Exceptional service in the national interest

Sandia National Laboratories

SAND2014-19902PE

Sandia National Laboratories

Information Session

U.S. DEPARTMENT OF ENERGY | NNSA | Operated By LOCKHEED MARTIN

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 2013-7019P

Sandia National Laboratories is an equal opportunity employer and a drug-free workplace. 8/2013

Sandia's Impact Video

Sandia National Laboratories

Sandia's Impact

Cleanroom invented 1963

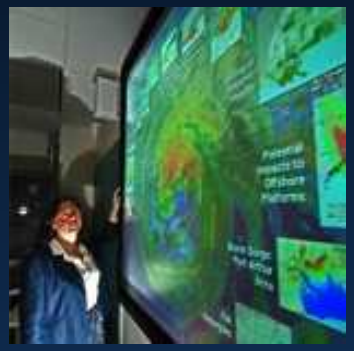
$50 billion worth of cleanrooms built worldwide It's used in hospitals, laboratories and manufacturing plants today.

9/11

Sandia sets contingency plans for release of materials and aircraft attacks on critical facilities immediately after 9/11. Search dogs are equipped with cameras for search and rescue K-9 handlers. The capability allowed search efforts to be carried out in spaces inaccessible to humans.

2008 Satellite Takedown

Red Storm computing helps shoot down rogue satellite.



Hurricane Katrina

Sandia is called to assess flooding and infrastructure failures.

Fukushima Quake

Sandia helps cleanup radioactive wastewater.

Gulf Oil Spill

Sandia works to help to develop an approach for securing the damaged well head, stopping the leak, and minimizing the severity of the oil spill.

Sandia - *Today*

Sandia National Laboratories

As a multi-faceted national security laboratory, Sandia has delivered essential science and technology for more than 60 years and plays a critical role in ensuring U.S. technical superiority.

At Sandia, you can become part of something more—and contribute to our quest to render exceptional service in the national interest.

Sandia is a National Laboratory

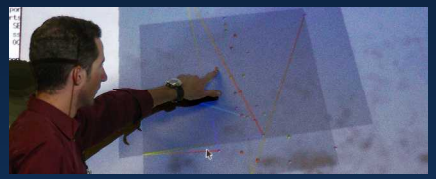
Fulfilling Our National Security Mission

Sandia National Laboratories

Modernize the Nuclear Deterrent

Work to Solve Global Security Challenges

Secure America's Energy and Environmental Future



Address National Cyber Security Issues

Deliver Advanced Solutions to Our Military

Modernizing the Nuclear Deterrent

Sandia assumes an increasingly pivotal role in sustaining the nation's nuclear deterrent.

Working to Solve Global Security Challenges

Nonproliferation

Securing America's Energy and Environmental Future

Sandia National Laboratories

Energy Security

Climate Security

Infrastructure Security

Enabling Capabilities

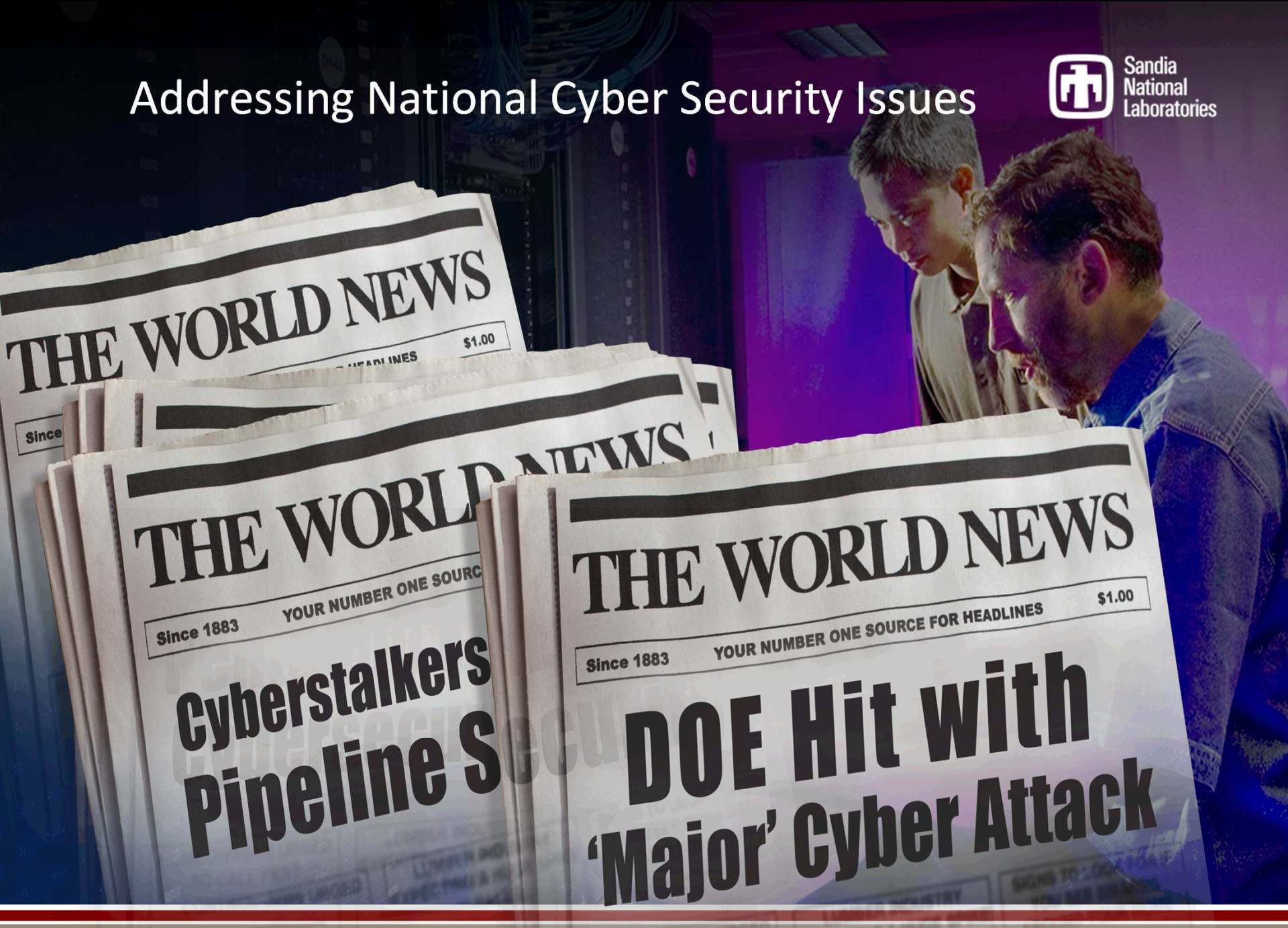
Anne Ruffing

Cyanobacteria Engineering for Liquid Fuels

Ph.D. Chemical Engineering, Georgia Institute of Technology

Addressing National Cyber Security Issues

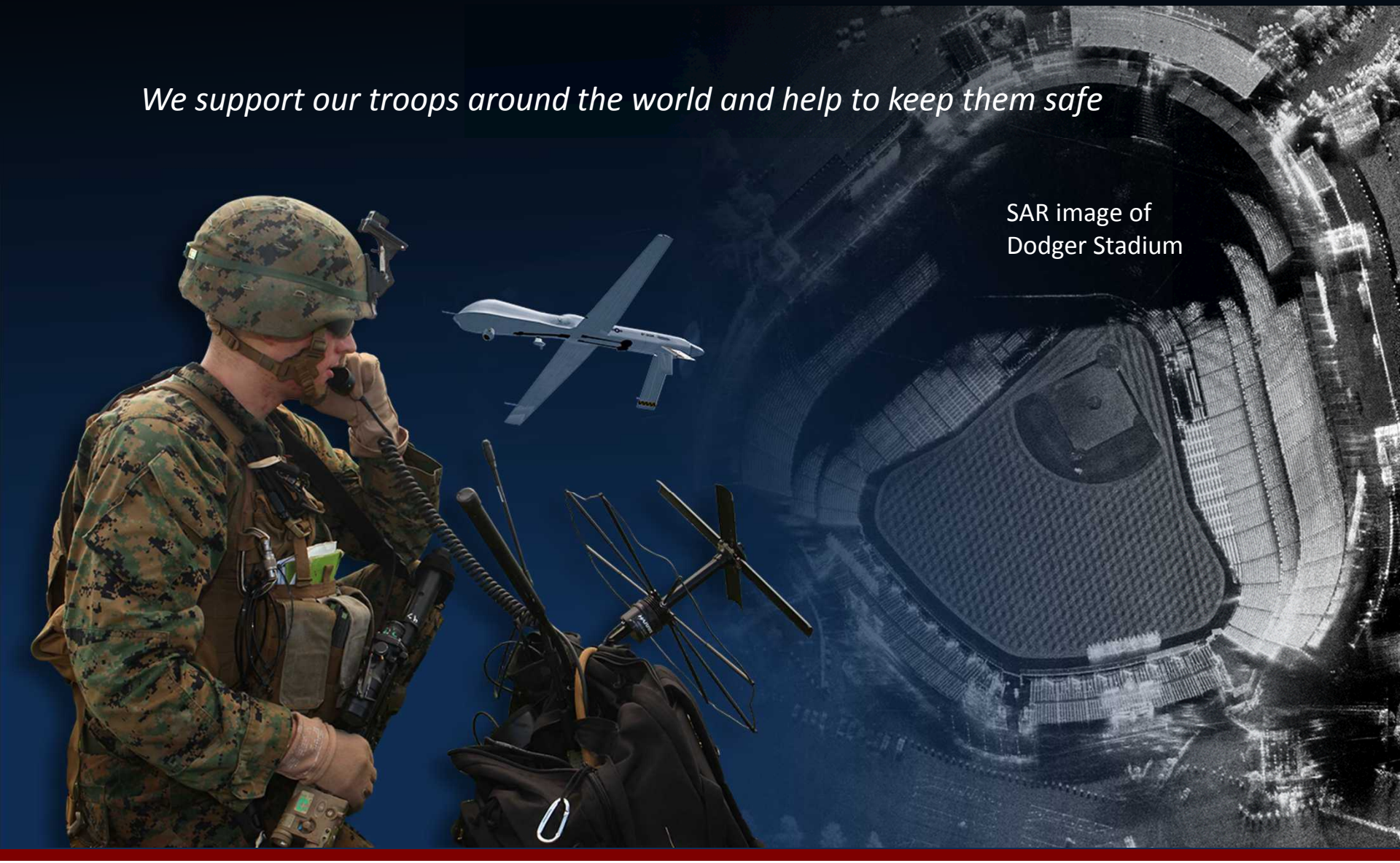
Sandia National Laboratories



Bringing Advanced Solutions to Our Military

Sandia National Laboratories

We support our troops around the world and help to keep them safe



SAR image of
Dodger Stadium

Our Foundations in Research

We support essential research-and-discovery activities that translate into invention, innovation, entrepreneurship, economic opportunity, and public benefit.

