SAND2011-6382C

NUCLEAR ENERGY & GLOBAL SECURITY

TECHNOLOGIES

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, 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

Overview of Sandia National Laboratories and Nuclear Energy Capabilities

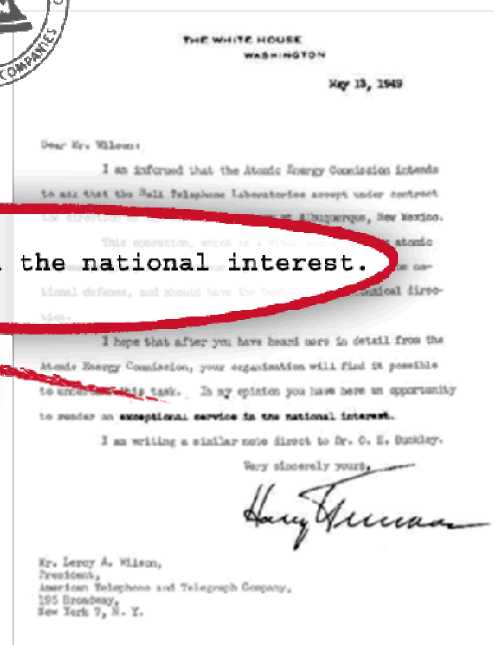
D.A. Powers

Senior Scientist

Sandia National Laboratories

Sandia's History

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 ... at Albuquerque, New Mexico.

This operation, which is a vital ... atomic ... tional defense, and should have the best ... 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,

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

Sandia National Laboratories

SANDIA Sites

Albuquerque,
New Mexico

Livermore,
California

Tonopah, Nevada

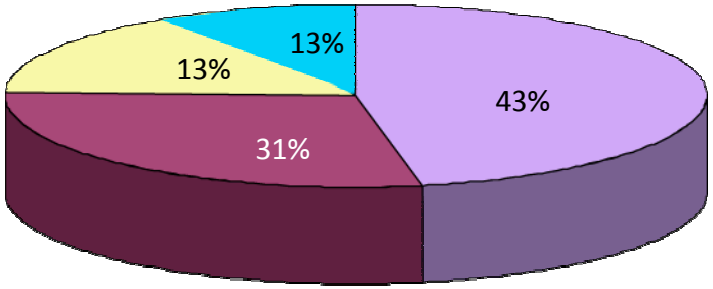
Waste Isolation Pilot Plant,
Carlsbad, New Mexico

Pantex, Texas

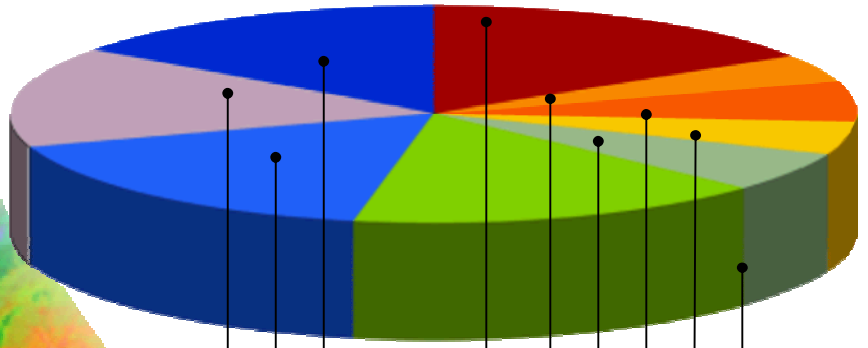
Sandia
National
Laboratories

People and Programs

- On-site workforce: 11,677
- Regular employees: 8,607



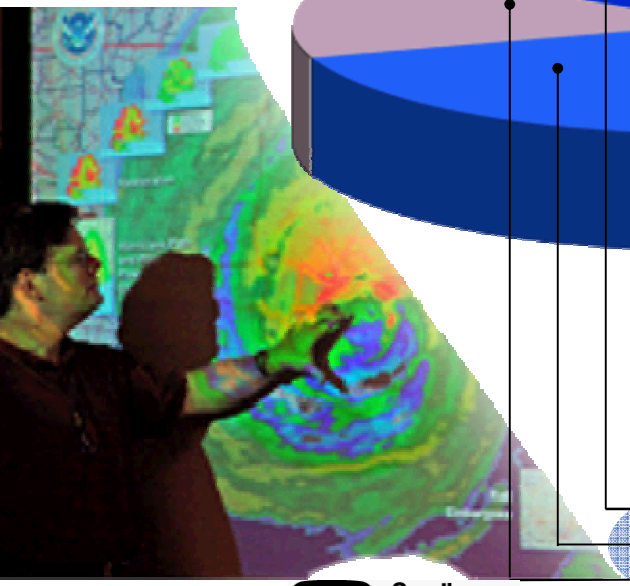
Technical staff (4,277) by discipline:



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

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

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



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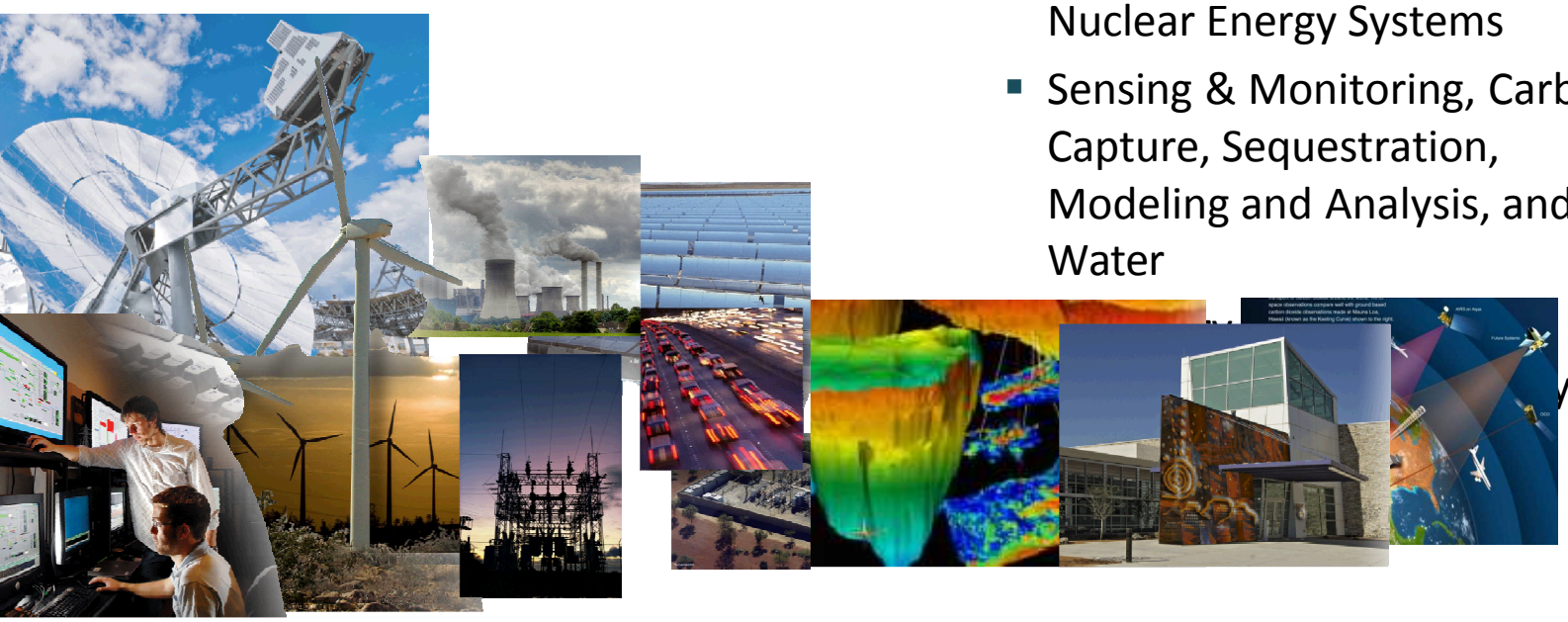
Energy, Climate, and Infrastructure Security

Program Areas

- Infrastructure Security
- Energy Security
- Climate Security
- Enabling Capabilities

Areas of Expertise

- Modeling & Analysis, Cyber, Electricity Distribution, and Energy Assurance
- Renewables, Energy Efficiency, Energy for Transportation, and Nuclear Energy Systems
- Sensing & Monitoring, Carbon Capture, Sequestration, Modeling and Analysis, and Water



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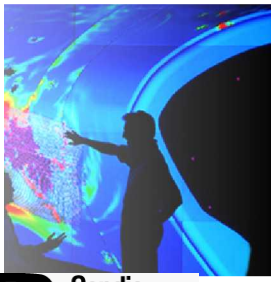

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How Sandia Got Involved in the Safe Production of Nuclear Energy

- **Atomic Energy Commission divided 1974**
  - Department of Energy to develop commercial nuclear energy
  - US Nuclear Regulatory Commission to assure nuclear energy development provides adequate protection of public health and safety
- **Sandia made a National, multi-mission laboratory**
  - Expertise in nuclear science and engineering
  - No past involvement with commercial nuclear power

Sandia National Laboratories

First Steps

- Experimental bases of risk analysis
  - Steam explosions
  - Hydrogen combustion
  - Core debris interactions with concrete
- Modeling of observed phenomena to scale to the size of nuclear power plants
- Probabilistic Safety Analysis

