Sandia National Laboratories

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Sandia National Laboratories and Its Research Strategy

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Sandia National Laboratories

10 October 2014

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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 2013-10549C.

Julia M. Phillips – BS Physics, College of William and Mary

Sandia's History

Exceptional service in the national interest

- **July 1945:** Los Alamos creates Z Division
- Nonnuclear component engineering
- **November 1, 1949:** Sandia Laboratory established
- **1949–1993:** AT&T
- **1995–Present:** Lockheed Martin Corporation (contract extended through April 30, 2016, with an option of an additional year.)

Sandia's Sites

Albuquerque, New Mexico

Livermore, California

Kauai, Hawaii

Waste Isolation Pilot Plant, Carlsbad, New Mexico

Pantex Plant, Amarillo, Texas

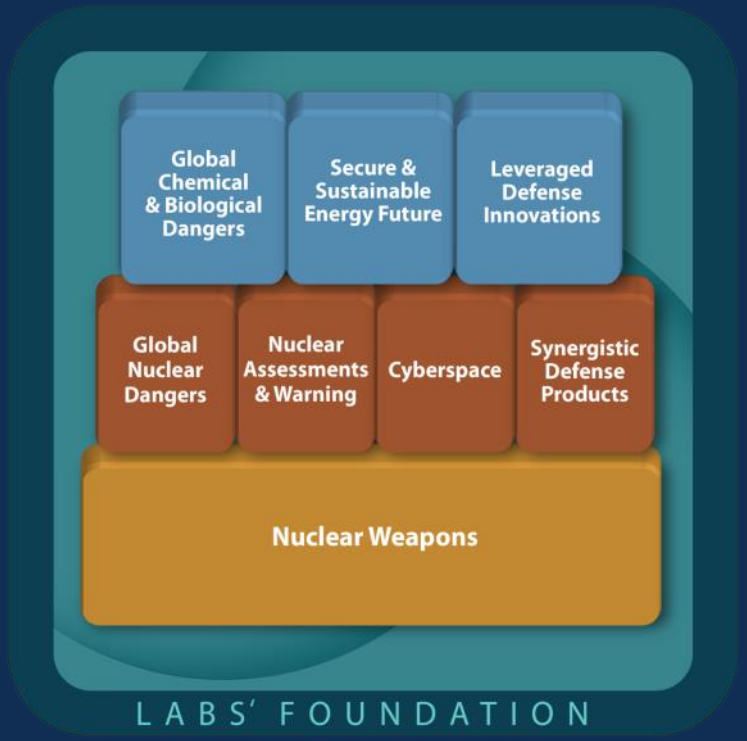
Tonopah, Nevada

Sandia's Mission Work Reflects National Security Challenges

1950s	1960s	1970s	1980s	1990s	2000s	2010s
NW production engineering & manufacturing engineering	Development engineering	Multiprogram laboratory	Missile defense work	Post–Cold War transition	Expanded national security role post 9/11	Cyber Biosecurity Proliferation
	Vietnam conflict	Energy crisis	Cold War	Stockpile stewardship		Evolving national security challenges

Sandia's National Security Missions

- Mission Areas provide the basis for prioritizing Sandia's work, and for shaping and driving our future
- Mission Area strategies are executed by Sandia's four Program Management Units
- Mission Area strategies and priorities provide the foundation for Sandia's research strategy



Labs Foundation: People, research, capabilities, facilities & tools

Sandia's Foundation

In concert, these elements form a solid base supporting our national security missions

People
- Diverse technical talent
- Multiple career paths
- Commitment to national service

Research
- Disciplined-based Research Foundations
- Multidisciplinary Research Challenges
- Internally funded R&D Investments

Example Facilities and Tools
- Major Environmental Test Facilities
- Microsystems and Engineering Sciences Applications (MESA)
- High-Performance Computing
- Pulsed-Power Facility
- Center for Integrated Nanotechnologies (CINT)
- Combustion Research Facility (CRF)
- …

Capabilities for Solving 21st Century National Security Challenges

- High-reliability engineering
- Sensors and sensing systems
- Cyber technology
- Pathfinders
- Reverse engineering
- Modeling & simulation and experiment
- Natural and engineered materials
- Micro- & nanoelectronics and systems
- Safety, risk, and vulnerability analysis

Sandia's Research Objective

Research conducted at Sandia shall enable mission delivery now and in the future and advance the frontiers of science and engineering.





