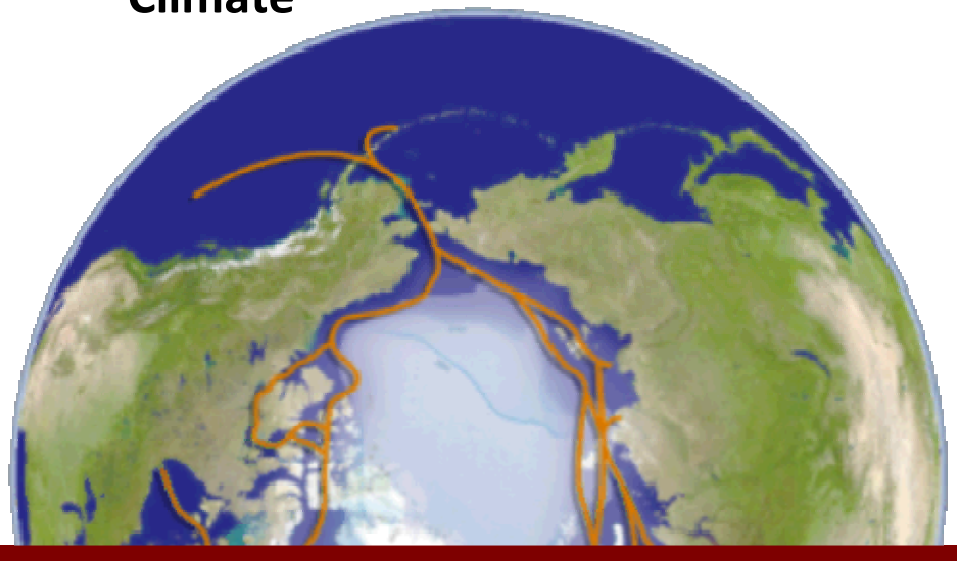
Infrastructure



Crosscuts and enablers



Climate



jbei
Joint BioEnergy Institute

International, Homeland, and Nuclear Security

Sandia National Laboratories

Critical asset protection

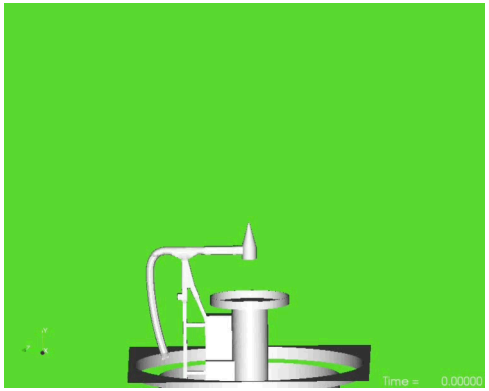
Homeland defense and force protection

Homeland security programs

Global security

Abnormal/Thermal Environment Complexity: Turbulent Reacting Flow with PMR

10 meter outdoor JP-8



Unique multi-physics coupling