Sandia National Laboratories

First Steps

- Experimental bases of risk analysis
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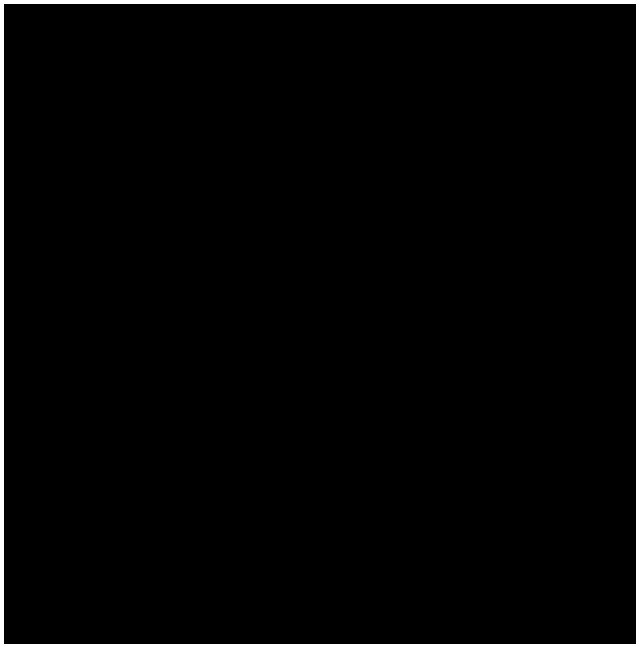

Test of melt interactions with structural concrete: concrete erosion, combustible gas generation and aerosol production.

Sandia National Laboratories

First Steps

- Experimental bases of risk analysis
- Modeling of observed phenomena to scale to the size of nuclear power plants
  - Accident analysis model MELCOR
  - Containment response model CONTAIN
  - Hydrogen combustion model HECTR
  - Consequence model MACCS
- Probabilistic Safety Analysis

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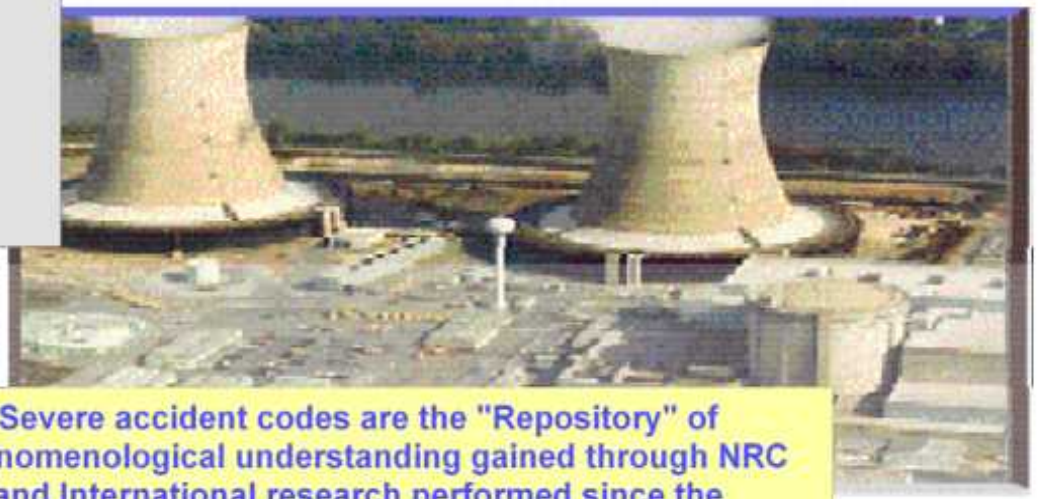
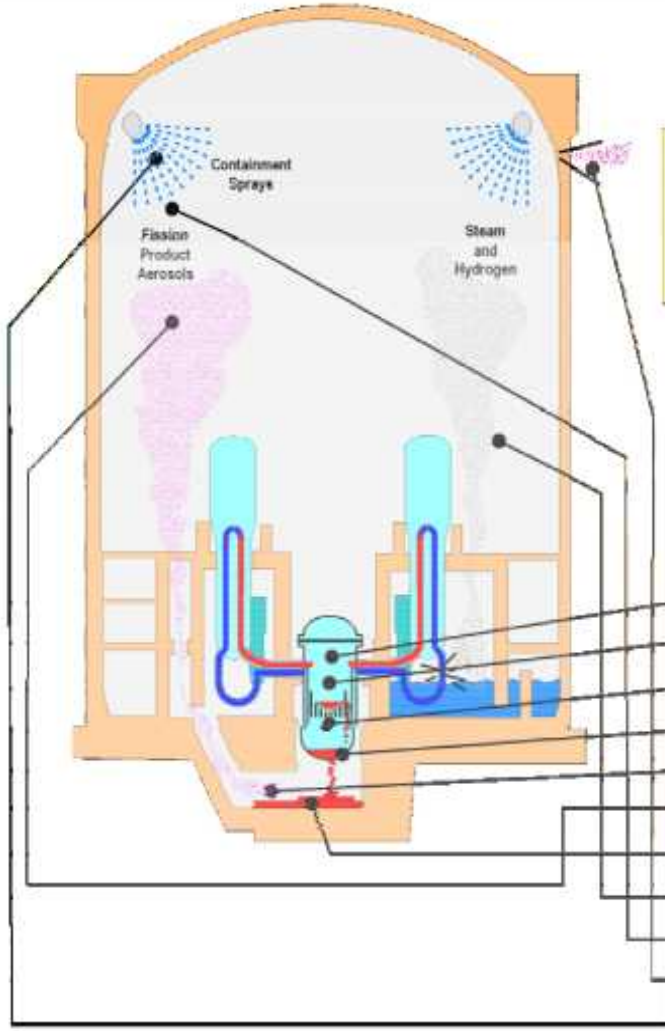
Modeling and Analysis of Severe Accidents in Nuclear Power Plants