- Bioscience
- Computing and Information Science
- Engineering Science
- Geoscience
- Materials Science
- Nanodevices and Microsystems
- Radiation Effects and High Energy Density Science

Our Workforce & Culture

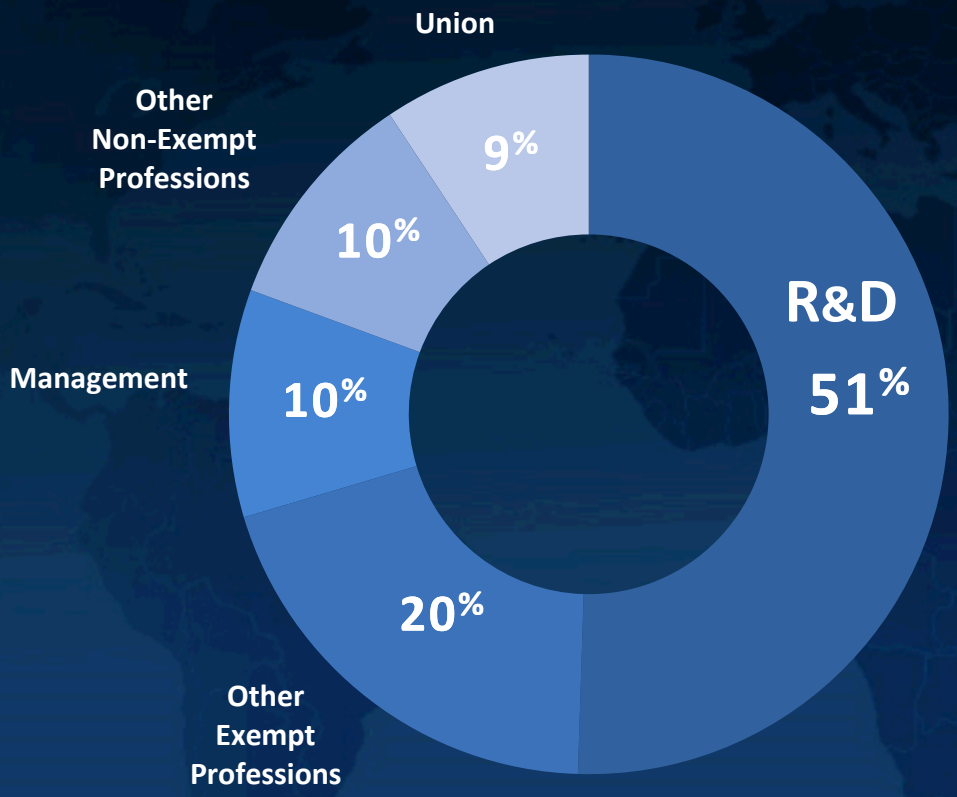
Our Workforce

Regular Employees	Highest Degree
1,757	PhD
3,770	Masters
1,768	Bachelors
8	Doctor of Medicine
35	Doctor of Law

Regular Employees	Years of Service
3,455	Less than 5 years
1,256	5–9 years
2,777	10–19 years
1,544	20–29 years
890	30–39 years
52	40+ years

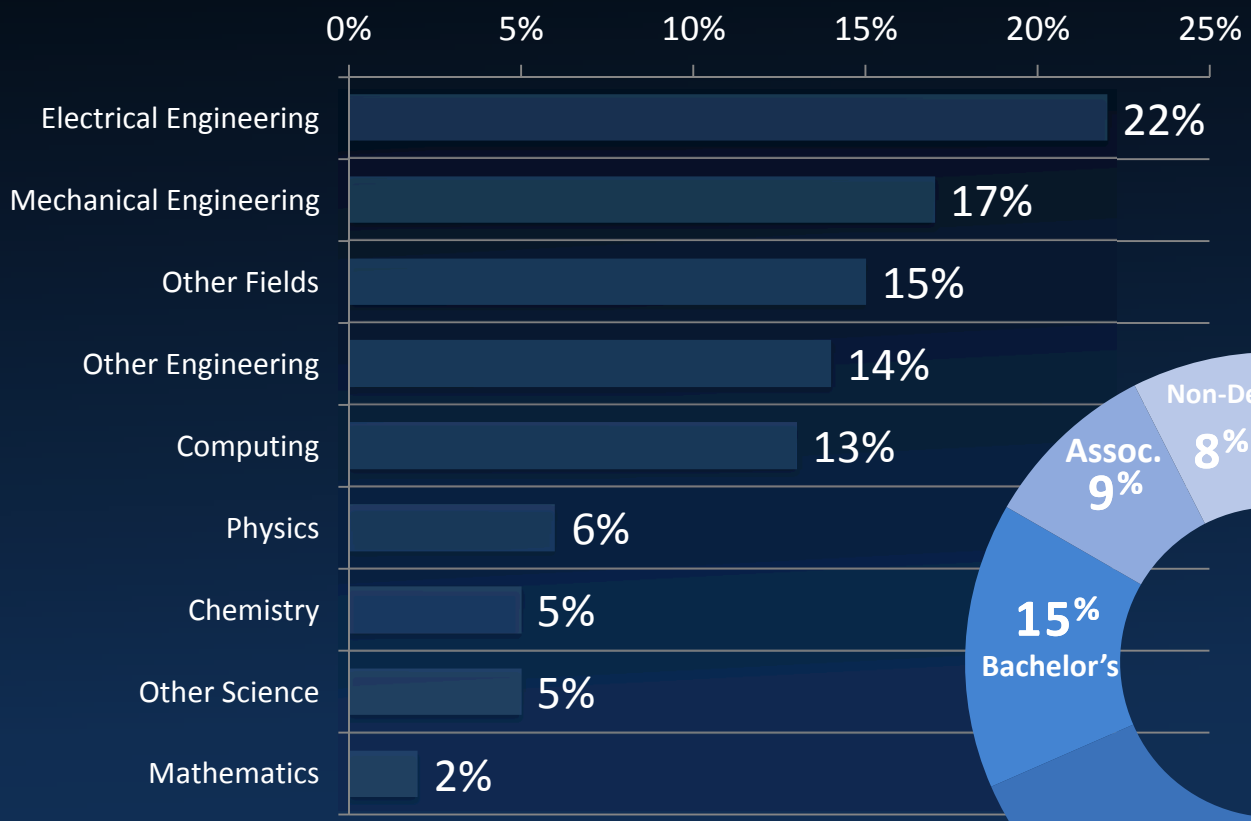
9,974 Regular employees

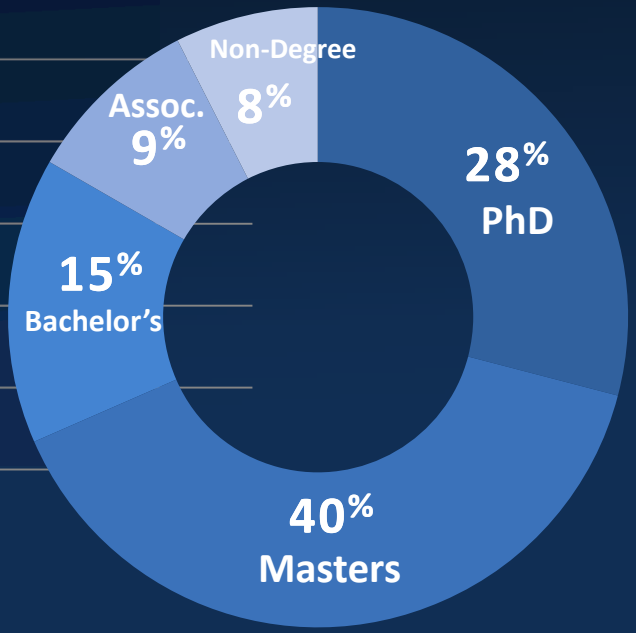
1,131 Temporary employees and contractor associates



Data as of Sept 2014

R&D by Discipline & Degree





Our Workforce spans the Nation

Sandia National Laboratories

What's a career like at Sandia?

The Work Experience

- Take on challenging assignments in state-of-the-art research facilities
- Work with internationally recognized scientists and engineers
- Receive recognition through service awards, employee recognition awards, R&D 100 Awards *and more*
- Take a leave to pursue qualifying research and professional opportunities
- Receive patent royalties, if eligible
- Pursue multiple careers through retraining and rotational opportunities
- Participate in diversity training and awareness programs that promote an all-inclusive workforce

Quality of Work/Life

Flexible Work Schedules

- 9/80 – work week
- Telecommuting arrangements
- Part-time options
- Vacation Buy Plan

