SAND2011-0605C

Sandia National Laboratories

Laboratories Overview, Nuclear Energy and Small Modular Reactors Overview

Presented to
White Sands Missile Range
February 3, 2011

Evaristo J. (Tito) Bonano, Benjamin B. Cipiti, Tom G. Lewis, Janette Lloyd & Jack B. Tillman

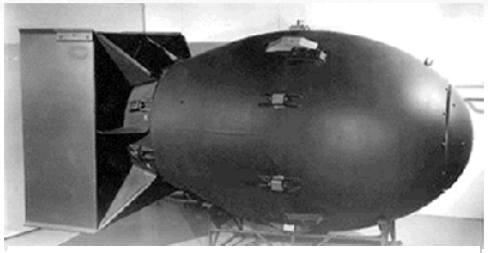
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

NNSA National Nuclear Security Administration

Sandia National Laboratories

Heritage

"Exceptional service in the national interest"



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. C. E. Buckley.

Very sincerely yours,

Harry Truman

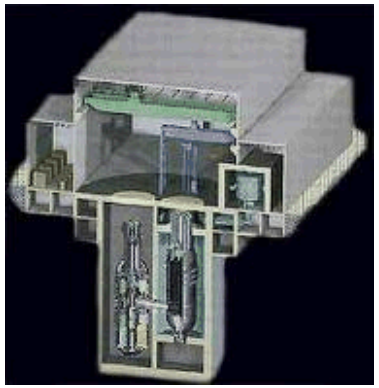
Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

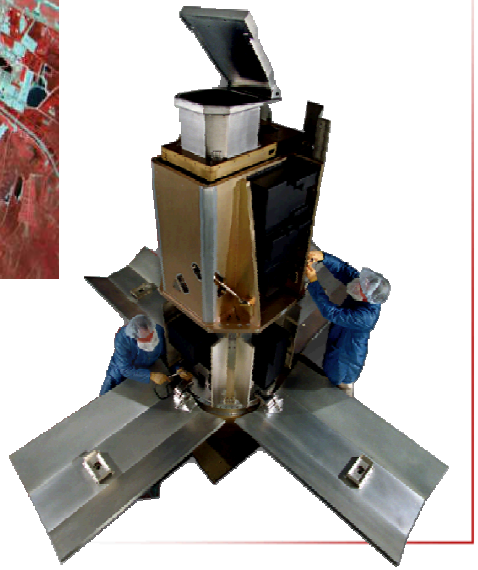
National Nuclear Security Administration

Sandia National Laboratories

Technologies for National Security

- **We develop technologies to**
  - **Ensure the stability and security of our nation's energy supply.**
  - Sustain, modernize and protect our nuclear arsenal
  - Provide new capabilities to our armed forces
  - Protect our national infrastructures





NNSA National Nuclear Security Administration

Sandia National Laboratories

Unparalleled Facilities and Test Capabilities

- User facilities
- Designated national capabilities
- Nuclear facilities for testing and qualification
- Real-life physical test ranges

Sandia's Administration

Government-Owned
Contractor-Operated

- AT&T: 1949–1993
- Martin Marietta: 1993–1995
- Lockheed Martin: 1995–Present

Federally
Funded
Research &
Development
Center

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Sandia National Laboratories

Sandia's Sites

Albuquerque, New Mexico

Livermore, California

Carlsbad, New Mexico

Tonopah, Nevada

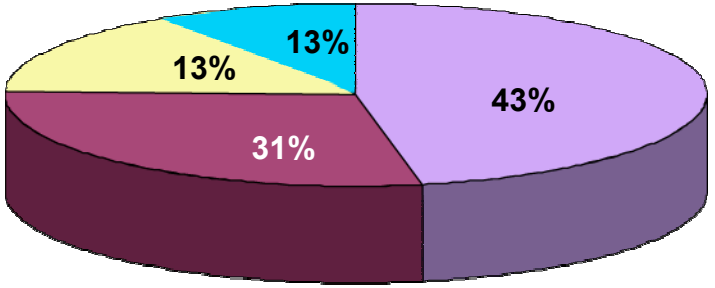
Pantex, Texas

Kauai, Hawaii

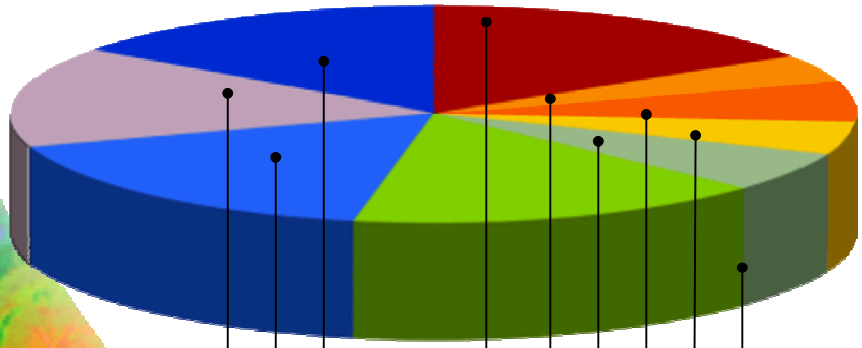
People and Budget

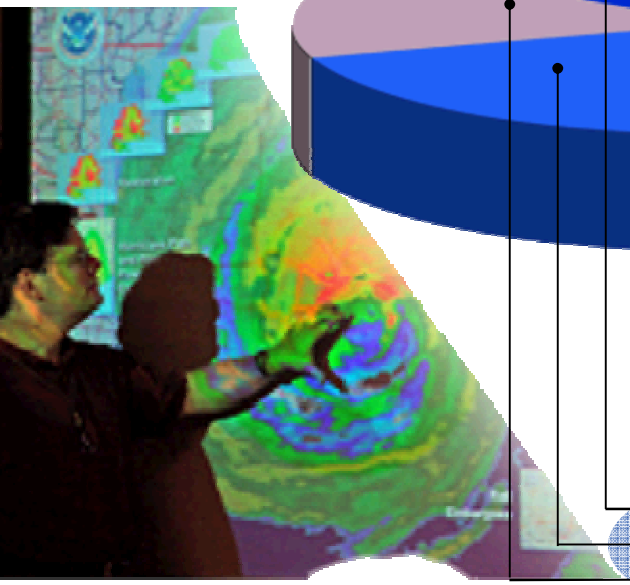
- On-site workforce: 11,677
- Regular employees: 8,607
- Gross payroll: ~$898.7 million

FY10 operating revenue
$2.3 billion



Technical staff (4,277) by discipline:





Computing 16%
Math 2%
Chemistry 6%
Physics 6%
Other science 6%
Other fields 12%

Electrical engineering 21%
Mechanical engineering 16%
Other engineering 15%

(Operating Budget)