Sandia's R&D Workforce

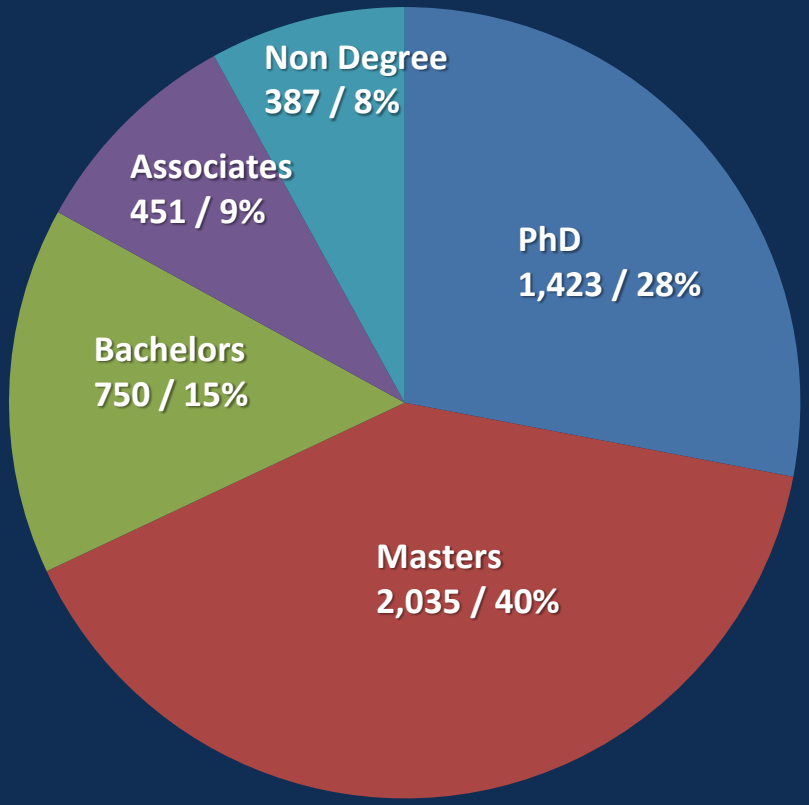
- **Total workforce: 11,065**
- **Regular employees: 9,910**
- **R&D staff: 5,046**