Severe accident codes are the "Repository" of phenomenological understanding gained through NRC and International research performed since the TMI-2 accident in 1979

Integrated models required for self consistent analysis



Important Severe Accident Phenomena

	MELCOR	CONTAIN	VICTORIA	ICOMP RELAP 5
Accident initiation	■			■
Reactor coolant thermal hydraulics	■			■
Loss of core coolant	■			■
Core meltdown and fission product release	■		◢	■
Reactor vessel failure	■			■
Transport of fission products in RCS and Containment	■	■	■	
Fission product aerosol dynamics	■	■	■	
Molten core/basemat interactions	■	■		
Containment thermal hydraulics	■	■		
Fission product removal processes	■	■	■	
Release of fission products to environment	■	■	■	
Engineered safety systems - sprays, fan coolers, etc	■	■		
Iodine chemistry, and more	■			

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First Steps

- Experimental bases of risk analysis
- Modeling of observed phenomena to scale to the size of nuclear power plants
- Probabilistic Safety Analysis
  - Level I: accident initiation frequency
    - Technology developed and transferred to industry
  - Level II: accident progression and radionuclide behavior
  - Level III: accident consequences

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Browns Ferry Fire

- “near miss” accident initiated at a nuclear power plant by the accidental ignition of electrical cables in the plant
  - “hot shorts” produce spurious actuations and disables plant cooling
- Nuclear Regulatory Commission establishes research on electrical cable behavior in fires at Sandia

“hot short” phenomenon in cables heat by radiant source to mimic a fire

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“Closing” the Fuel Cycle

- Safety of fast, breeder reactors for fuel production and transmutation
  - Core disruption experiments
  - Debris bed cooling
  - Sodium fires and interactions with concrete
- Waste disposal
  - Defense waste: Waste Isolation Pilot Project for defense waste
  - Commercial waste: Yucca Mountain Project for high level waste including commercial reactor fuel
- Nuclear Material Transportation

Sodium spray fire to simulate piping leak in air-filled cell

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SNL is Recognized Internationally as a Lead Laboratory for Storage & Transportation Technology Development: *Testing, Analysis, Regulatory Support*

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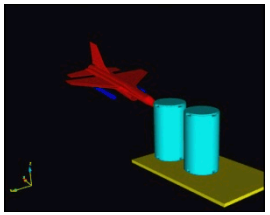
NUREG-0170
- Transportation EIS
- RADTRAN

PAT-I

TRUPACT-II

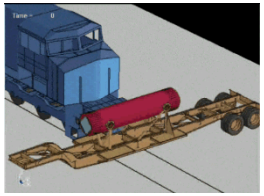
9/11 vulnerability assessments for NRC



TRUPACT-III

Sandia assigned lead transportation lab for DOE/DP

Full-scale tests

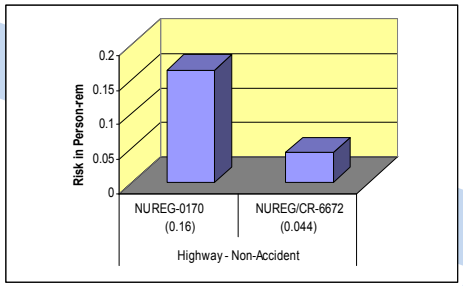


F-16 sled track test

Sabotage

Tech basis analysis for NRC rule-making

Canister testing for INL



NUREG/CR-6672
Risk Analysis

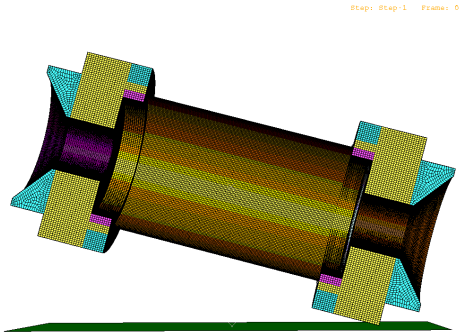
DOE/NE lead lab for storage & transportation