- Nuclear Weapons
- Defense Systems & Assessments
- Energy, Climate, & Infrastructure Security
- International, Homeland, and Nuclear Security

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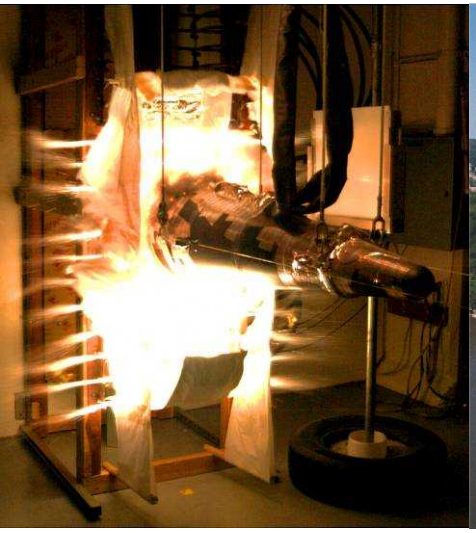
Four Mission Areas

- Nuclear Weapons
- Defense Systems and Assessments
- Energy, Non-Proliferation and High-Consequence Security
- Homeland Security and Defense



Nuclear Deterrence for National Security

Defense Programs Mission

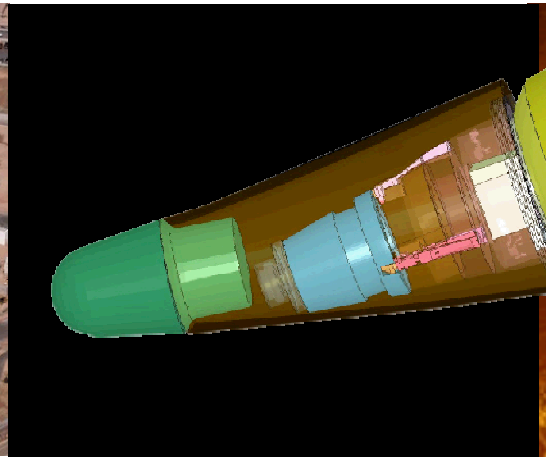
Credible deterrence built on

(1) a safe, secure and reliable nuclear weapons stockpile capable of meeting all military requirements now and in the future, and

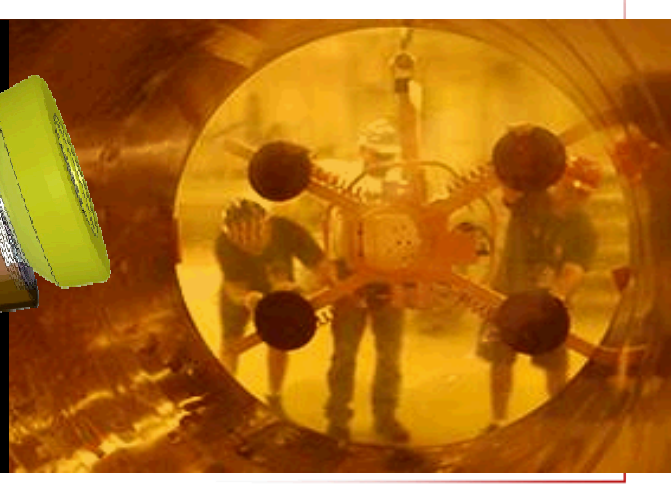
(2) a science-based engineering infrastructure capable of responding to national security needs whenever they arise.

Microsystems and Engineering Sciences Applications (MESA) complex

AF&F impact simulation



Environmental Testing Pulsed power— Z Machine

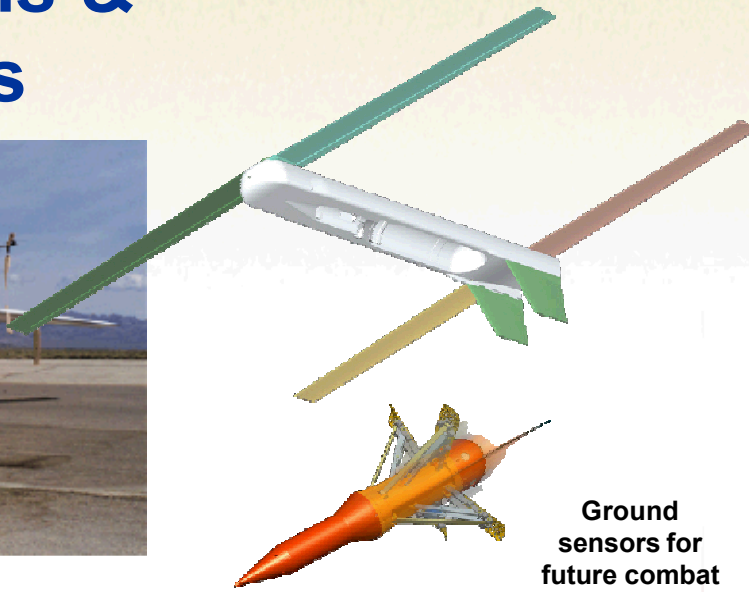


Defense Systems & Assessments

Predator UAV with SAR

Shuttle Orbital Inspection System

Small robotic vehicles



Ground sensors for future combat systems

Target launches for Ballistic Missile Defense

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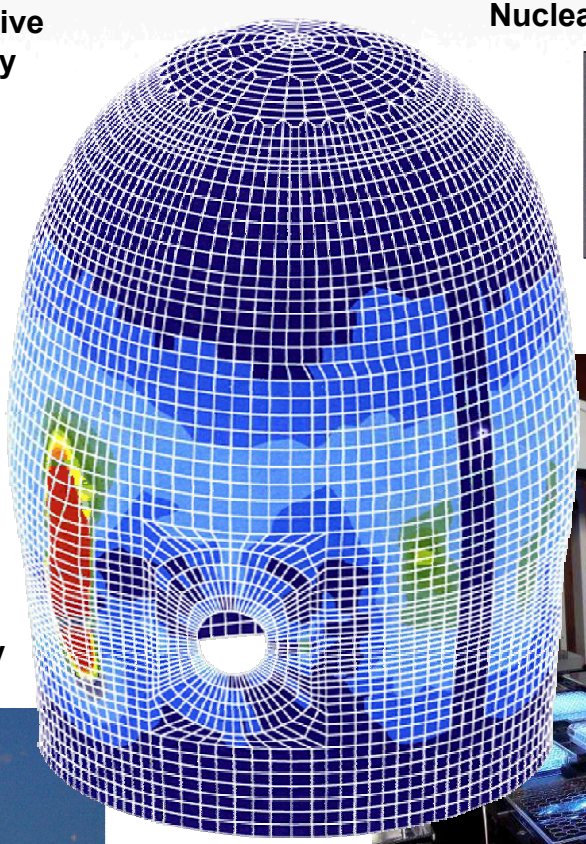
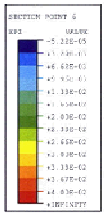
Energy, Nonproliferation and High-Consequences Events