Sandia* College of William & Mary Graduates

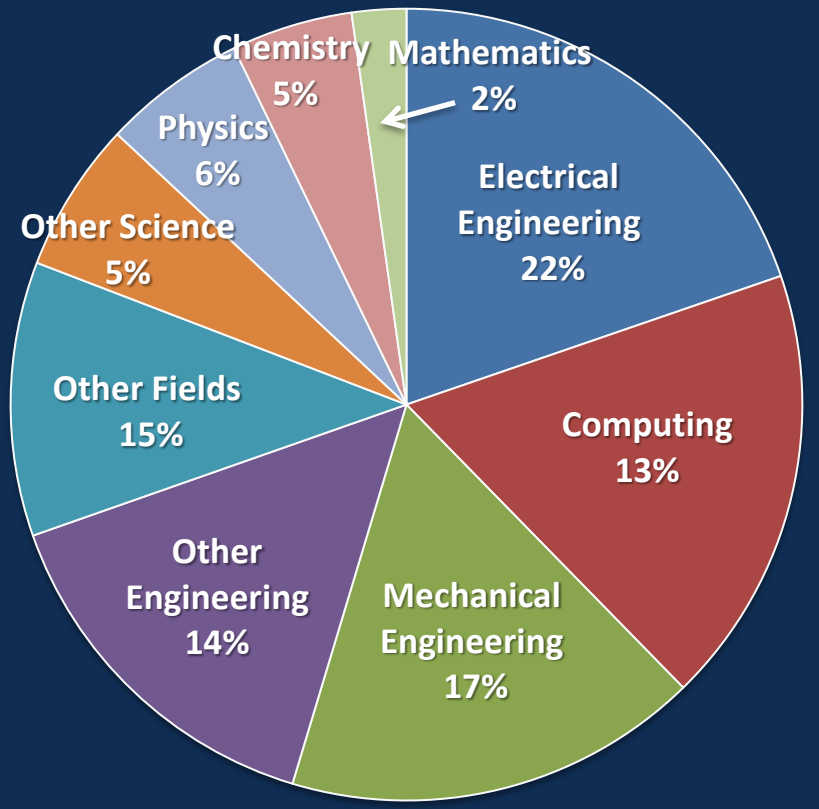
- **Masters – 1**
- **Bachelors – 6**

* On roll

R&D staff by degree



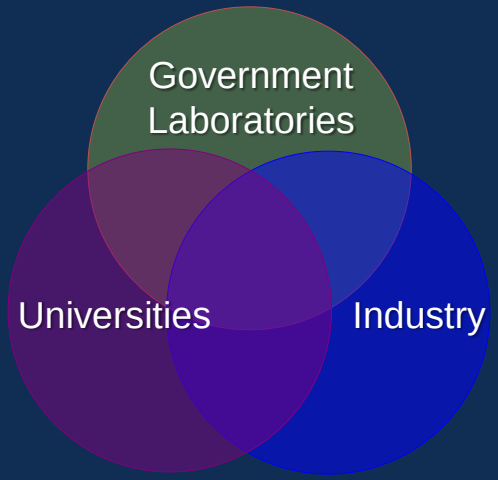
R&D staff by discipline



Data as of July 31, 2014

Critical Components of our Research Enterprise

- **Research Foundations**
- **Research Challenges**
- **Research Environment**
- **Internal Research**
- **Partnerships, Intellectual Property, and Technology Transfer**



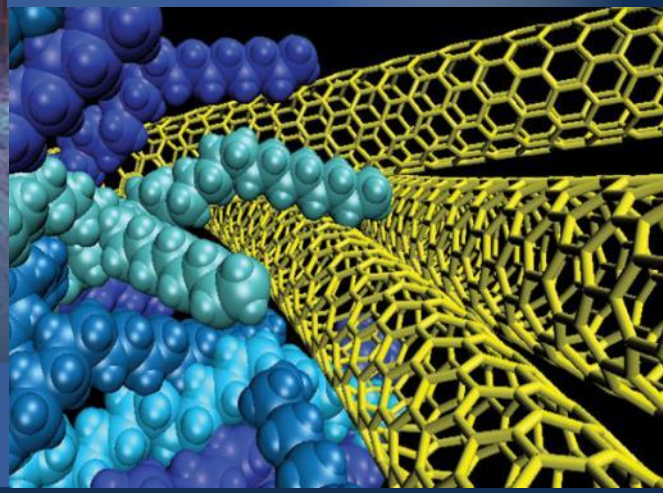
Our Research Framework

Strong research foundations play a differentiating role in our mission delivery

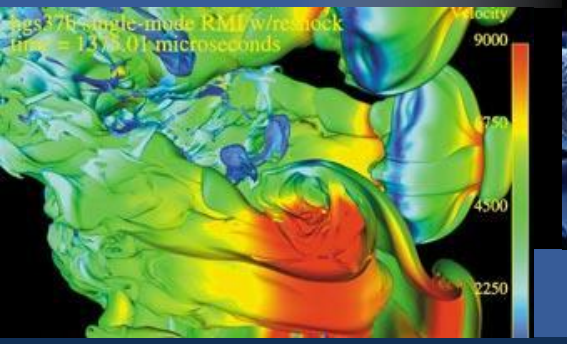
Computing & Information Sciences

Radiation Effects & High Energy Density Science

Materials Science

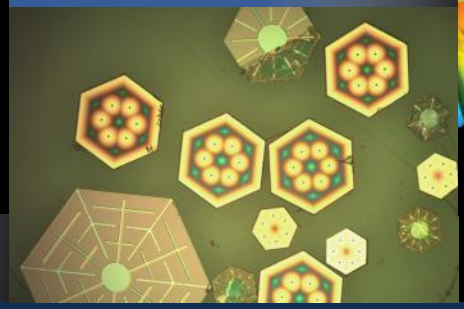


Engineering Sciences

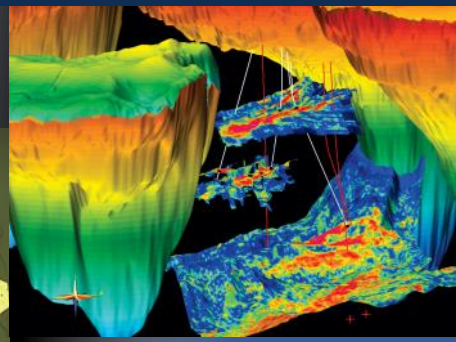


Bioscience

Nanodevices & Microsystems



Geoscience



Sandia's Research Challenges

Research Challenge attributes

- Advances the frontiers of science and engineering
- Surmounts a critical path technical obstacle for a mission chall
- Long-lived, with a measurable endpoint
- Integrates in multiple dimensions
- Requires partnerships

EXAMPLE: Beyond Moore's Law Computing

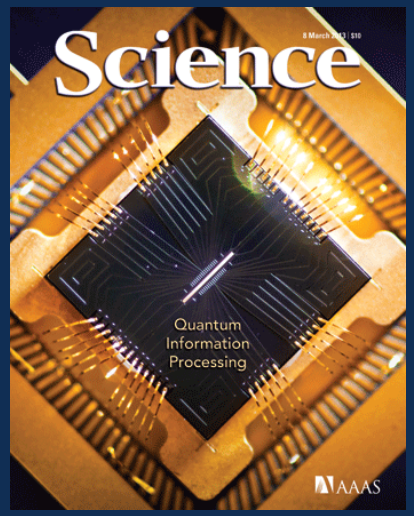
- Identify new technologies to succeed silicon CMOS
- Identify new component architectures to provide high performance, energy efficiency, and a path for several generations of performance increase through scaling
- Design and prototype new computing architectures