DOE/DP&EM → DOE/RW → DOE/NE

NRC/Research, NMSS, and NSIR →

'80s '90s '00s

Nuclear Material Transportation Safety



Simulations

Experiments
- impact
- fire

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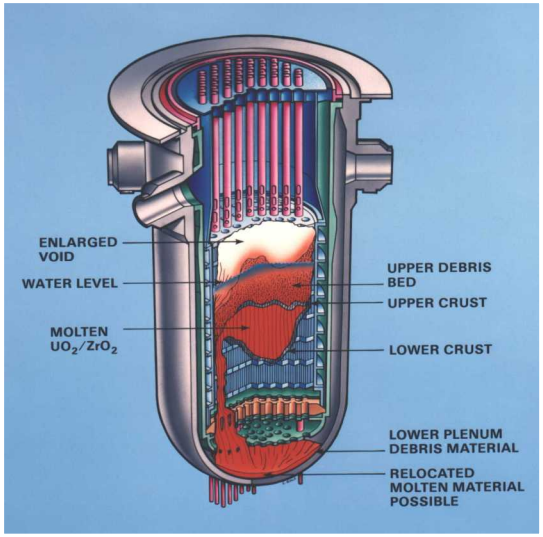
Aftermath of the Reactor Accident at Three-Mile Island

- Traumatic event for the US and world nuclear power communities
- Established the utility of probabilistic methods for safety analysis relative to older, deterministic methods
- Nuclear Regulatory Commission demands more detailed understanding of accident progression and radionuclide release



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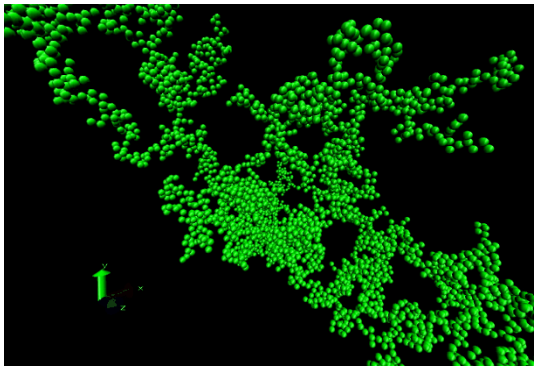
Intense Phenomenological Research on Severe Reactor Accidents

- In-pile and out-of-pile experiments on reactor core degradation
- Fission product chemistry
- Aerosol physics

Annular Core Research Reactor used for fuel degradation testing



Fractal aerosol particle impact with reactor coolant system surface

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Post-TMI Research Culmination

- **Detailed, Level III, probabilistic risk assessment of five representative US nuclear power plants with uncertainty analysis**
  - **Identification of dominant accident scenarios**
  - **Risk information used for revision of regulatory system to a risk-informed basis.**

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Aftermath of 9/11 Terrorist Attacks

Airport security

Maritime security

Energy supply

Infrastructure security

Physical security, base protection

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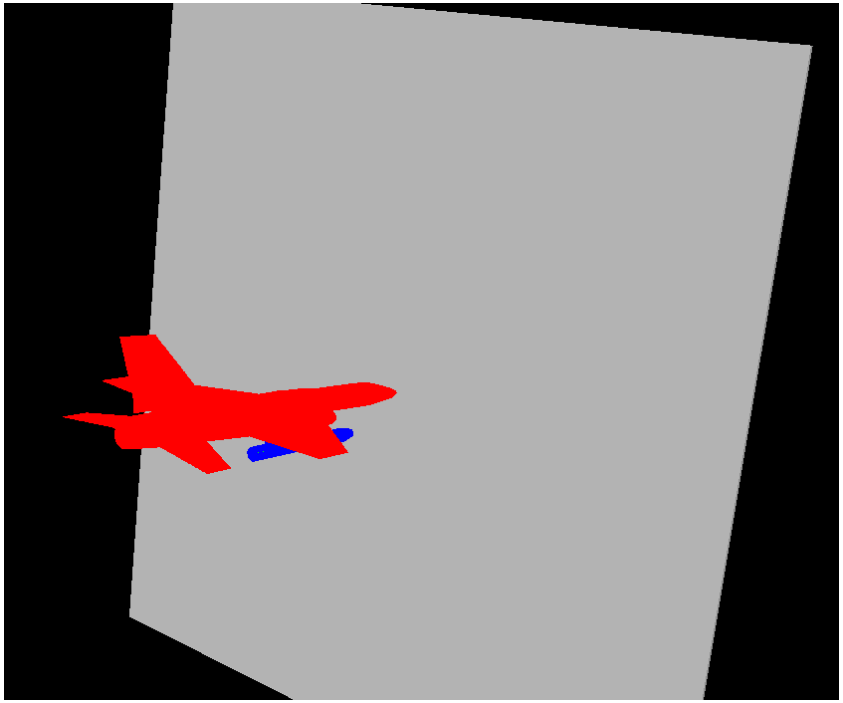
Aircraft Impact Testing