Renewable and alternative energy

Nuclear energy





Energy systems

Global security

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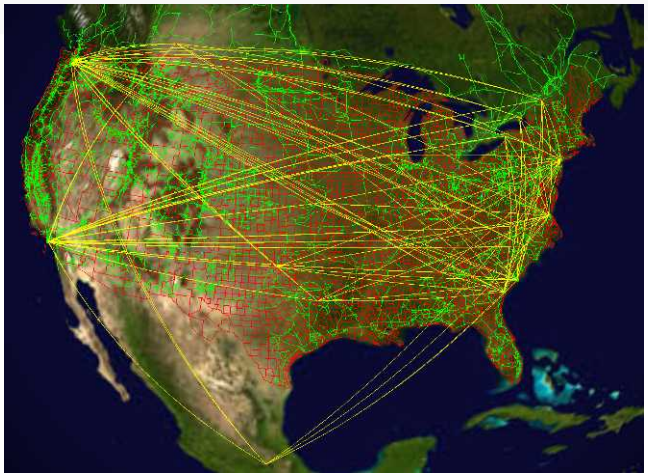
Homeland Security & Defense

Modeling catastrophic events



Infrastructure modeling and protection

Physical security and force protection

Maritime security

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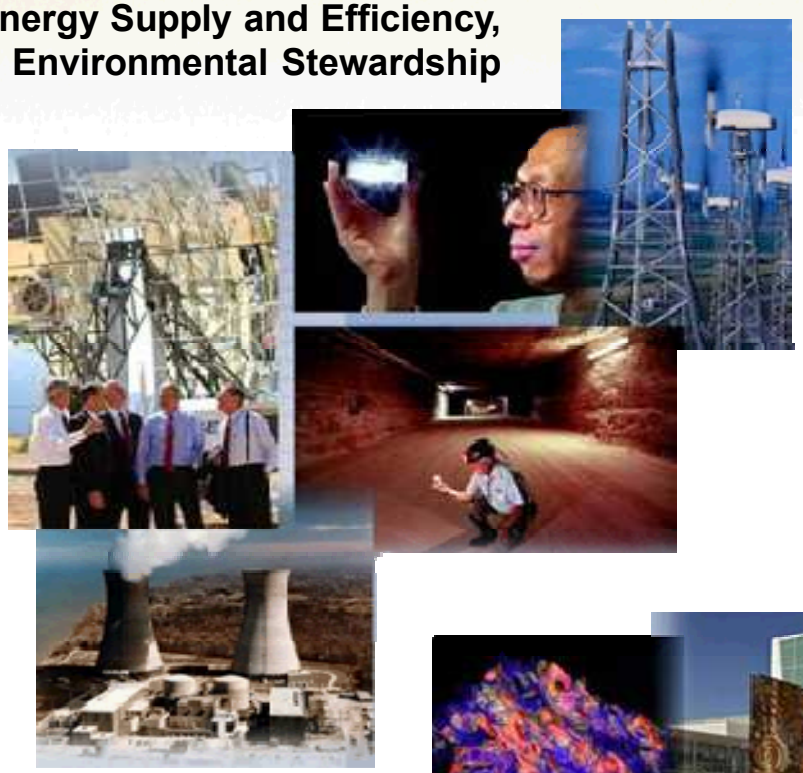
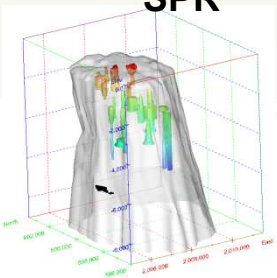
"Science Underpins and Enables Technology for Our Energy Missions"

Energy Supply and Efficiency, and Environmental Stewardship

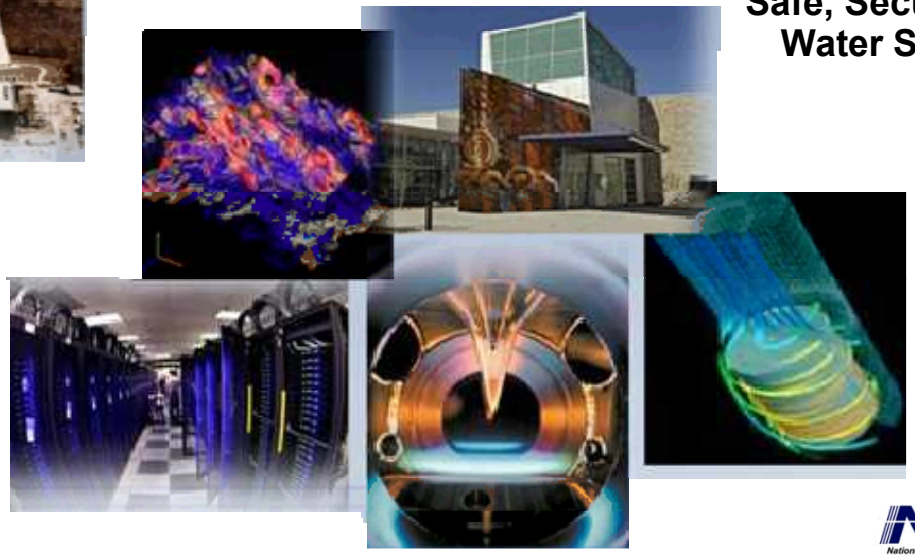


SPR



Safe, Secure, Reliable Energy and Water Supply and Infrastructure

Science and Technology



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Nuclear Energy

Program

"Renew U.S. leadership in 'Nuclear Energy' . . ."

National Technical and Policy Leadership

- Safety and Security
- Proliferation Assessment
- Storage
- Transportation
- Repository Science

Key System Demonstrations

- Nuclear-Solar Hydrogen
- Advanced Energy Conversion Systems
- Small Reactor Development
- International Fuel Return Demonstration

Nuclear Fuel Cycle Science

- Sustainable LWR Nuclear Energy
- Advanced Fuel Cycle Technologies
- Advanced Modeling and Simulation
- Small Modular Reactors
- Confirmatory Nuclear Experiments

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Nuclear Energy

Goal: The United States leads the world in nuclear energy technology

- Reactor technology
- Fuel recycling
- Material security
- Waste disposal

What needs to happen?