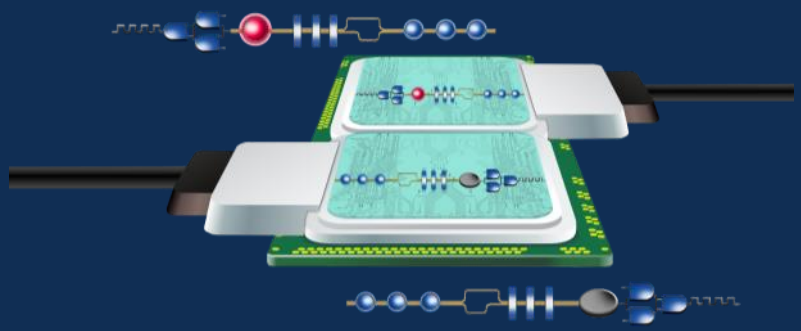
Sandia's Research Challenges

- Beyond Moore Computing
- Data Science
- Cyber Resiliency
- Trusted Systems & Communications
- First to High-Yield Fusion
- Detection at the Limit
- Engineering of Materials Reliability
- Power on Demand
- Resiliency in Complex Systems
- Science and Engineering Quantum Information Systems
- Revolutionary Approaches to the Stockpile
- Integrative Biological Systems Analysis and Engineering
- Human Dimension

Research Challenge: Science & Engineering of Quantum Information Systems

Sandia-built ion trap





Miniaturized quantum key distribution systems will enable quantum cryptography for mobile applications

Goal: In 10 years, develop few-qubit devices, with algorithms and protocols & applications to

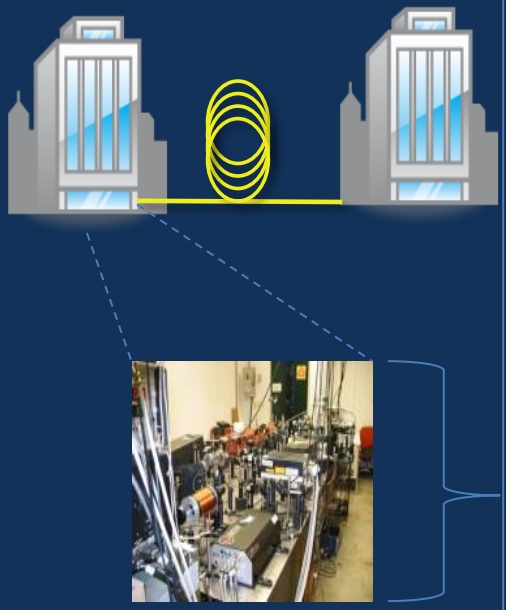
- enable novel approaches to sensing, information processing, and communications

Example Project: LDRD Grand Challenge: Sandia Enabled Communications and Authentication Network using Quantum Key Distribution (SECANT QKD)

Project Progress: First on-chip QKD transceiver designed and in fabrication

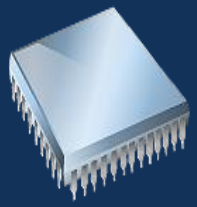
Quantum Key Distribution

Current QKD



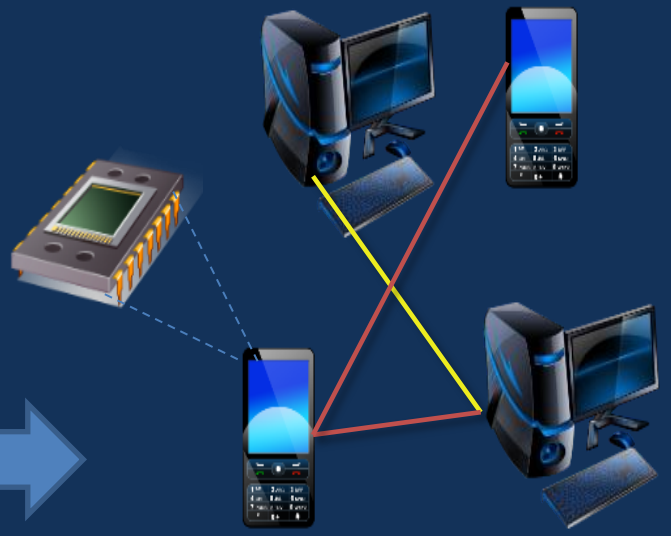
Rack-mounted table-top systems in large buildings