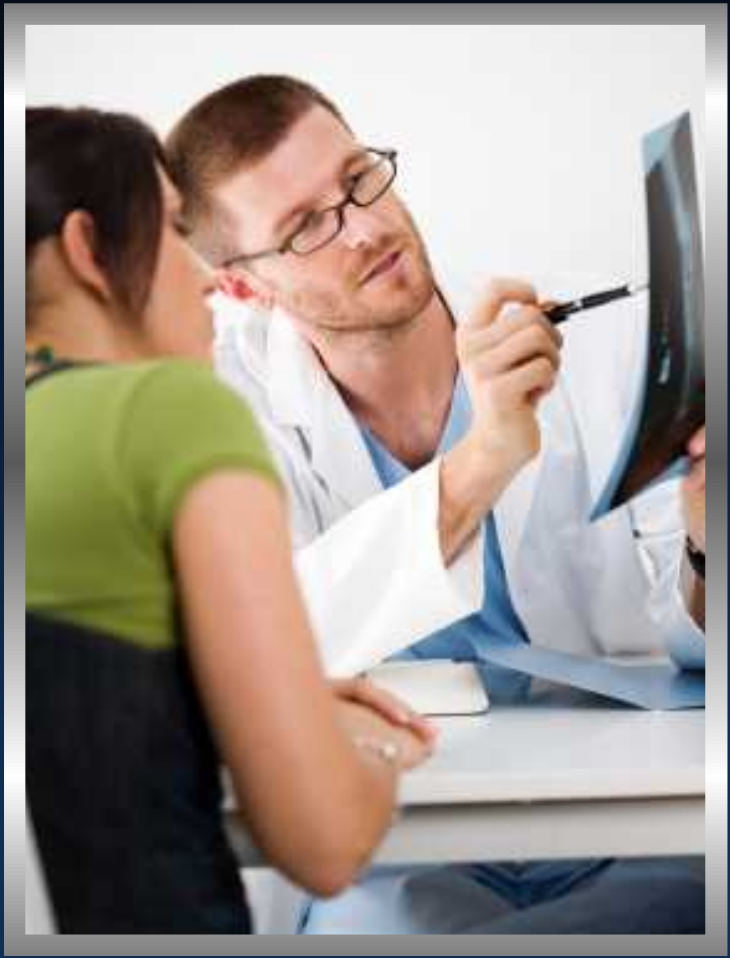
Family Life

- Referral services/Workplace options
- Adoption assistance
- Family recreational activities

Health

- Health risk assessment screenings
- Onsite fitness facility and fitness programs
- Onsite health clinic
- Health education
- Behavioral health
- VirginHealth Miles Program

Convenience



On-site Amenities

- Medical Clinic
- Sandia Laboratory Federal Credit Union
- Café
- Fitness Center
- Access to group exercise classes, clubs and sporting activities
- Employee self-formed sports teams

**These amenities are available at CA and NM sites only*

Living in Albuquerque

Life in Albuquerque

- Albuquerque is the largest city in New Mexico with a population of over 500,000
- Affordable housing, reasonable cost of living
- Minimal traffic congestion

Albuquerque Environment

- Nestled between Rio Grande River and Sandia Mountains
- High desert climate with 278 annual days of sunshine
- Average temperatures between 78˚ and 40˚
- Wide-open spaces

Things to Do

- Outdoor recreation - Ski, snowboard, hike, etc.
- Santa Fe – rich culture
- International Balloon Festival (timelapse)
- Explore Indian pueblos and our Hispanic heritage
- Green chile – N.M. Cuisine
- Museums, Parks, Sports

Living in Livermore

Life in Livermore

- Livermore's relaxed lifestyle populates nearly 81,000
- Close proximity to first-tier universities, Silicon Valley companies, and other top research laboratories and facilities
- Access to California's finest public and private schools

Livermore Environment

- 260 annual days of sunshine
- Average temperatures between 73˚ and 46˚
- Annual average rainfall: 14.8 inches

Things to Do

- Vineyards
- Beaches
- State Parks
- Sports – Nearby are six major league franchises
- Art haven
- Proximity to SF Bay Area

For more information, visit: http://www.trivalleycvb.com

Employment Opportunities

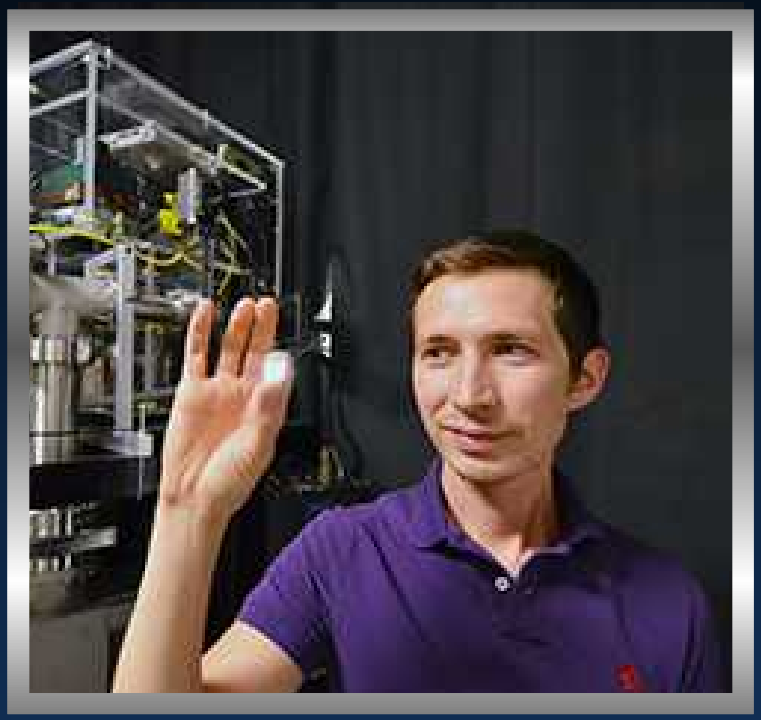
Internships

Encourages qualified students to develop interests in critical skills areas related to our mission, with the ultimate objective of developing our pipeline for our future. Available for Summer, Year Round and Co-op.

Eligibility Criteria

- Min. cumulative GPA (3.2 Undergrad/3.5 Grad)
- U.S. citizenship
- Full-time enrollment status at an accredited college, university, or local high school
- At least 16 years of age

Post-doc opportunities



Key areas for postdocs at Sandia:

- Biosciences and biotechnology
- Chemistry and materials science
- Combustion
- Computational mechanics
- Computer science
- Hydrogen
- Microelectronics and microfluidics
- Nanotechnology
- Physics

Eligibility Criteria

- Min. cumulative GPA (3.5 Undergrad/3.7 Grad)
- U.S. citizenship
- A recent PhD (awarded within the past three years) or the ability to complete all PhD requirements before beginning
- No previous postdoc appointments at a national laboratory

Special Degree Programs & Fellowship Opportunities

Special Degree Programs

- Critical Skills Master's Fellowship Program
- Master's Fellowship Program

Ph.D. Level Fellowships

- Harry S. Truman Fellowship
- John Von Neumann

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Changing gears…

“Wouldn’t you prefer to play a nice game of chess?”

Joshua / WOPR supercomputer
WarGames (1983)

Serious games

The world we model is far more complex…

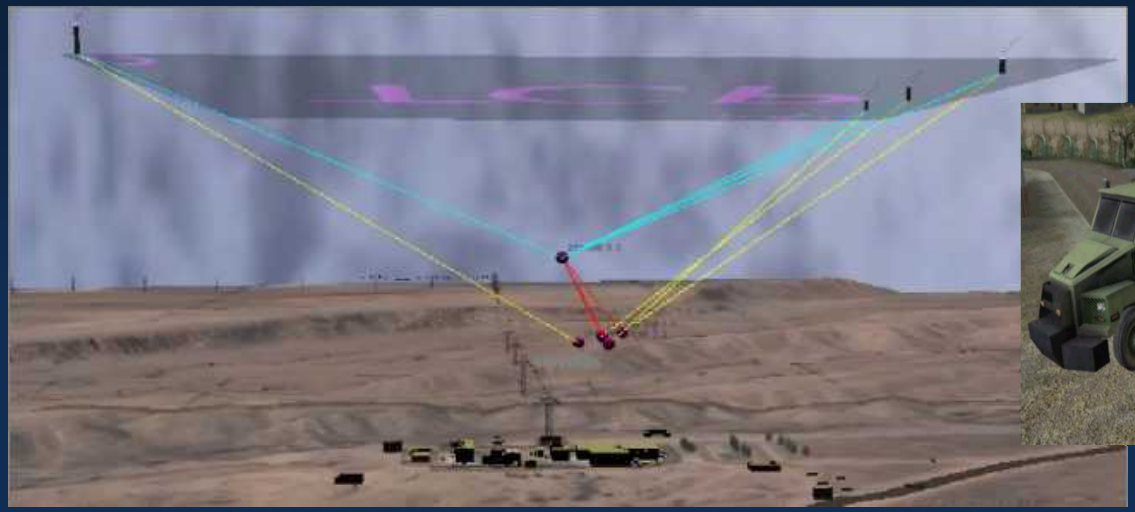
- "Complex Adaptive Systems of Systems"

http://sg.sandia.gov

Let's build games…

At the "human" time-scale:

- Sensing
- Communications
- Transportation
- Human behaviors, actions, and capabilities
- Tasks and planning
- Cyber / cyber-physical interactions
- … etc.



How are they played?

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“Games” played or developed by Sandia

Degree of interactivity

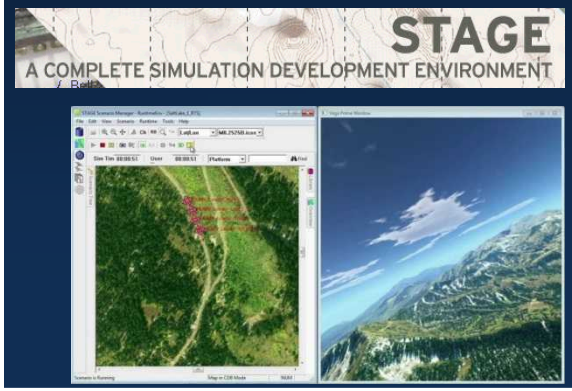
Human-in-the-loop — Turn-based — Batch analysis

JCATS [1]

Live exercises
Augmented reality training

Table-top exercises
Tactics simulation games

STAGE [2]



Simajin® [3]

[1] JCATS, Lawrence Livermore National Labs, Conflict Simulation Laboratory
[2] STAGE, AI.implant, etc., Presagis Inc., presagis.com
[3] Simajin, RhinoCorps LTD, rhinocorps.com

How are they played?

Sandia National Laboratories

Trade-offs by level of interactivity

Degree of interactivity

Human-in-the-loop — Turn-based — Batch analysis

Human-in-the-loop	Turn-based	Batch analysis
• Quick to see preliminary results, individual runs are in “real-time”.	• Relatively quick to see results; need to make decisions at each turn and iterate.	• Single simulations may be quick, analysis may require 1000s of runs (hours to days)
• Requires more man-power (to operate/puck the agents/teams).	• Requires less man-power (individuals control many entities).	• Least man-power required to run the analysis (completely controlled by simulation).
• Frequently incorporates human factors through operator inefficiencies.	• Human behaviors can be considered while the game is playing out.	• All human behaviors and coordination must be programmed.