Experiment



Simulation

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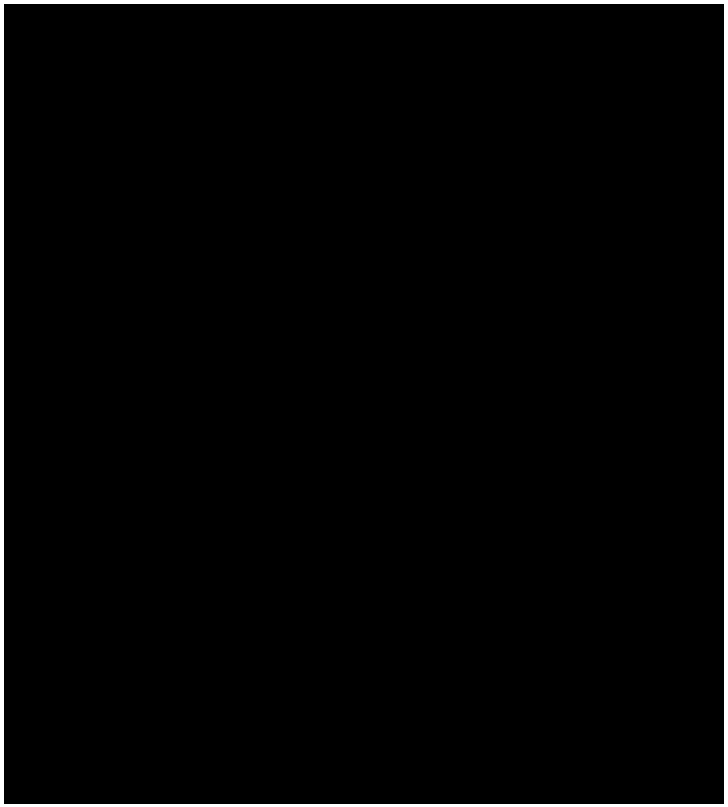
Containment Structural Integrity Studies

- Model containments 1/32 to 1/8 scale overpressurized
- Containment structures impacted
  - Aircraft
  - Telephone poles
  - Turbine rotor blades



Sandia-NUPEC containment structural integrity test

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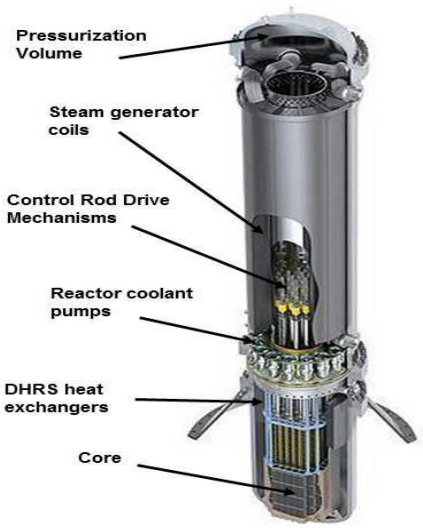
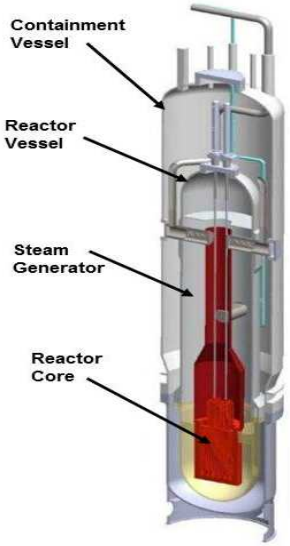
Current and Future

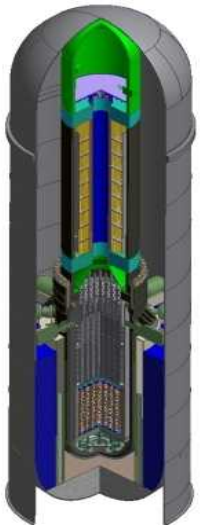
- **Safety of Small Modular Reactors (SMRs)**