SECANT QKD Program



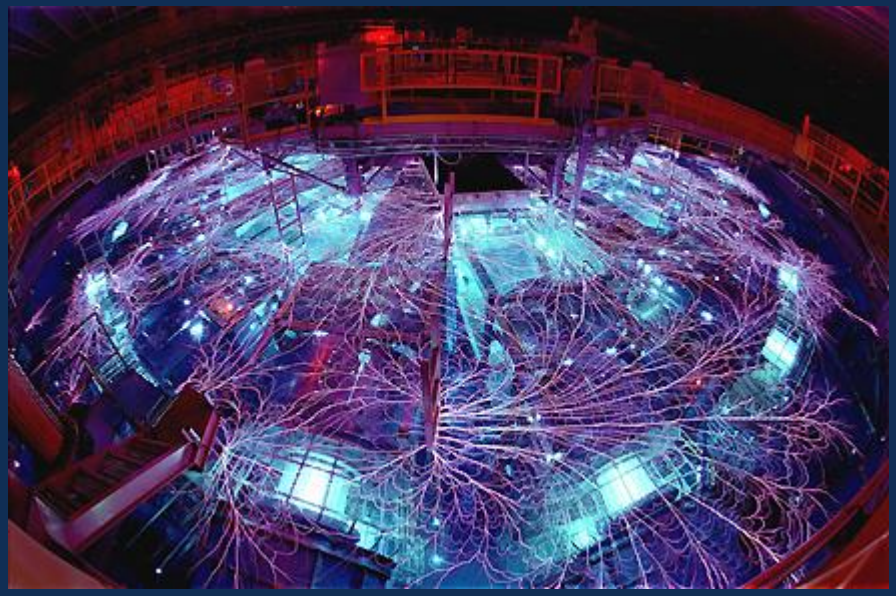
Microscale integration using Sandia silicon photonics platform