- Reactors:
  - License, construct, and operate next generation of Light Water Reactors in US
  - Develop and implement grid-appropriate reactors
  - Recycle used nuclear fuel
- Used Fuel
  - Develop and implement a cohesive used fuel management strategy (interim storage, spent fuel take-back, geologic disposal)
- Ensure global nuclear material security
  - Harmonize US nuclear policies
  - Develop systems that meet needs of developing countries
  - Develop supporting technologies

SNL NE Technical Foundations & Enablers

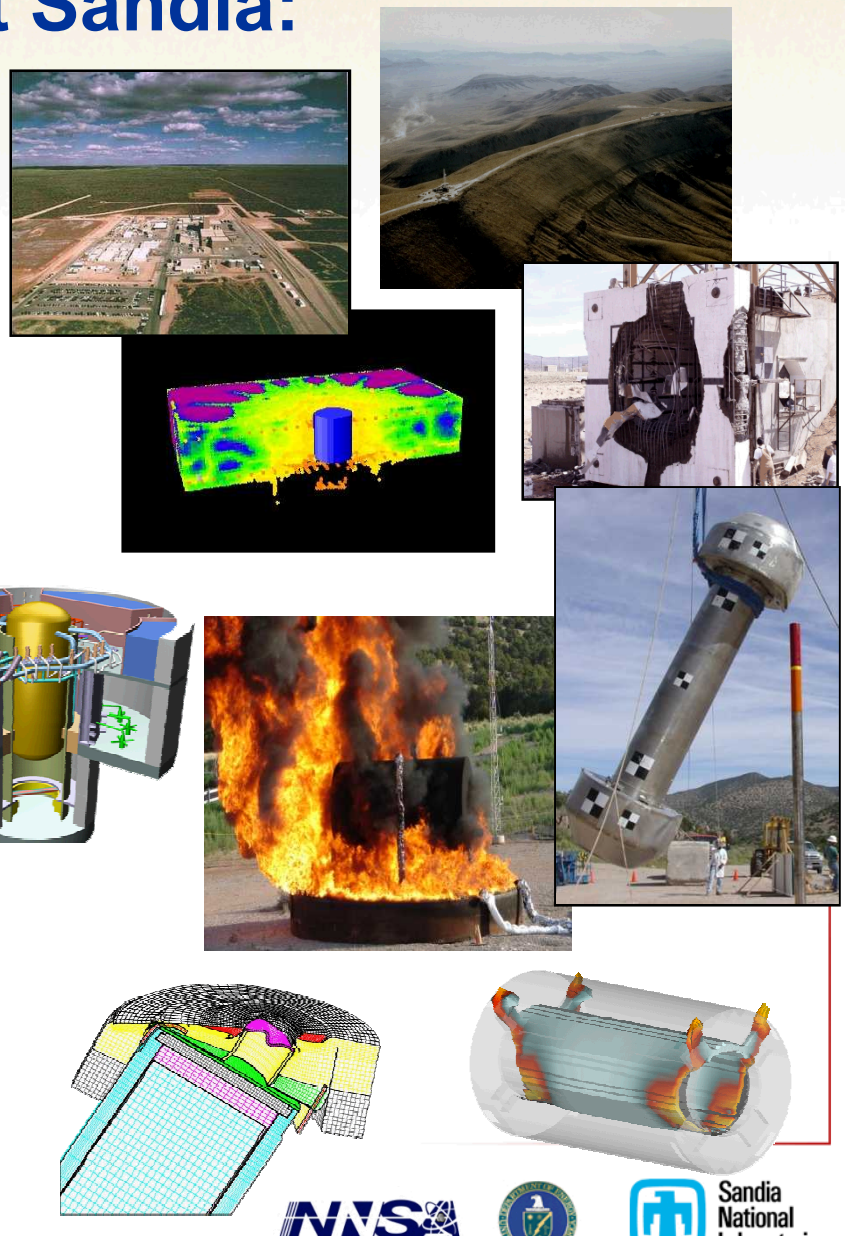
- **Reactors**
  - Safety and security
  - Energy conversion systems
  - Special-purpose reactor design and experiments
  - Advanced manufacturing and robotics
  - Modeling and Simulation

- **Used Fuel**
  - Safety and Security for storage
  - Transportation: design, safety, security, testing, analysis
  - Recycling: advanced technologies, safety
  - Repository science

- **Nonproliferation**
  - System modeling and analysis
  - Data management/analysis and information security for transparency & safeguards
  - Remote sensing and tamper-indication
  - Processes, pilot projects and facilities that enable integration

Nuclear Energy Program at Sandia: Core Capabilities

- **Repository Science**
  - WIPP
  - Yucca Mountain Project
- **Safety and Security**
  - Research and Licensing Support for NRC
  - Safety for Advanced Fuel Cycle Applications
- **Advanced Nuclear Energy Systems: specialty technologies**
  - Space Launch Safety
  - Energy Conversion
  - Right-sized Reactor
  - Nuclear Hydrogen
- **Transportation of nuclear materials**
  - Safety, Security, Testing, Analysis
- **Modeling and Simulation**
  - Crosscuts all areas of the Program
  - Enabled by weapons program investments
- **Experimental Validation**
  - Extreme Environments
  - Severe Accident Mitigation Demonstration



DIVISION 6000 ENERGY, NON-PROLIFERATION, and HIGH-CONSEQUENCE SECURITY

6200 NUCLEAR ENERGY AND FUEL CYCLE PROGRAMS
Andrew Orrell

6210 DEFENSE WASTE MANAGEMENT PROGRAMS
Ray Finley, acting

- 6211 PERFORMANCE ASSESSMENT AND DETECTION ANALYSIS — Moo Lee
- 6212 REPOSITORY PERFORMANCE — Christi Leigh
- 6213 EXPERIMENTAL PROJECTS COORDINATION — Dave Kessel, actg

6220 ADVANCED NUCLEAR ENERGY
Tito Bonano

- 6221 ADVANCED NUCLEAR CONCEPTS — Gary Rochau
- 6222 RADIOLOGICAL CONSEQUENCE MANAGEMENT & RESPONSE — Kevin McMahon
- 6223 ADVANCED NUCLEAR FUEL CYCLE TECHNOLOGIES — Ken Sorenson
- 6224 NUCLEAR FUEL CYCLE SYS ENGR. AND INTEGRATION — Bob MacKinnon
- 6225 ADVANCED SYSTEMS ANALYSIS — Palmer Vaughn

6230 NUCLEAR SECURITY SAFETY TECHNOLOGIES
Susan Pickering

- 6231 RELIABILITY ANALYSIS — Shawn Burns
- 6232 REACTOR MODELING AND ANALYSIS — Randy Gauntt
- 6233 STRUCTURAL INTEGRITY AND LICENSING — Imane Khalil
- 6234 TRANSPORTATION AND ENVIRONMENTAL SAFETY — David Miller

GLOBAL NUCLEAR FUTURES
Tom Sanders (6200)