These all fall short…

How else can we consider / explore / analyze the "space" of scenarios?

<u>Some notable challenges:</u>

- Modeling the world with sufficient fidelity.
- Modeling the "human" element.
  - Human demands ($$) of human-in-the-loop / human-drive exercises.
- Computational demands of "batch" simulations.

"A strange game. The only winning move is not to play."
Joshua / WOPR on Thermonuclear War
WarGames (1983)

These all fall short…

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How else can we consider / explore / analyze the "space" of scenarios?

"A strange game. The only winning move is not to play."
Joshua / WOPR on
Global Thermonuclear War
WarGames (1983)

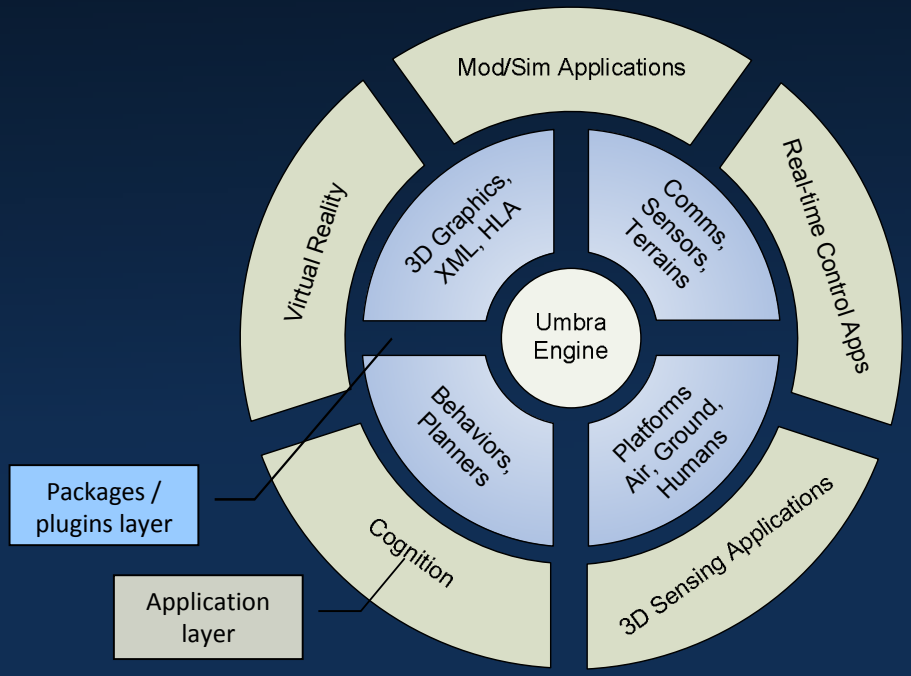
Some notable challenges:

- Modeling the world with sufficient fidelity.
- Modeling the "human" element.
  - Human demands ($$) of human-in-the-loop / human-drive exercises.
- Computational demands of "batch" simulations and world complexity.

Umbra Simulation Toolkit
Rumba Parallel Multi-Simulation

Case study: Umbra worlds

- **Sandia's Umbra Engine (Software Framework) Version 4.8**
  - Modular C++ Core based on Object Oriented Design
  - Enables both Physics-based (time-step) & Event-based Models to co-exist
  - Supports Batch and 3D Interactive Mode
  - Optimized Computational Geometry Package
  - Umbra Worlds support non-linear interactions



Force-on-force with DANTE

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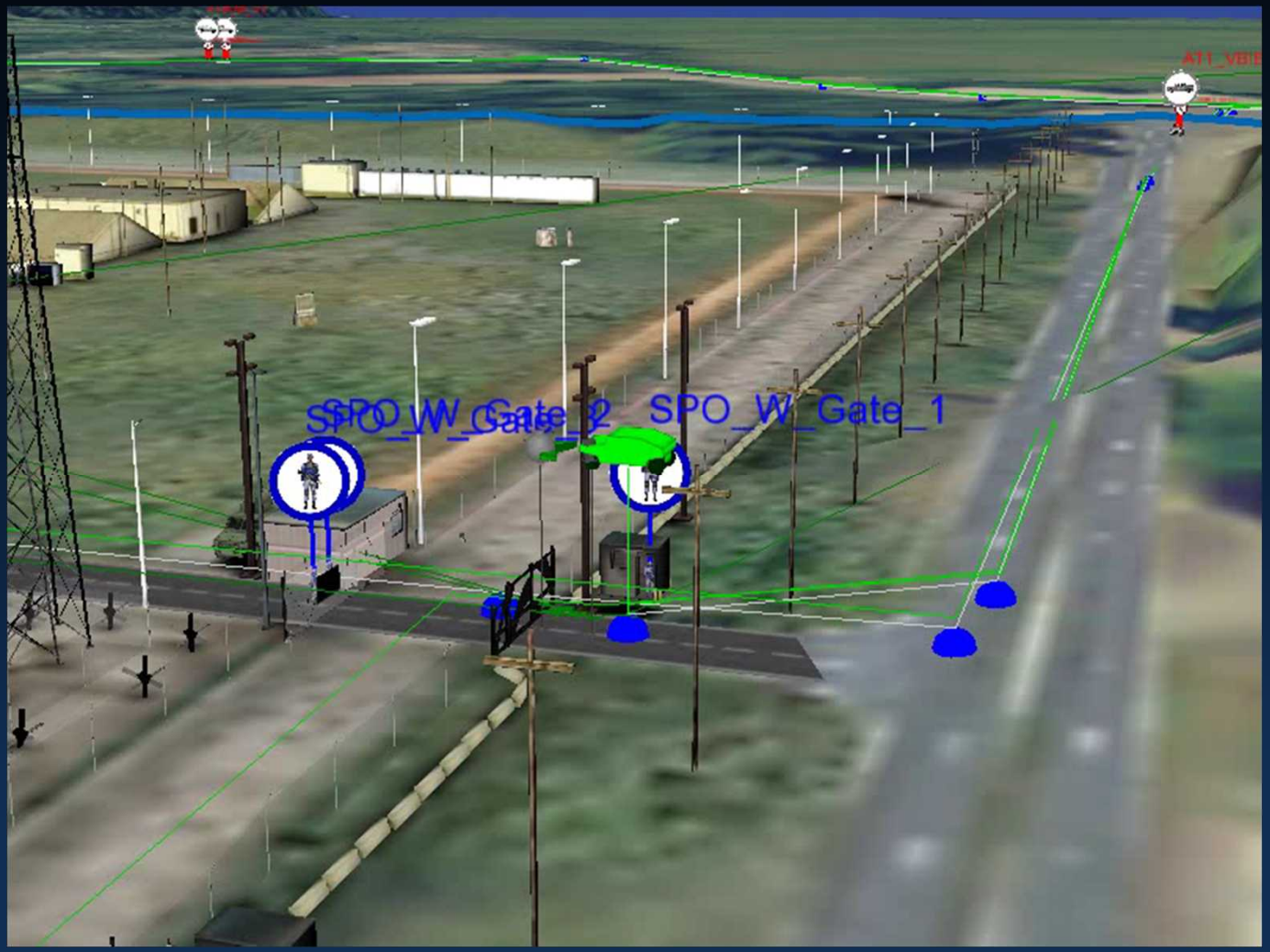
DANTE™

DANTE Application Suite

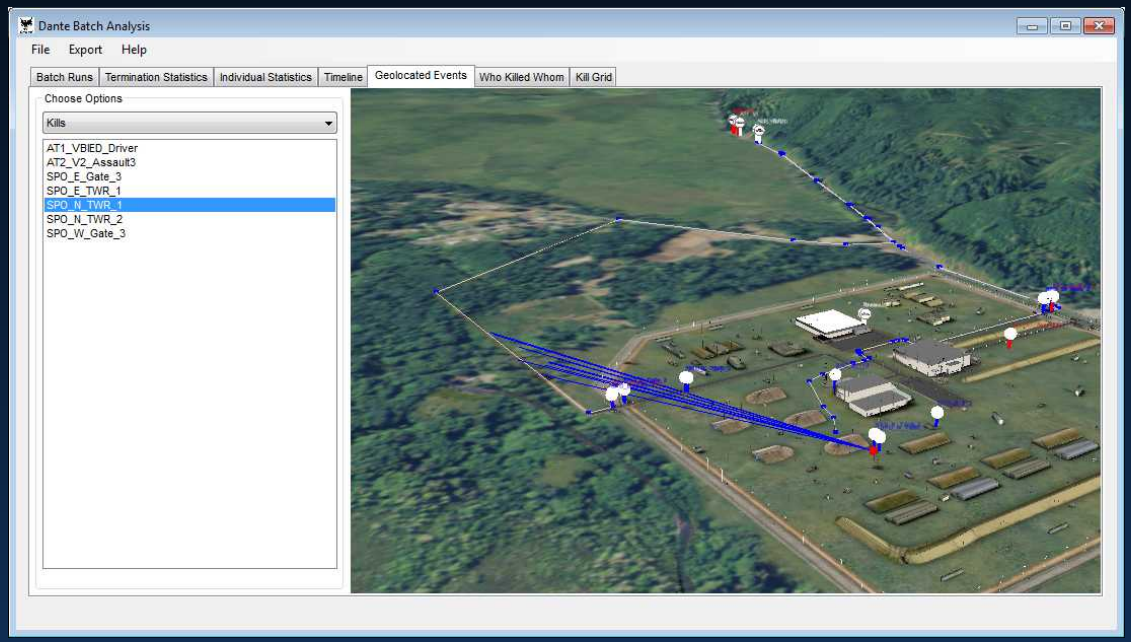
- Automated behaviors and perception
- Weapon modeling (direct and indirect)
- Combining physical interactions with statistical modeling
- Human-in-the-loop not required (i.e. batch modes)

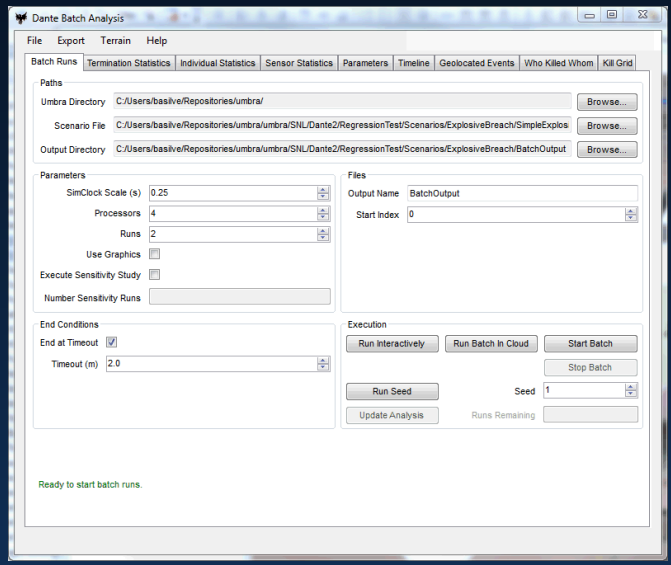
DANTE Notional Scenario



Batched analysis of outcomes

Even the simplest analyses (e.g. win/loss) may requires hundreds to thousands of individual runs.