mPower (Babcock & Wilcox)
125 MWe



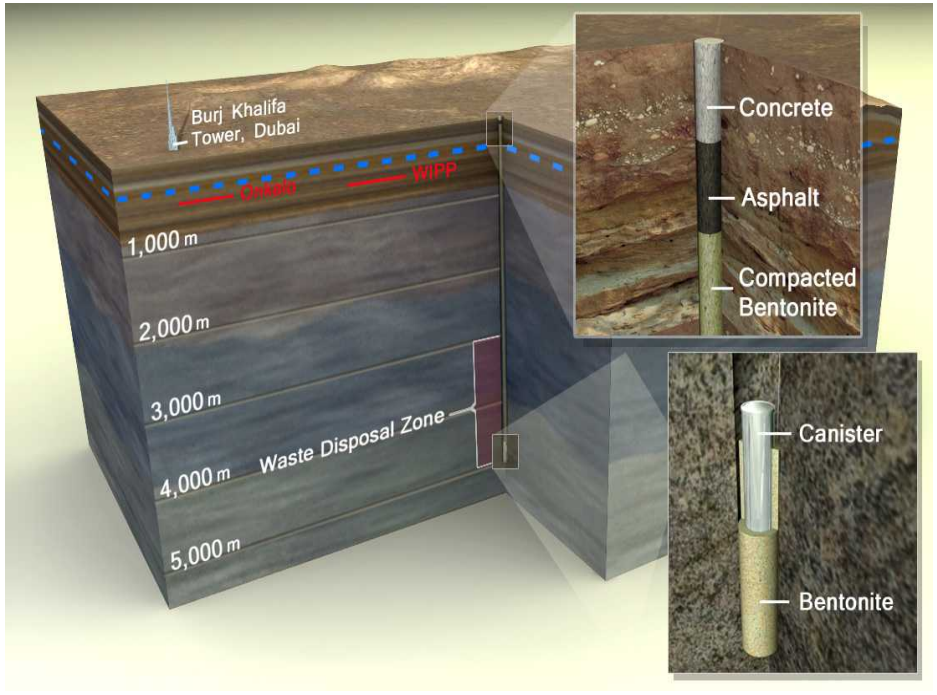
NuScale (NuScale)
45 MWe



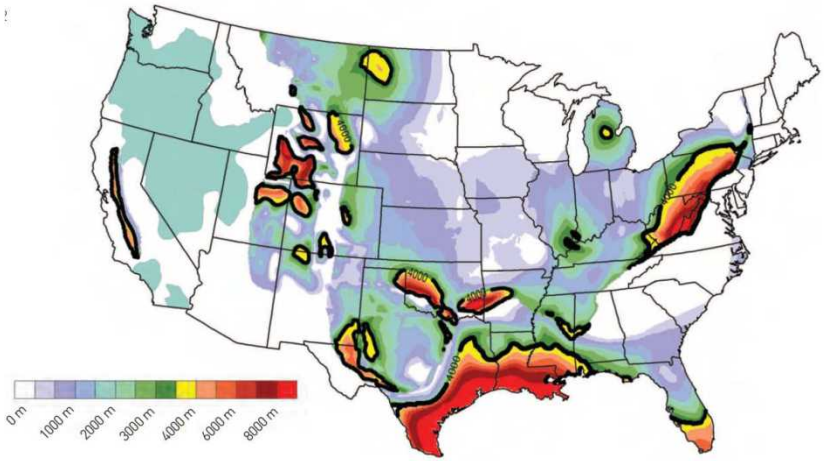
Westinghouse

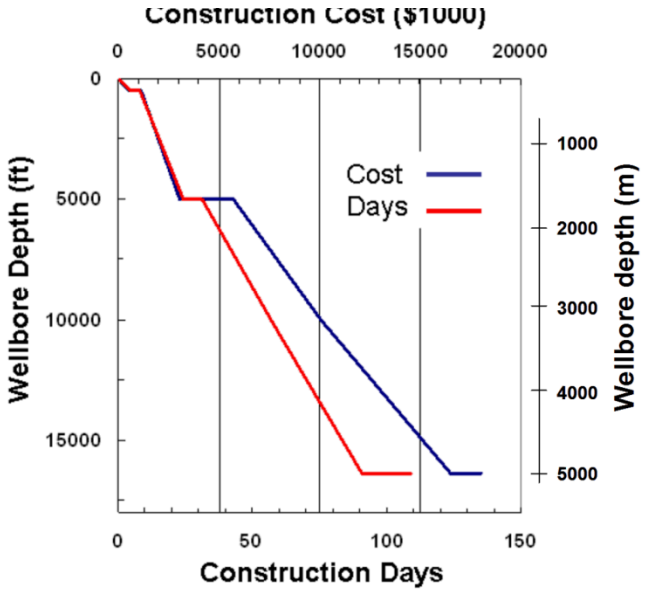
Sandia National Laboratories

Deep Bore Hole Waste Disposal



Sediment Thickness Map





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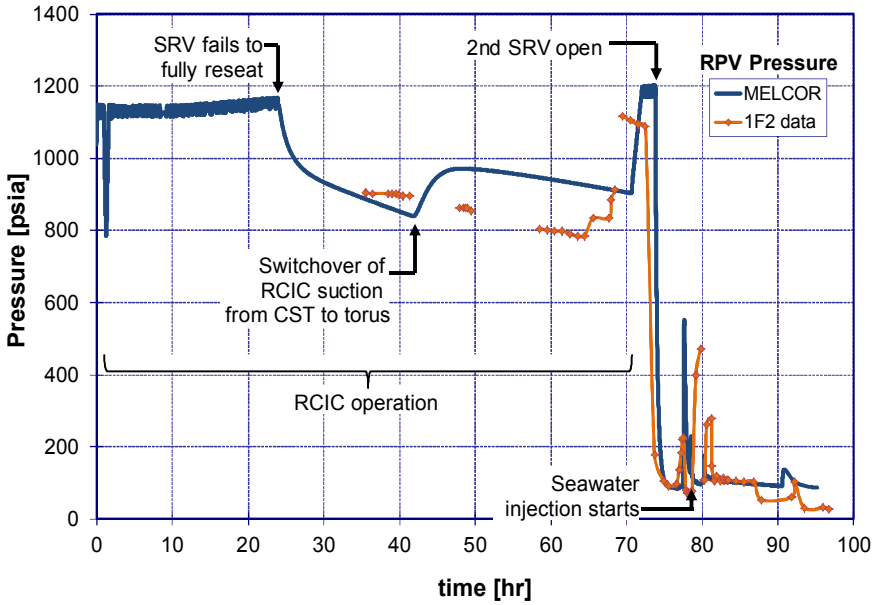
Fukushima Accident Forensics