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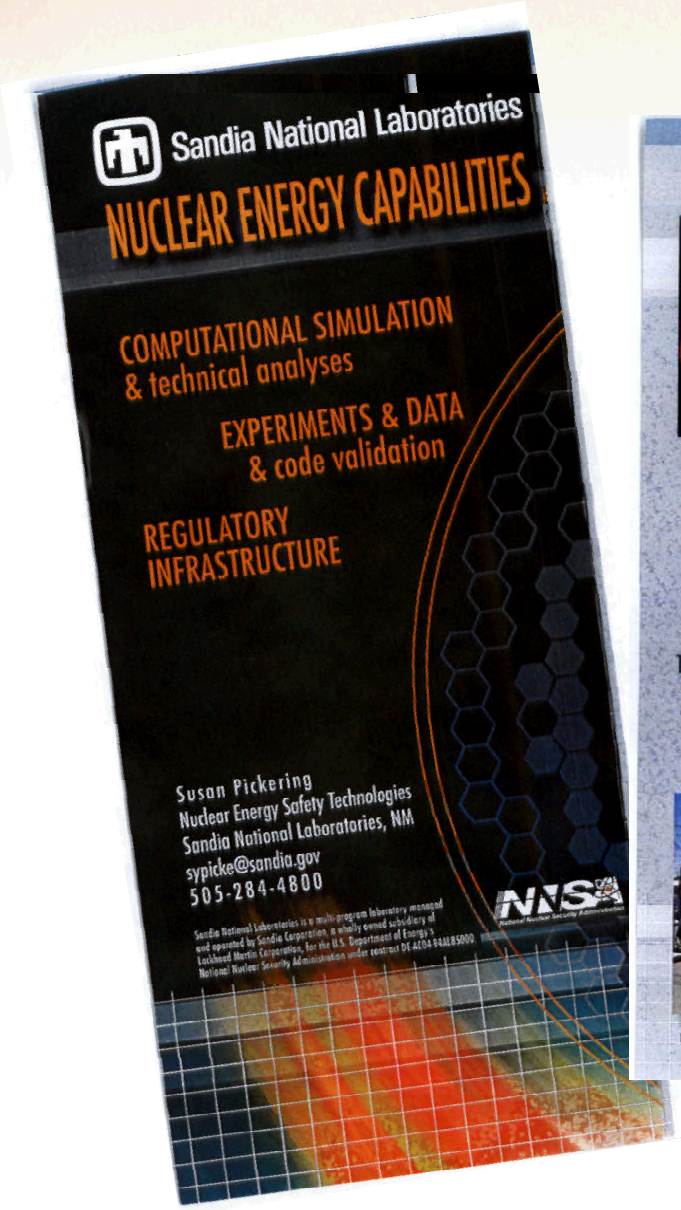
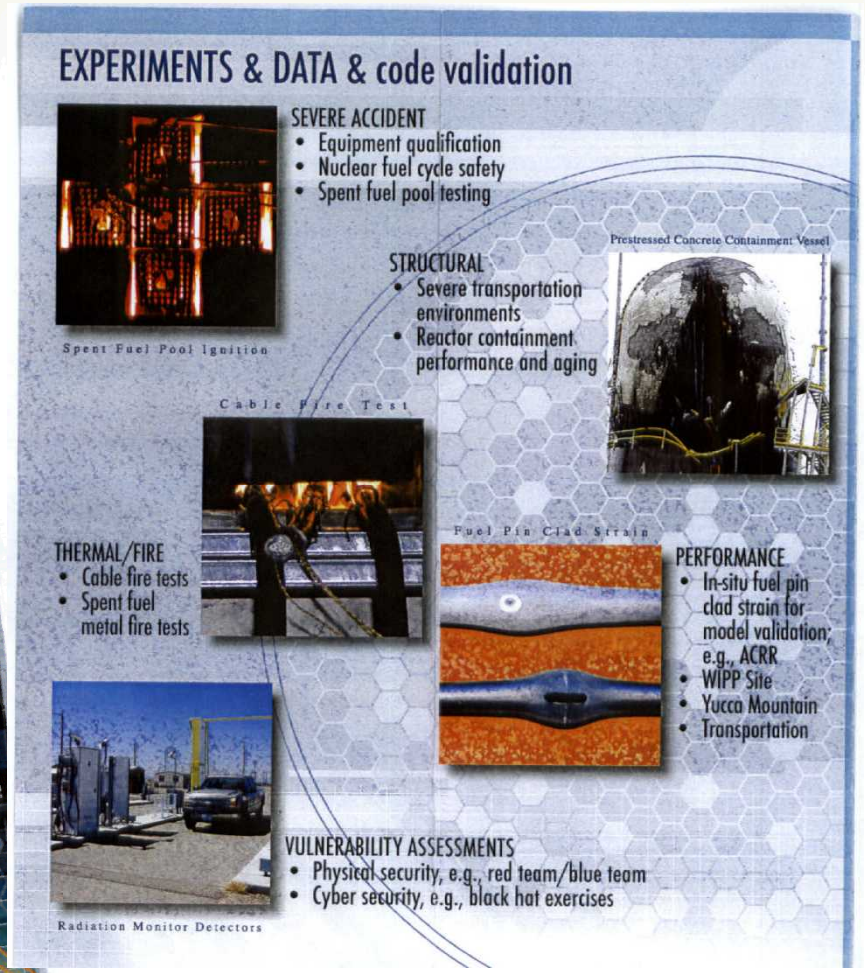
National Leadership in Radioactive Waste Management

- **Science Advisor for WIPP**

- **Lead Lab for YMP**

U. S. Nuclear Regulatory Commission Program





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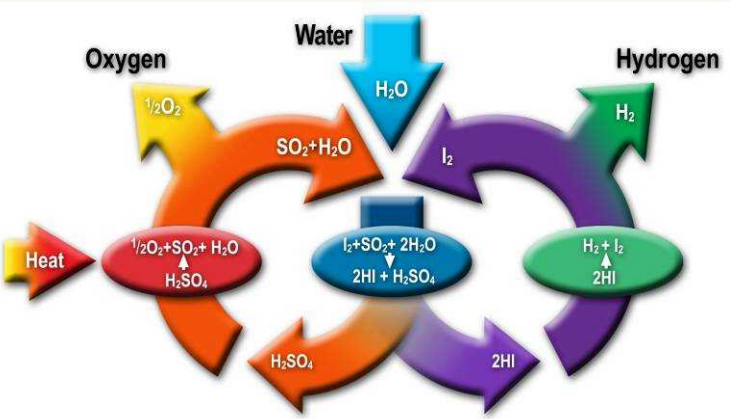
Advanced Nuclear Energy Programs