DANTE Batch Manager

Parallel multi-simulation

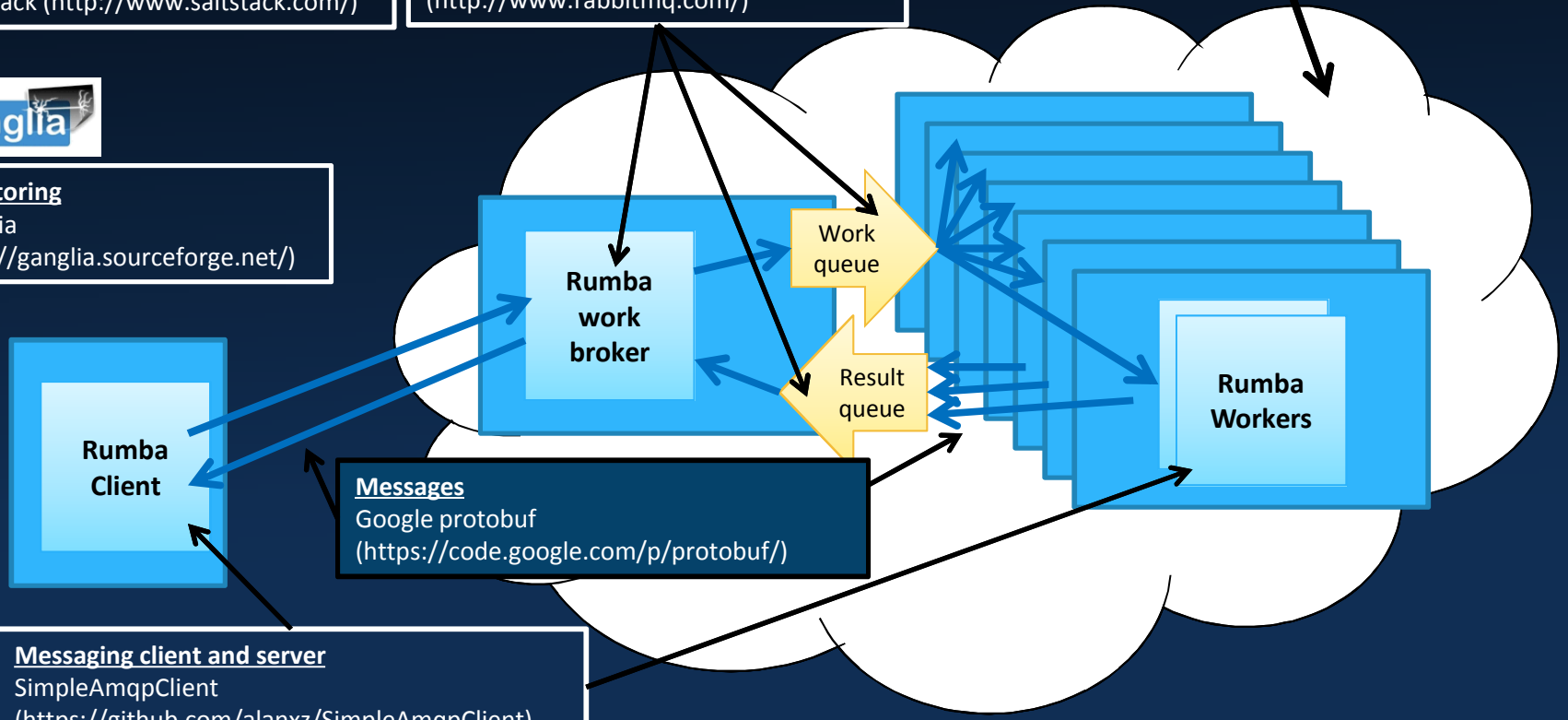
We want to be able to execute many scenario runs in parallel.
Rumba: Our "cloud"-based implementation.

Configuration Management
Puppet (http://puppetlabs.com/)
SaltStack (http://www.saltstack.com/)

Task scheduler / Message broker
RabbitMQ "Messaging that just works"
(http://www.rabbitmq.com/)

Cloud/VM administration
OpenStack (http://www.openstack.org)
MiniMega (SNL, https://code.google.com/p/minimega/)

Monitoring
Ganglia
(http://ganglia.sourceforge.net/)



Messages
Google protobuf
(https://code.google.com/p/protobuf/)

Messaging client and server
SimpleAmqpClient
(https://github.com/alanxz/SimpleAmqpClient)

Rumba: Performance

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Run-time dominated by:

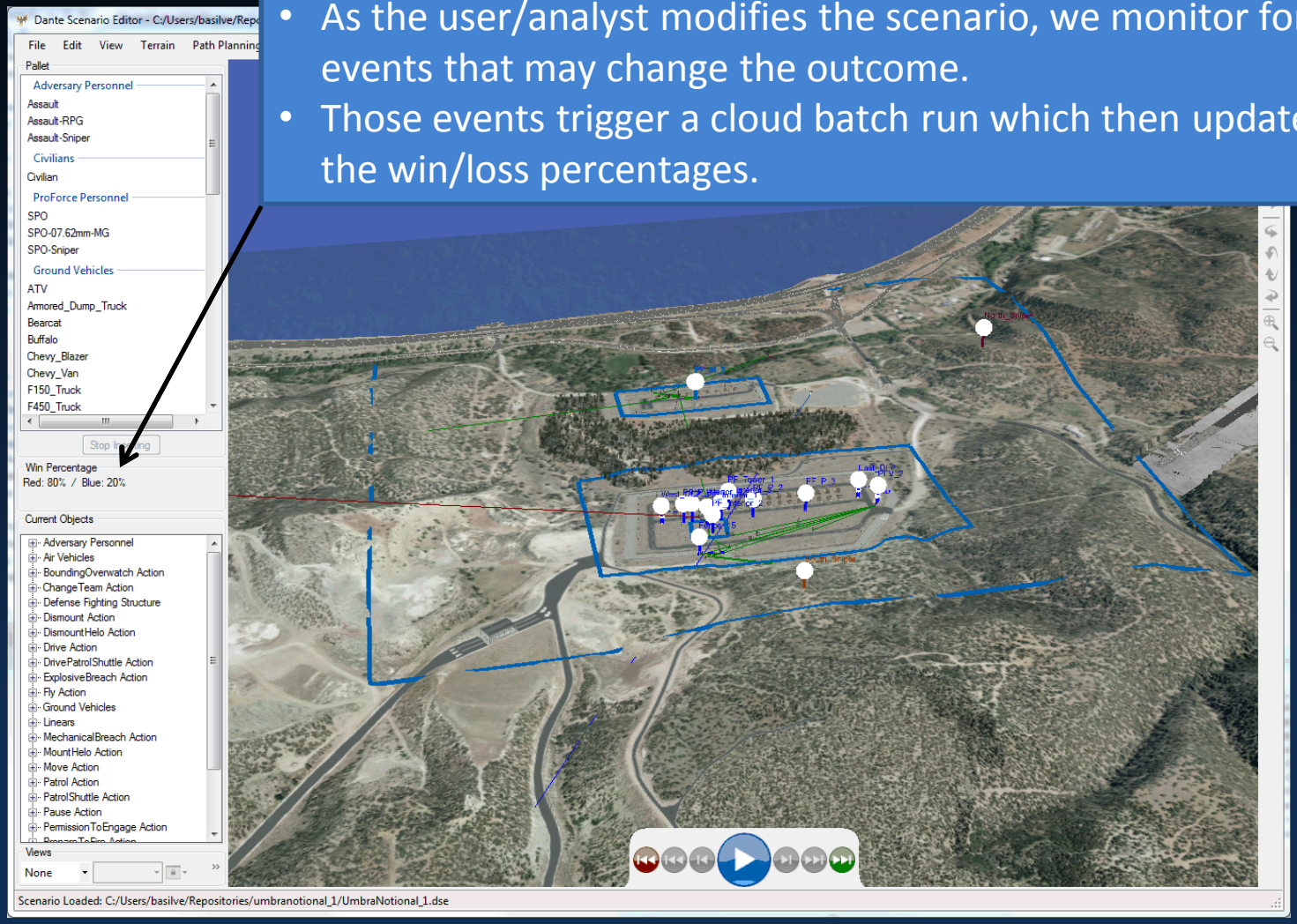
- Number of available umbra workers or the slowest running scenario.

Making the scenarios run faster:

- Compute bottlenecks:
  - Line-of-sight: A considerable portion of the run-time.
    - Implemented an optimization based on Intel “Embree” that can accelerate this by about 36x.
    - ~300K queries per second to ~11M queries per second using Embree “natives”.
- Adjust simulation parameters
  - Time step size, etc.