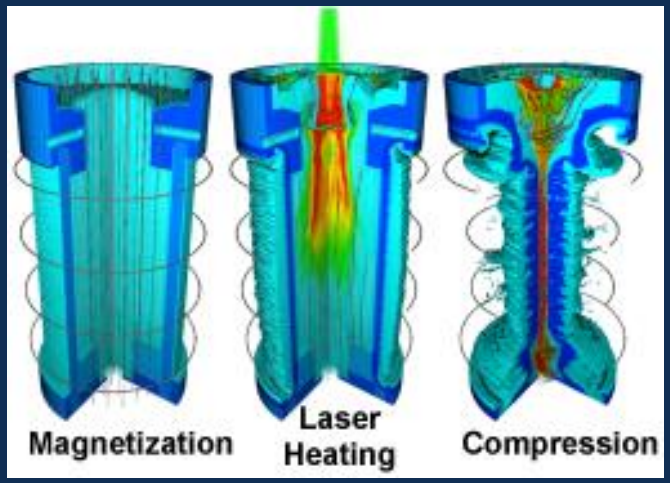
Next Generation QKD



Microsystems enabled secure communications network using QKD

Research Challenge: First to High-Yield Fusion



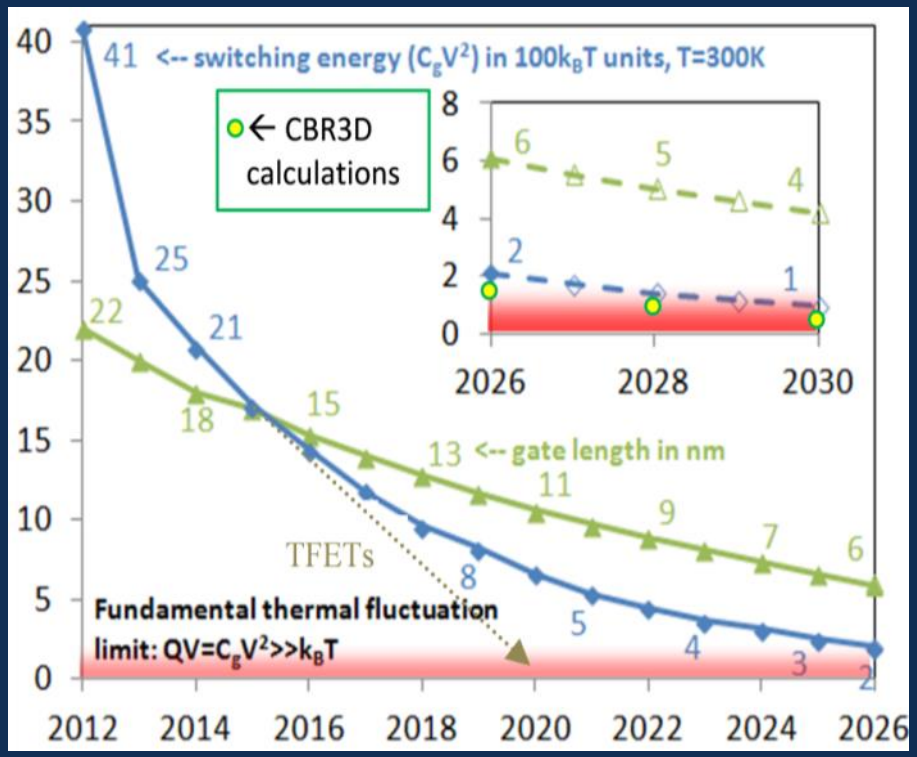


Research Challenge Goal: By 2035, achieve controlled fusion in the laboratory with fusion yield of at least 1 gigajoule per pulse (equivalent to ~0.24 tons of TNT)

Approach: We are using the Z pulsed power facility at Sandia to develop and test target designs that will scale to a GJ yield. We are also working on maturing new Linear Transformer Driver (LTD) pulsed power technology. This technology will scale well to the larger facility size needed for 1 GJ.

Progress: Our initial target experiments with Magnetized Liner Inertial Fusion appear promising. We have demonstrated LTD components that meet the driver requirements.

Research Challenge: Beyond Moore Computing

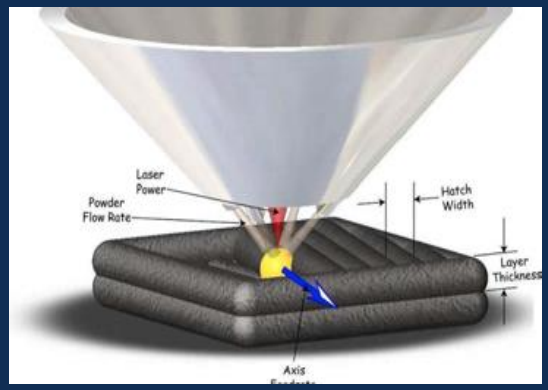


Research Challenge Goal: By 2022, prototype an "accelerator" employing disruptive device technology and radical computing concepts that will succeed CMOS field effect transistors (FETs).

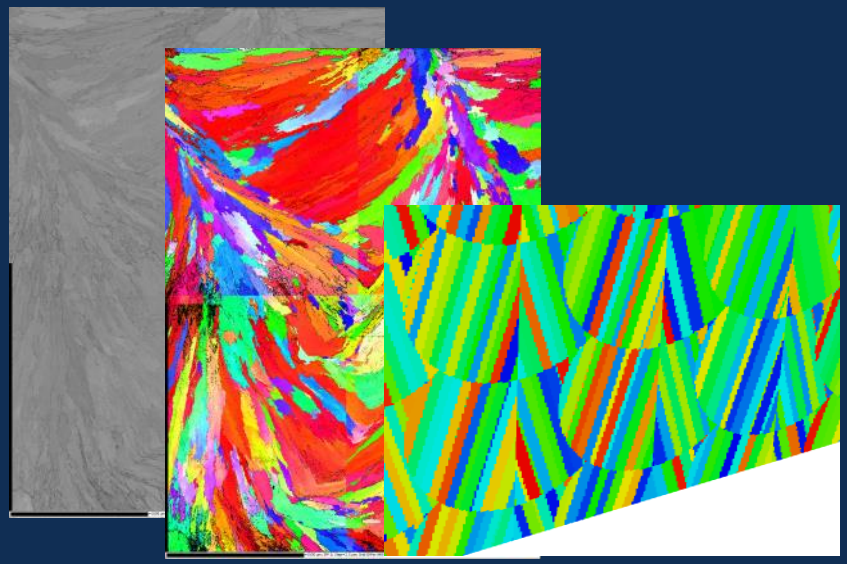
Approach: Use Sandia's expertise in materials, microelectronics, computer science, and computation to design components and sub-systems of future computing systems.

Progress: The downscaling limit of FETs has been identified as a gate length of 5nm. Room temperature thermal energy (100kT) is comparable to switching energy of FETs. As this likely holds for *all charge-based FET technologies*, industry should consider non-FET alternatives; e.g., memristors, super-conducting logic, spintronics.

Research Challenge: Engineering of Materials Reliability



LENS microstructure with orientation information and DNS models will enable anisotropic deformation models



Research Challenge Goal: To become world leaders at incorporating material variability in predictive, probabilistic, performance and optimization tools .