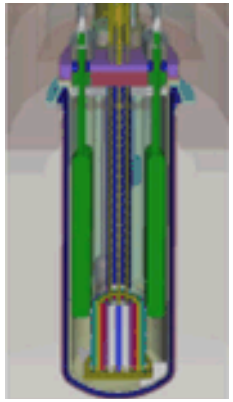


Nuclear Hydrogen Initiative
Sulfur Iodine Thermochemical
Water-Splitting Cycle

Thermochemical
Hydrogen Production,
using Sandia's Solar
Facility (NSTTF)

GEN IV Advanced Energy Conversion
World's Largest Closed Brayton Cycle;
Supercritical CO2 Technology for ABR

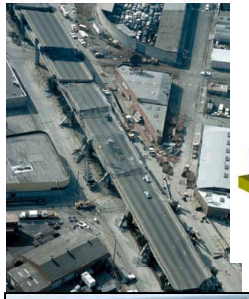
Space Nuclear Power
Mars RTG Launch Safety
Science Lab Rover

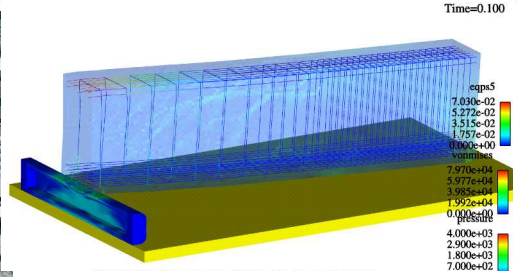


Right
Size
Reactor
(RSR)

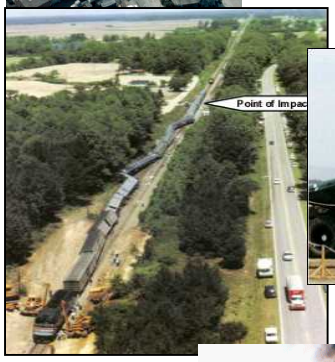
Transportation

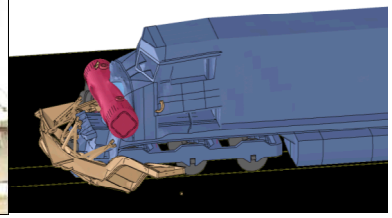
Sandia uses a wide range of engineering disciplines to evaluate cask response to severe mechanical and thermal accident environments.



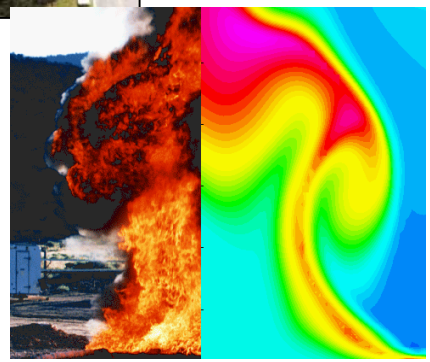


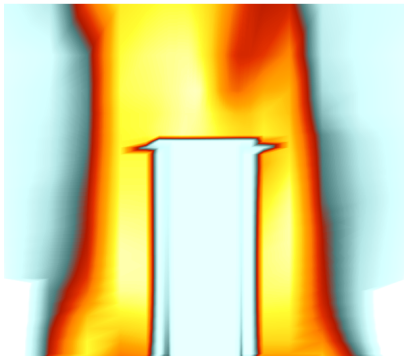
Nimitz Freeway collapse: simulated loading onto a truck spent fuel cask





Testing and analysis to simulate cask response to a locomotive impact event





Validating fire models allows for accurate cask response to severe thermal environments

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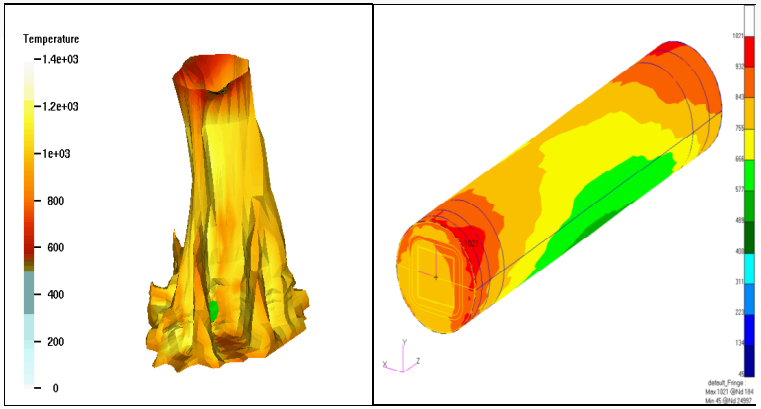
Nuclear Security and Safety Research Facilities

TESTING for validation of models

Impact Testing

Fire Testing and Modeling



Water Slug Impact Test (NRC)

F4 Crash Test
(Japan)

¼-Scale Prestressed Concrete
Containment Vessel Test to Failure (Japan)