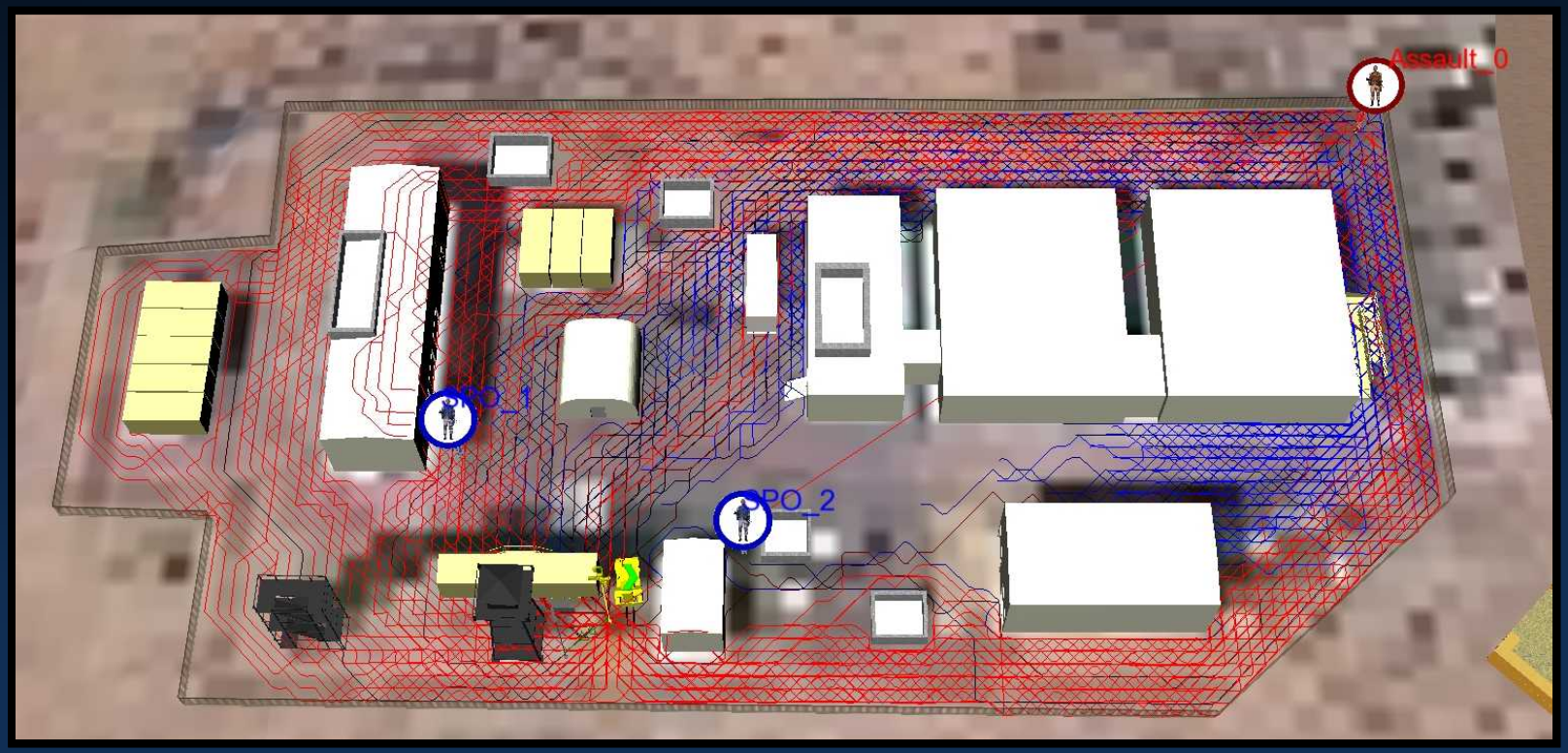
New tool: DSE-Live

- As the user/analyst modifies the scenario, we monitor for events that may change the outcome.
- Those events trigger a cloud batch run which then updates the win/loss percentages.



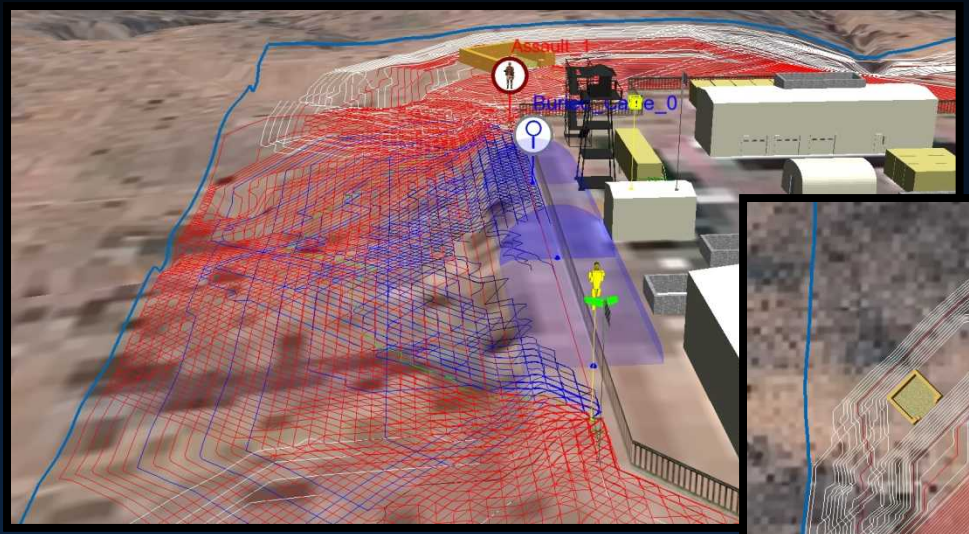
New tool: Pathways analysis

- A “brute-force” approach to explore the space of viable routes.
  - Modify Umbra’s path planner to return the “n-best” paths.
  - Use cloud when per-path batch analysis is needed
    - E.g., dynamic events such as engagements and finding cover many change outcomes along a single path.



Engagement avoidance – Red is trying to reach the yellow forklift. Paths colored by success, intensity indicates how successful the result is (e.g. brightest blue means blue always wins).

New game: Pathways analysis



Avoid detection – Red adversary is trying to bypass a sensor. Red colored-lines indicate success, blue lines indicate that the adversary was sensed, and white means the adversary did not make it to the goal in time.

Summary / Lessons learned…

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- Serious games offer a compelling way to learn, interact, and experiment. It's about the level of engagement.
- Interactivity and ease of use are extremely important to users.
- Users and decision makers are always looking for new ways to experiment with complex models and datasets.

- It's hard to decide what you can/want to learn from a game. Failure is a good outcome. Tie the game to the goal.
- Lots of compute is available if you know where to look for it.
- Don't build a hammer without a nail.

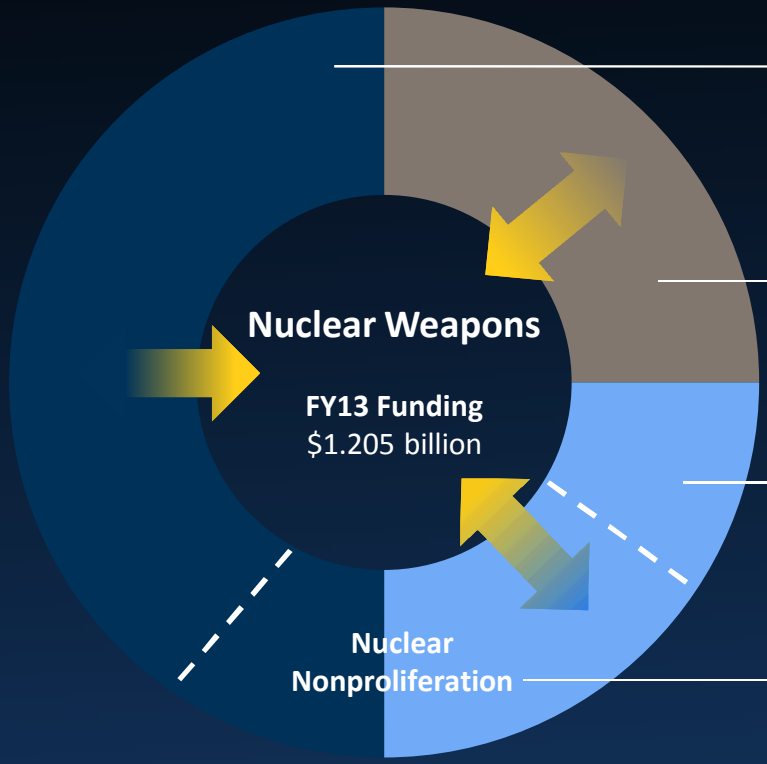
Exceptional service in the national interest

Sandia National Laboratories

Thank You

Backup Slides

Sandia's Funding



Department of Defense
$562M + $97M (Nuclear Nonproliferation) = $659M

Department of Energy (DOE) Energy Programs
$190M

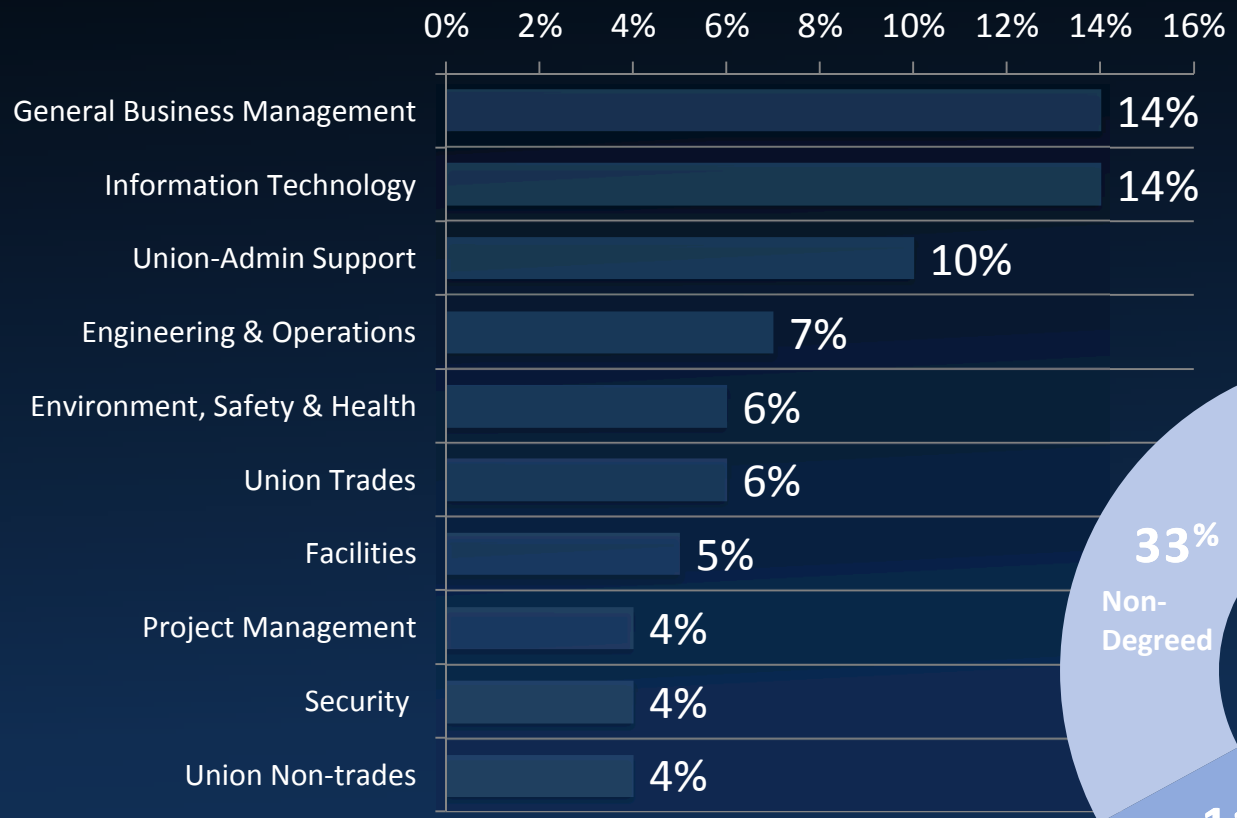
Department of Homeland Security & Department of Defense Infrastructure Security
$96M