Approach:

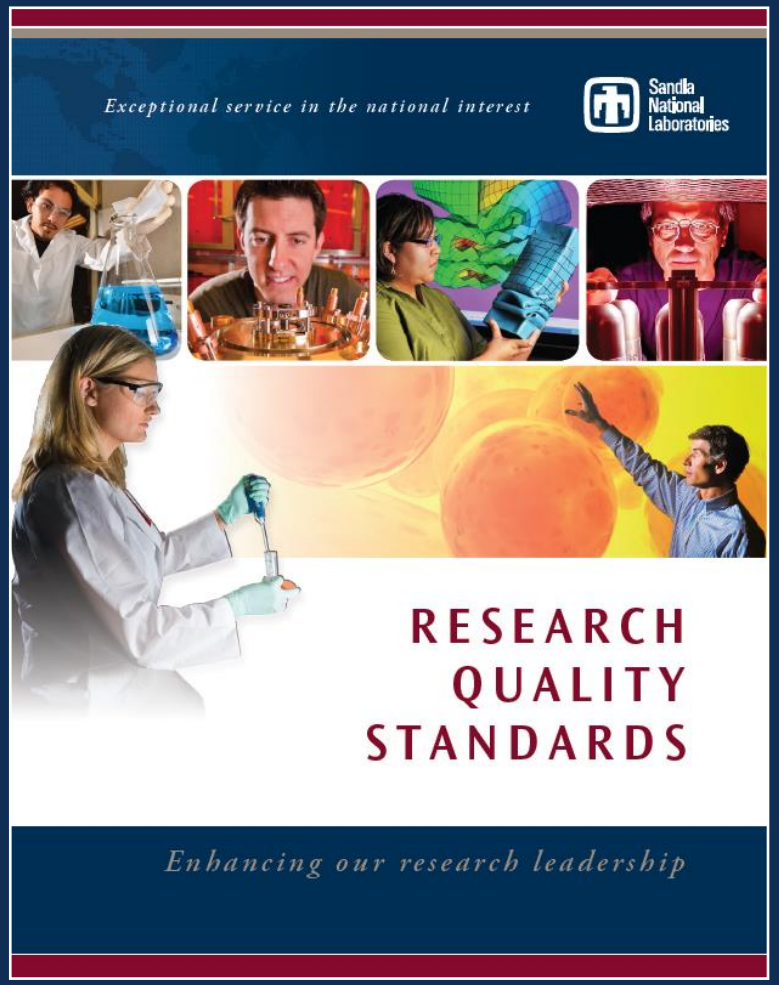
Implementing a multiscale experimental and computational framework for mechanistic discovery and propagation of stochastic material properties with appropriate physics

- **Exemplars provide focus**
- **Additive manufacturing first exemplar**

Progress:

Application of direct numerical simulation to explore the effects of grain orientation for additive manufactured stainless steel

Research Environment: Research Quality Standards



Released in February 2014

Fifty case studies cover all phases of research

Technical staff comments:

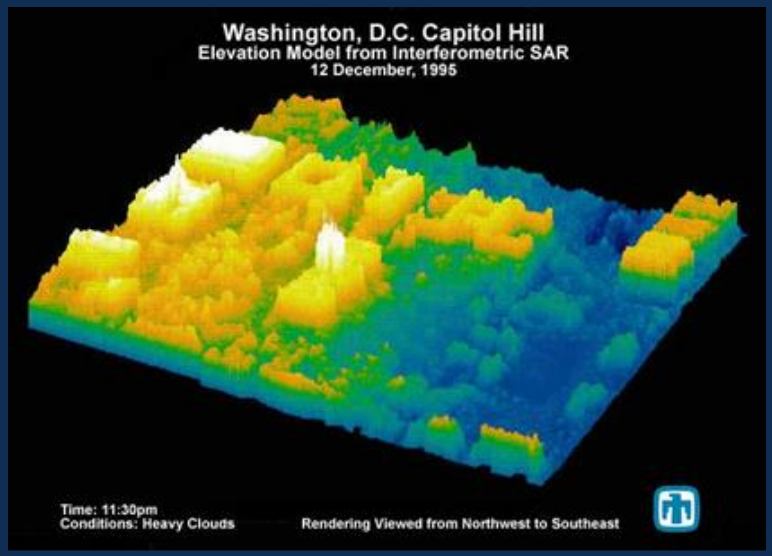
- *"I've been at Sandia for only a couple of years and the standards document was suddenly like having 30 years of mentors."*
- *"It's an incredibly useful document. I've sent it to many of my colleagues at Sandia."*
- *"I think the standards are helpful and I like the case-style format."*
- *"Clarification on issues specific to conducting research at Sandia—legal, review, and approval, LDRD, and so on—is where the standards provide the most value."*