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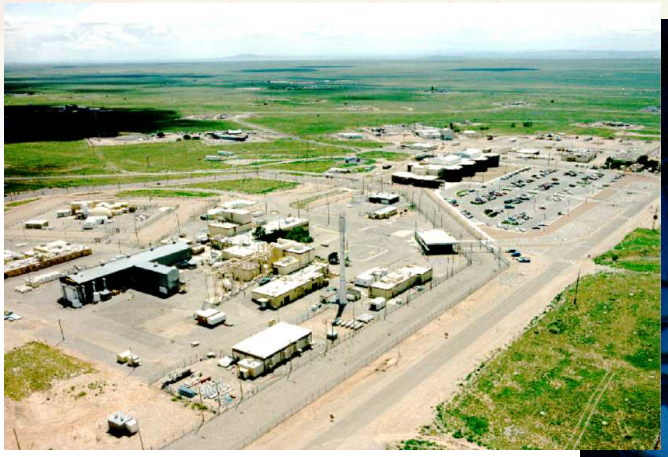
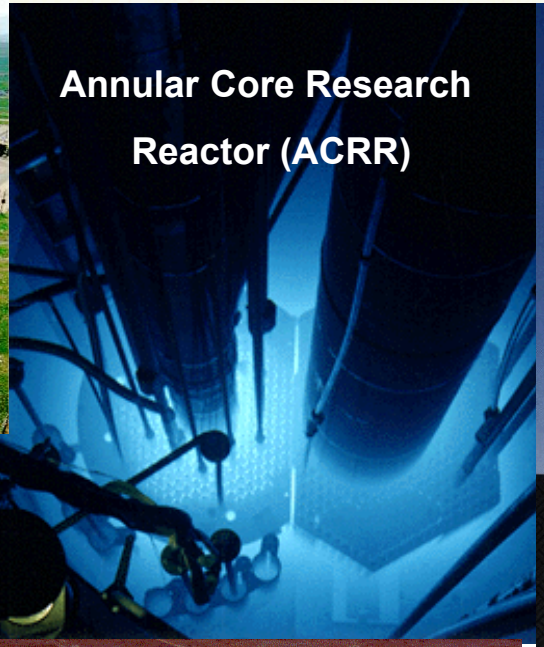
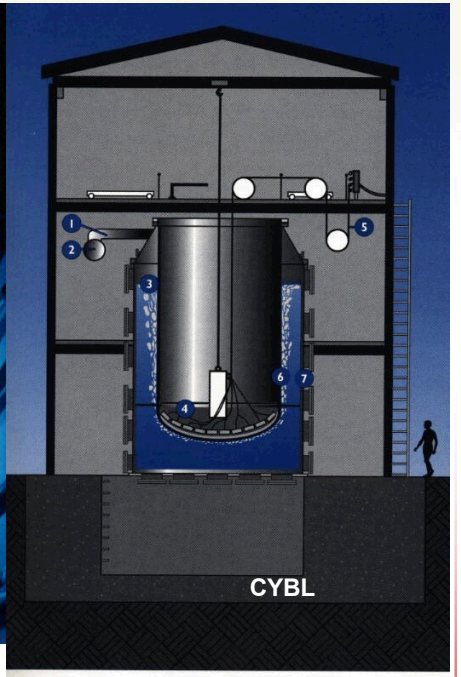
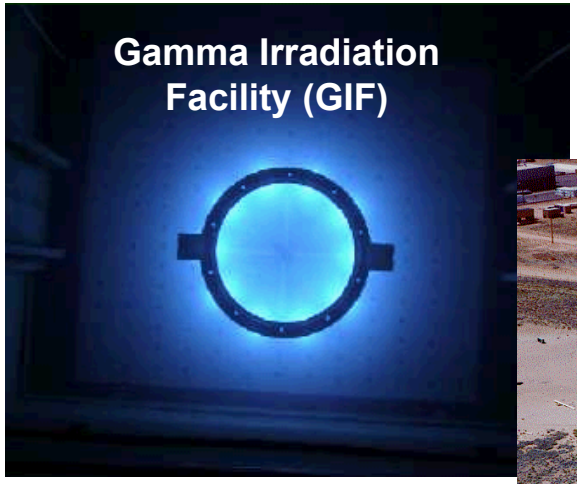
Experimental Capabilities









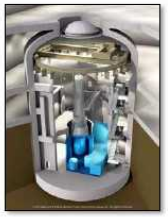
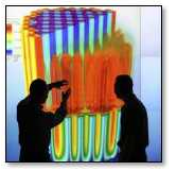
Current Activities: DOE/NE SMR Program

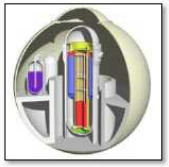
- **SMR Program Goal**
  - Collaborate with industry, NRC, academia and National Laboratories on advancing Small Modular Reactor (SMR) technology to improve the affordability of nuclear energy and increase the potential to revitalize the U.S. manufacturing sector
  - As a new start in FY11, DOE is in the process of developing the SMR program plans and budget allocations. Using the recent workshop and the subsequent development of the R&D portfolio to finalize the program planning

smr Workshop
DOE ▪ Office of Nuclear Energy

DOE-NE program seeks to address SMR development and deployment challenges

Design certification partnerships	Assessment tools	Technology R&D	Advanced concepts
Establish cost-shared projects with industry partners to accelerate design certification	Support development of new analysis tools, codes and standards, and cost models to support objective assessments of safety, performance, and economics	Develop new technologies that further reduce costs or enable advanced features and functionality	Develop innovative concepts that utilize advanced technologies to achieve expanded functionality



Additional DOE investment is needed to offset FOAK risk and accelerate deployment

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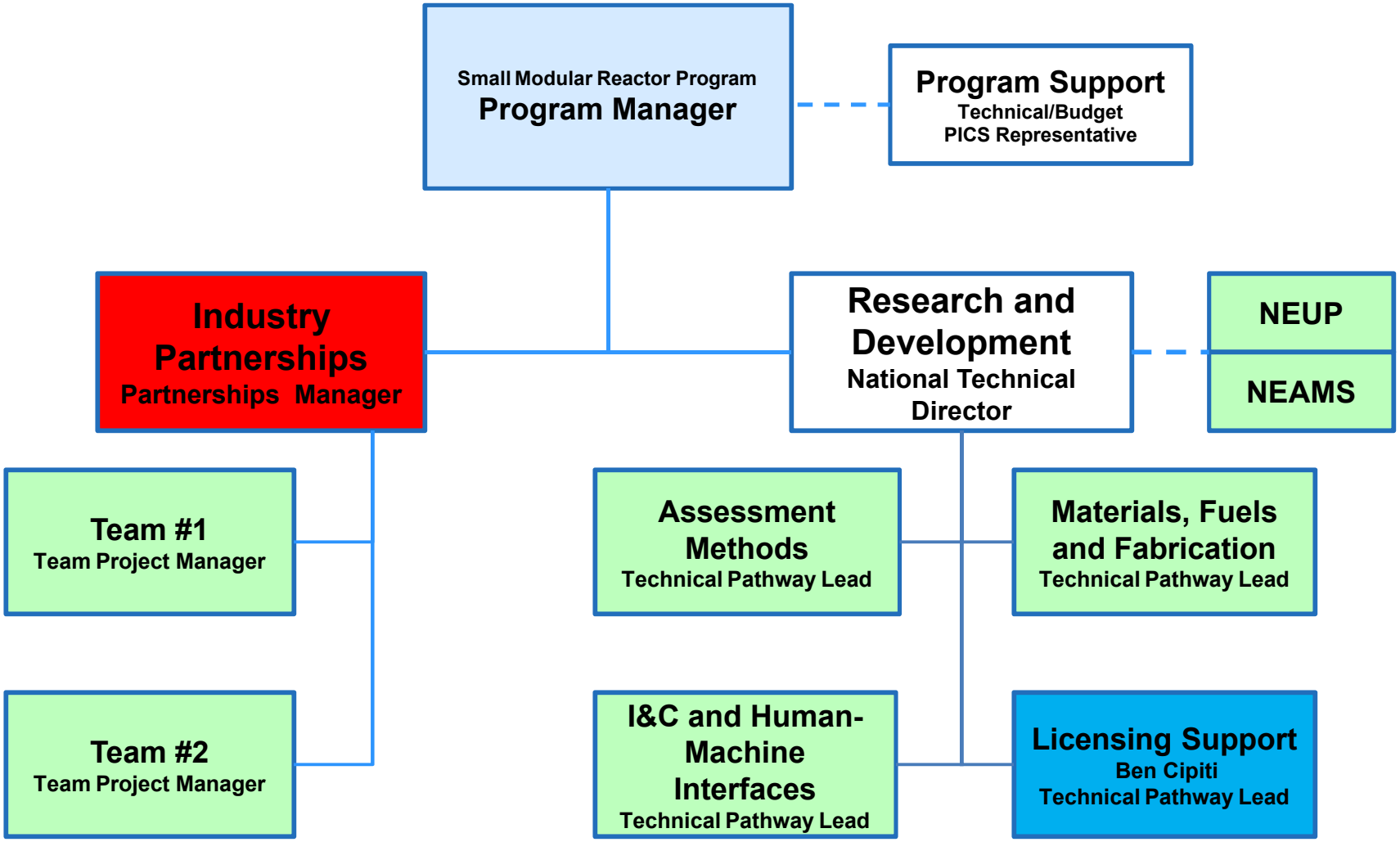
Proposed Program Structure