- Understanding accident progression and events
- Definition of critical data to be obtained in the recovery and decommissioning of the Fukushima reactors
- Implications for US reactors and the regulatory process



Pressures within Fukushima Unit-1 calculated with the MELCOR code

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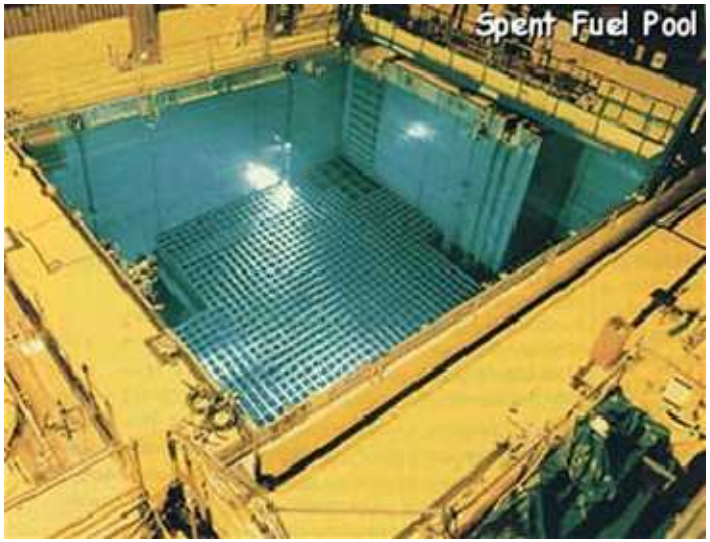
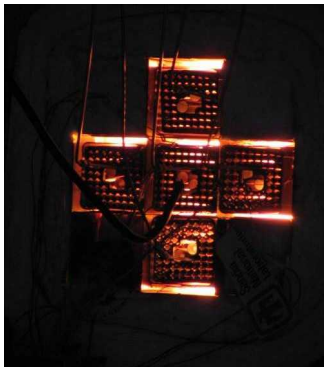
Safety of Spent Fuel Pools

- **Experiments and modeling**





Heat-up of fuel bundles following pool drain event

Fuel bundle assembly after the test.

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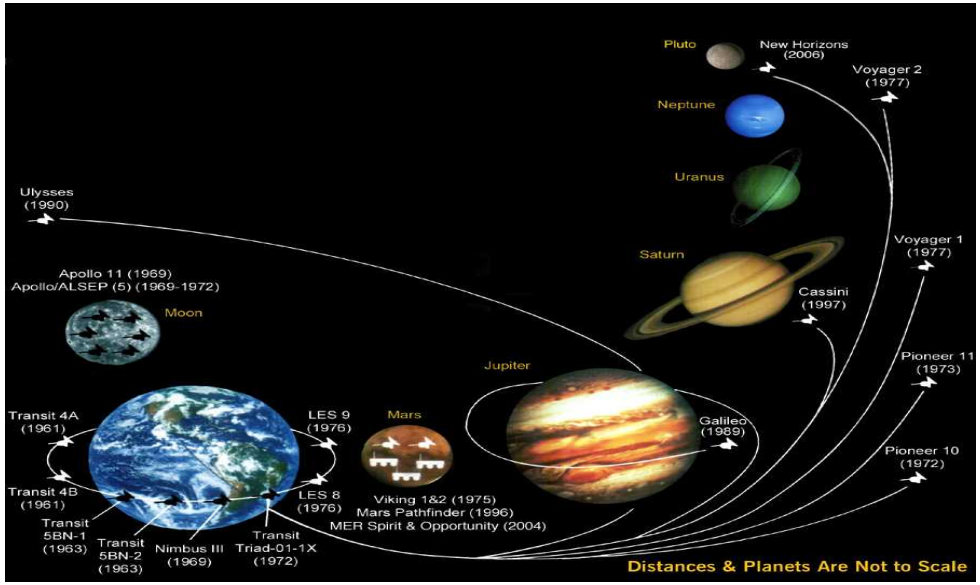
Safe Launch of Radioisotope Thermoelectric Generators (RTGs) for Space Exploration

RTGs have been used in 23 successful space missions



The safety concerns are dominated by launch failures

Studying:

- behavior of radioisotopes in launch accidents
- probabilities of accidents
- consequences of accidents

Sandia National Laboratories

Concluding Comments

- **Sandia** – **a multi-mission laboratory applying advanced science and engineering in service to the nation's interests.**

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