Internal Research Investments: Fundamental Science to Mission Impact

Sandia National Laboratories

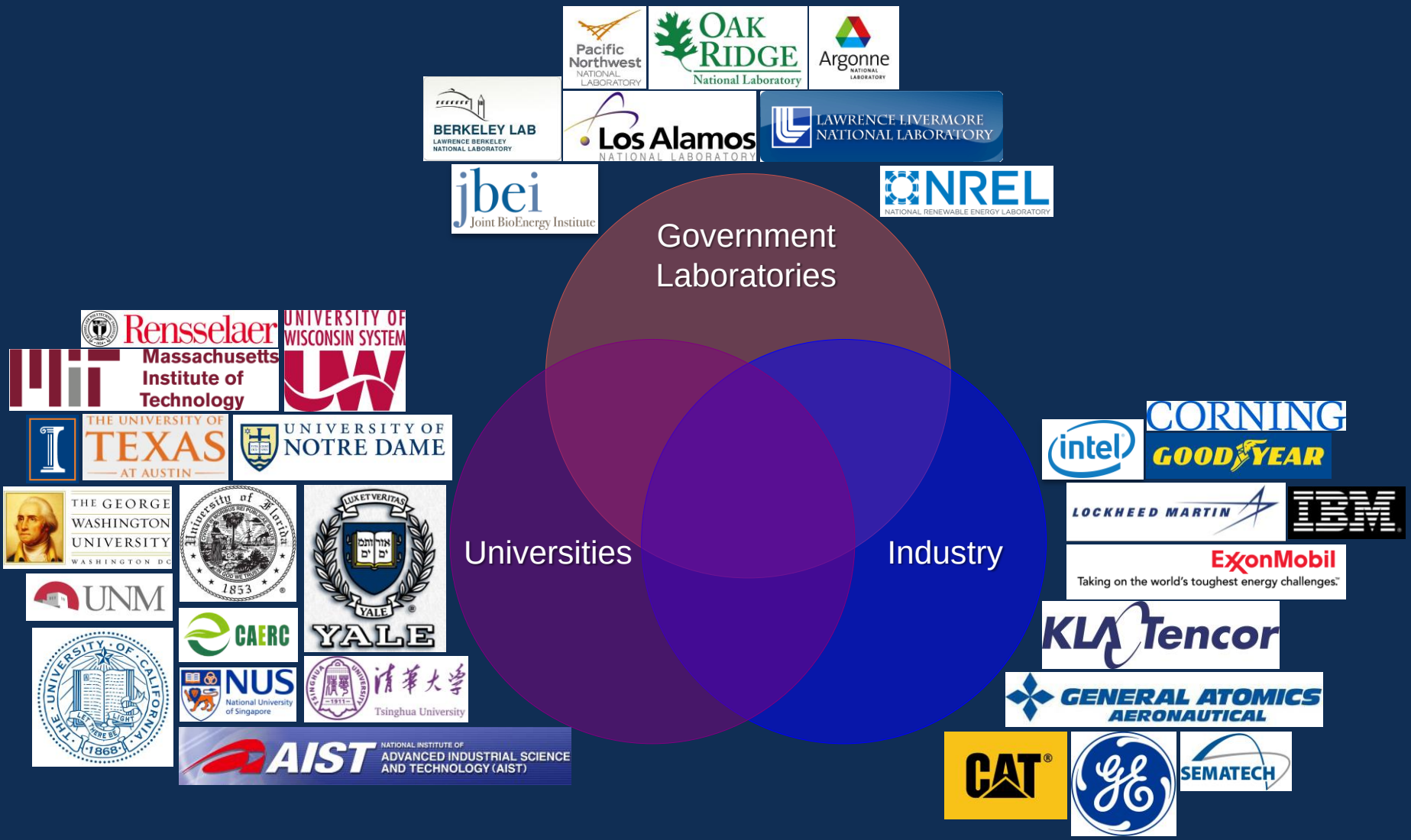
Shock Physics Code Applied to Understand Russian Meteor

Miniaturized Synthetic Aperture Radar for Mission



Capitol Hill

Partnerships and Collaboration Are Essential to Our Success



Conclusion …

Research conducted at Sandia shall enable mission delivery now and in the future and advance the frontiers of science and engineering.




Sandia National Laboratories

BACK-UPS

Our research strategy

Enable mission delivery now and in the future and advance the frontiers of science and engineering

Sandia National Laboratories

MISSION DELIVERY