Current Activities for SMR Program

- **The SMR program will incorporate multiple activities to support SMR development:**
  - Establish a cost-shared effort with industry
  - Explore R&D needs

- **DOE will also**
  - Collaborate with NRC and industry on SMR licensing process
  - Identify and address gaps in nuclear industry codes and standards that will enable design and development of SMR technologies

SNL's Role in DOE/NE's SMR Program

- **Lead Licensing Support Component of SMR Program**
  - Regulatory Evaluation of SMR Siting Issues
  - Development of Advanced Design Tools and Techniques for Security Integration
  - Human Factor Evaluation for Reduced Staffing in SMR Operations
  - Contributions to NESCC for Codes and Standards Developments
  - Interface with NEI, ANS and NRC on SMR Regulatory Issues
- **SMR Demonstration at DoD Installation***
  - Business Case under Development for New Mexico NNSA Site to Partner with DoD Site for SMR Demonstration.

* Program Plan for Small Modular Reactor Program (DRAFT), DOE Office of Nuclear Energy, Rev. 11, December 2010.

Sandia's Contributions to DoD Deployment

- **Microgrid design for energy security**
- **Integrated Systems Engineering**
- **Nuclear site characterization and qualification**
- **Supporting licensing for either DOE or NRC regulation**
  - Complete PRA assessment
  - Severe Accident assessment and mitigation technology
- **Emergency Planning**
- **Waste Management**
- **Balance of Plant assessment and design**
  - Advanced energy conversion technology (air-cooled)
  - Plant security assessment and design (safeguards by design)
  - Evaluation of human factors
  - Secure digital instrumentation and control

What Sandia Offers

- Leadership to determine if a DOE or NRC regulated installation on a DoD site
- Assistance in changing the regulatory posture for SMRs in reduced staff and licensing costs
- Support to obtain license from the regulatory authority
- Leadership in standing up the engineering/operating/service organization to meet DoD requirements
- Provide siting qualification
- Provide the systems interface with the DoD
- Provide the security/safeguards design and minimize extrinsic requirements.

Pursuing a DoD Project

- **DoD-wide initiative analogous to mission-critical weapon or support systems that Congress authorizes and appropriates for**
  - DoD has multiple missions in multiple environments, CONUS islanding is only one.
  - Development to first deployment could easily be $0.5B and up
- **A systematic approach is needed to guide to military reactor development**
  - Define missions and deployment “environments”
  - Define system functional requirements
  - Power levels and cycling requirements
  - Lifetime and availability constraints
  - Costs / Economics, etc
- **Identify / define candidate system concept and technology options**
  - Evaluate options against requirements
  - Performance
  - Technical maturity
  - Technical development risk
  - Cost and schedule

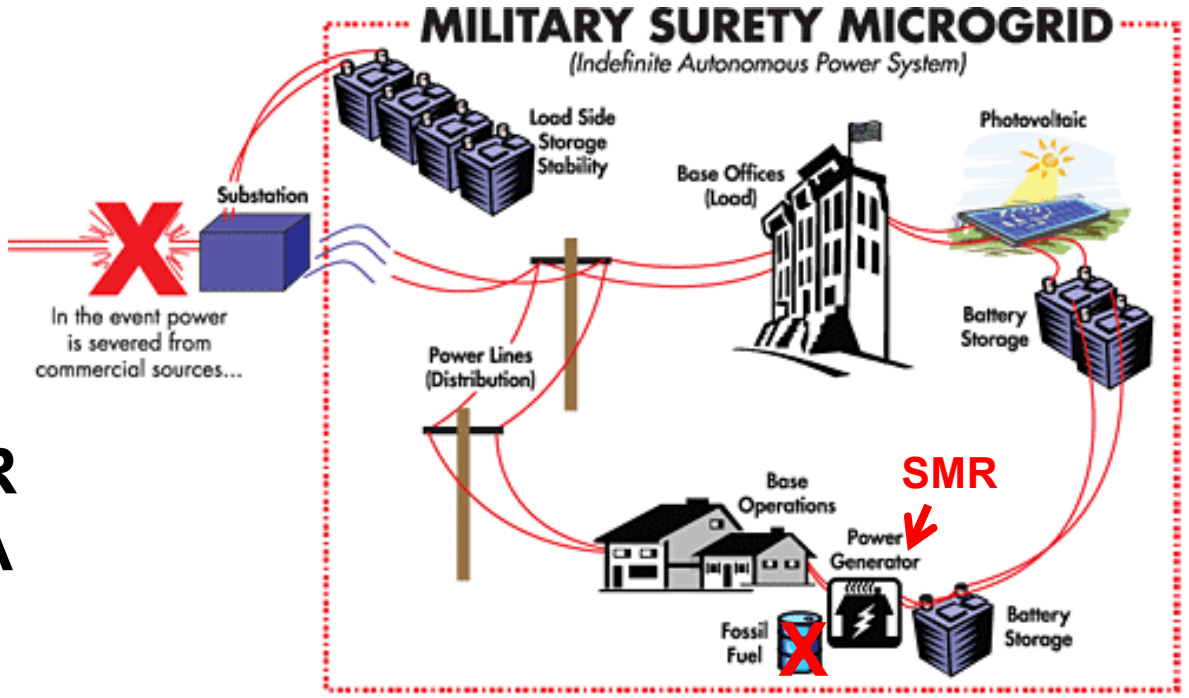
1. Establish Evaluation Criteria & Metrics
2. Reduce Options to short list
3. More detailed evaluations
4. Reduce to Primary and Backup System Options
5. Develop preliminary designs
6. Formalize development plans

Sandia's Strategy for DOD Energy Security

- **A Proposal to Develop a Pilot Demonstration of Energy Security at White Sands Missile Range with Small Modular Nuclear Reactor Technology**

- **Combine with a Engineered Microgrid**

- **Partner with a Commercial LWR vendor for a FOA proposal**



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