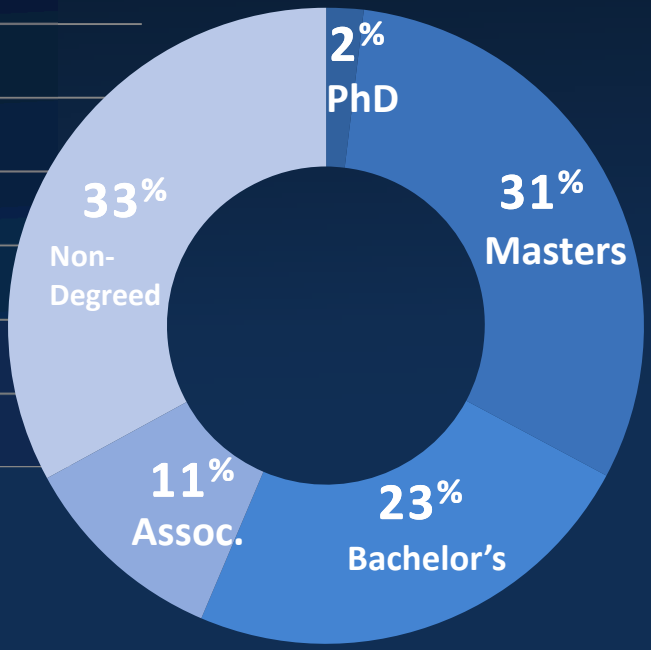
NNSA Nuclear Nonproliferation
$151M

Note: **Other DOE and non-DOE Funding**
$198M

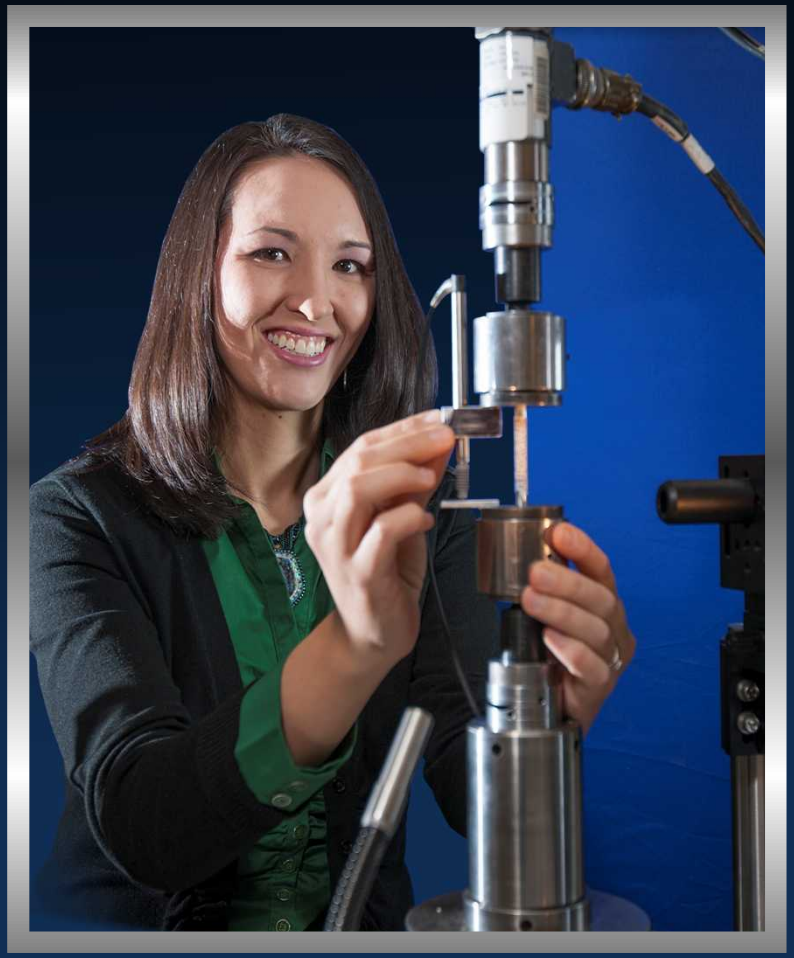
High reliability, high consequence of failure, challenging environments, and technology solutions

Business & Operations Staff





Our Culture – Our Values



- Serve the nation
- Deliver with excellence
- Respect each other
- Act with integrity
- Work as a team

Sharlotte Kramer
PhD, Aeronautics
California Institute of Technology

Community Involvement

Sandians volunteer 110,000 hours annually

- Coaching/food banks/community boards
- Science Bowl
- Junior Achievement
- Education programs - STEM
- Habitat for Humanity – 12 homes built
- Make a Difference

$5.5 million donated to United Way in 2012

>>Watch Video

Special Programs, Education and Mentoring

University-based Education

- Tuition assistance programs
- Special degree programs
- University part-time program
- Special Master's program
- Doctoral study program

In-house Education, Training and Mentoring Programs

- Business
- Communication
- Design and drafting
- Energy
- Health and wellness
- Information technology
- Manufacturing
- Marketing
- Project management
- Sciences

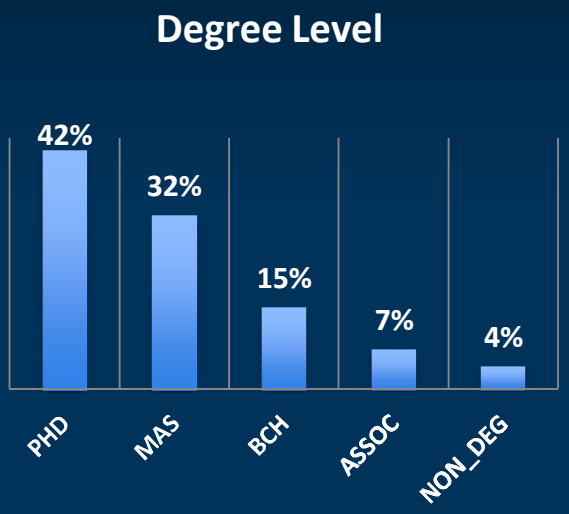
Sandia California - *Livermore*

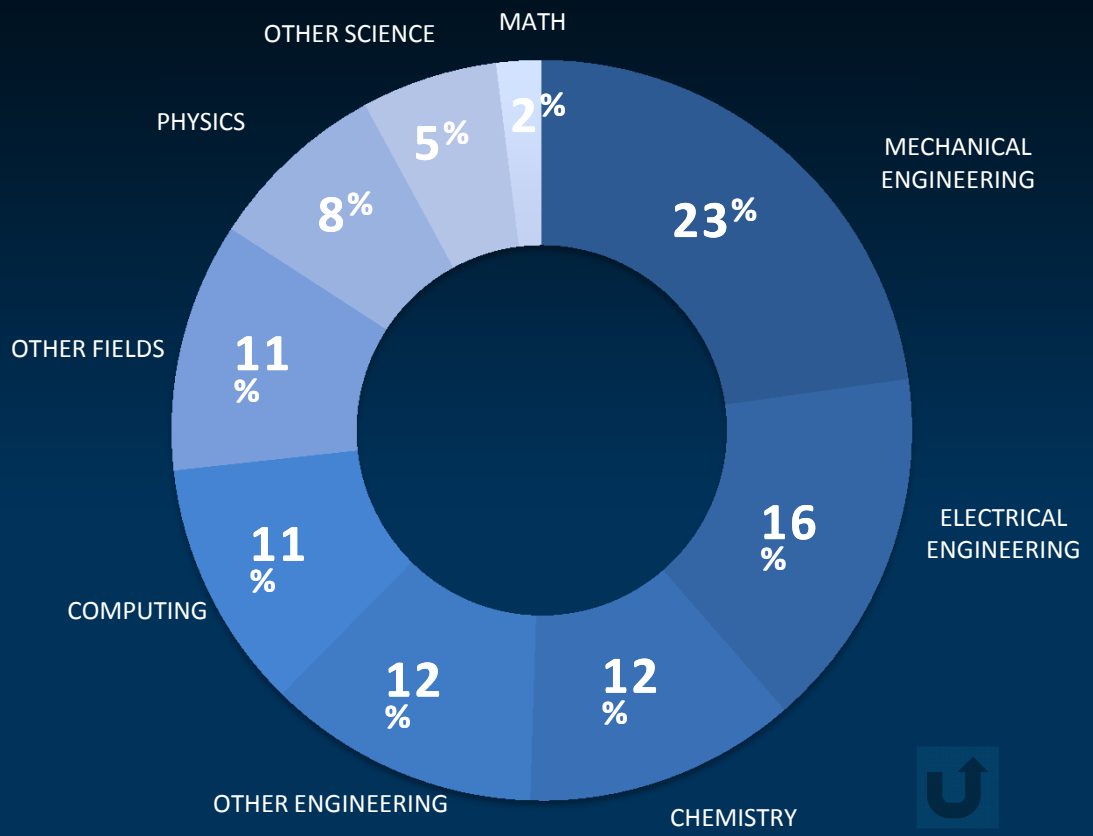
On-site workforce: ~1,000

R&D staff: ~550

Distinguishing research capabilities:

- Applied Biosciences
- Combustion Research
- Information Systems
- Micro & Nano Technologies and *more*





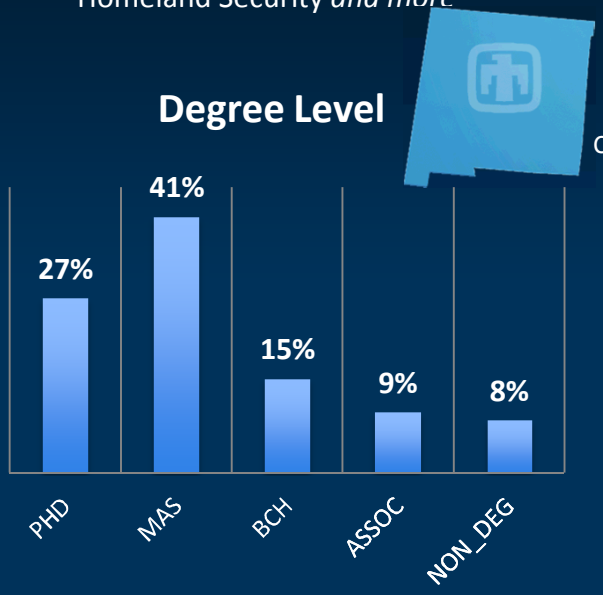
Sandia New Mexico - *Albuquerque*

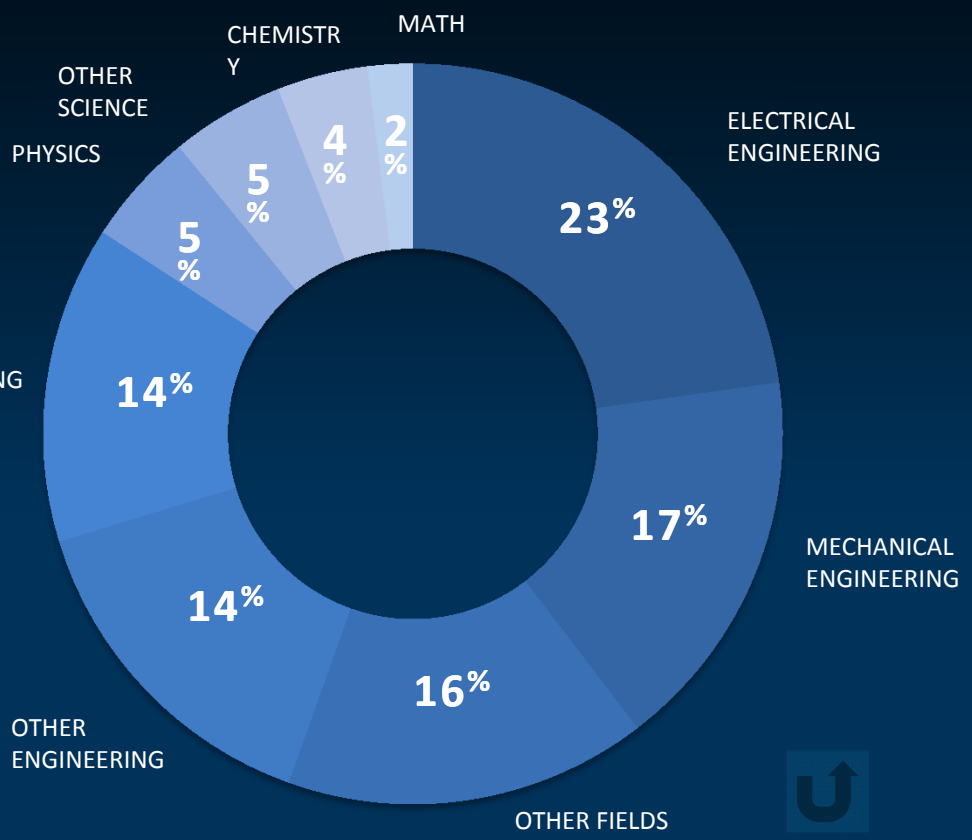
On-site workforce: ~8,500

R&D staff: ~4,000

Distinguishing research capabilities:

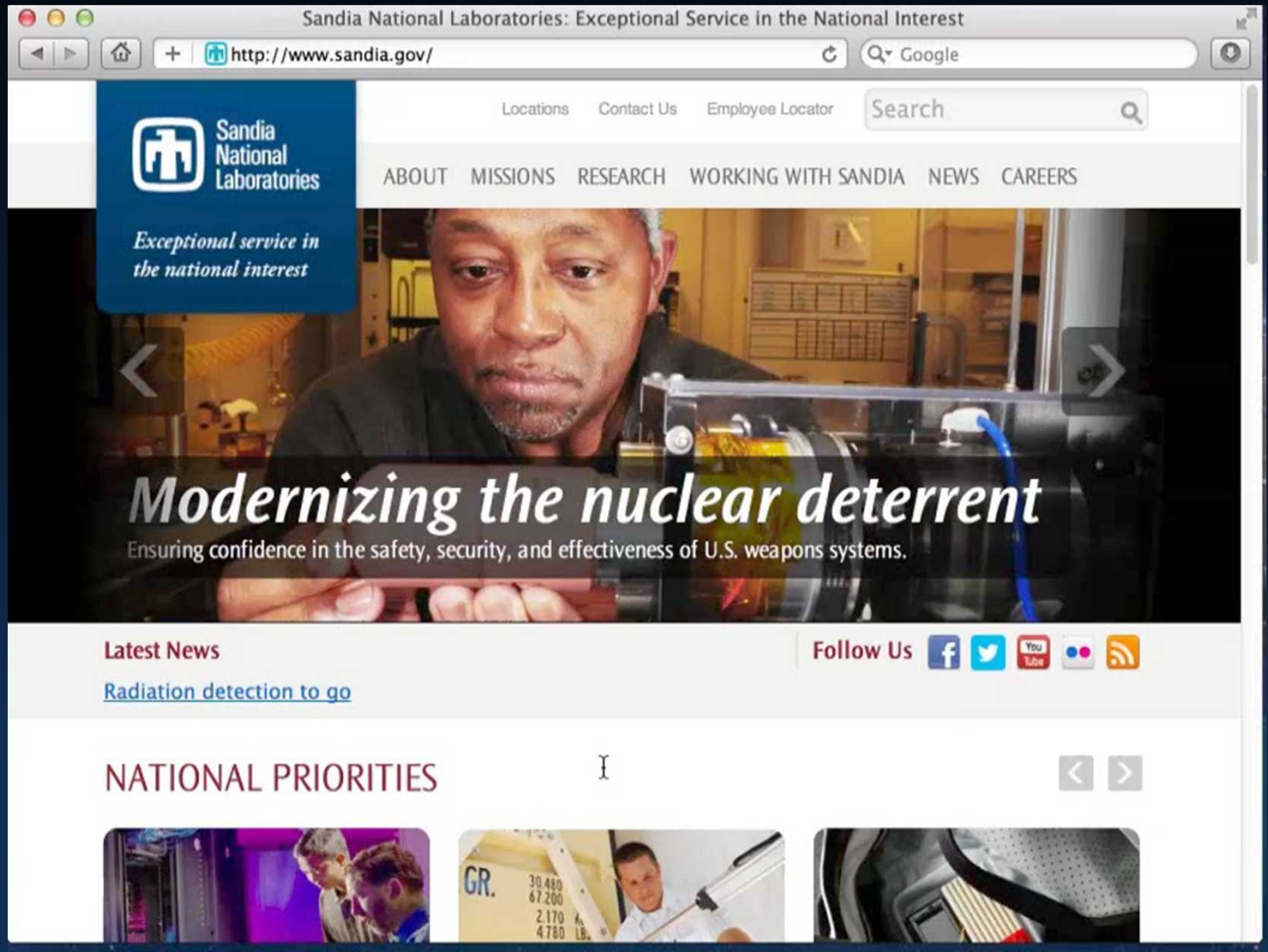
- Renewable Energy
- Micro-electronics/Semiconductors
- Cyber Security
- Homeland Security *and more*





How to Apply - sandia.gov/careers

Basic Search

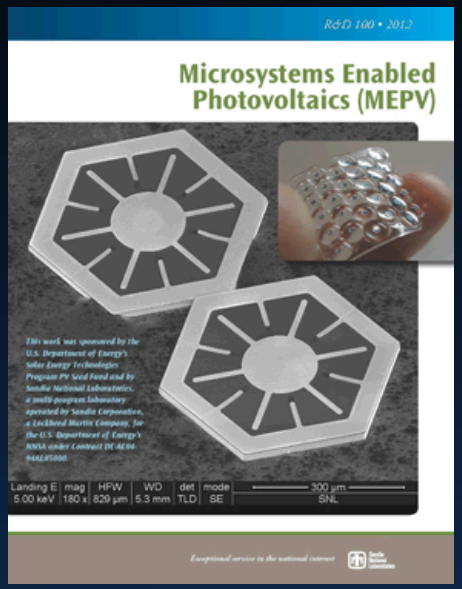


How to Apply - sandia.gov/careers

Advanced Search & Job Agent/email notification

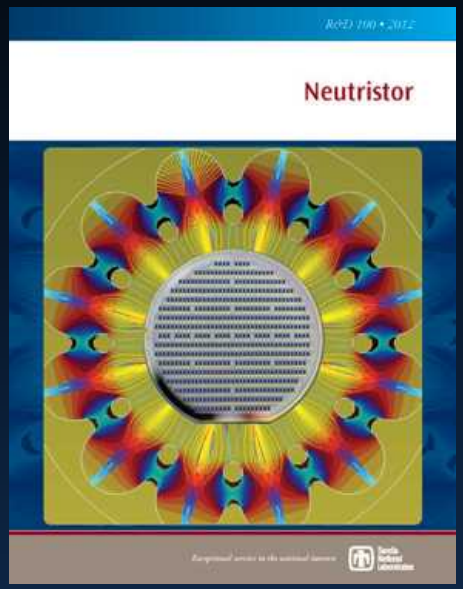
Work with real-world impact

Sandia's 2012 R&D 100 Awards



Microsystems Enabled Photovoltaics
Sandia developed tiny glitter-sized photovoltaic (PV) cells that could revolutionize solar energy collection.

>> WATCH VIDEO



Neutristor
A thousand times smaller than the closest competitor, this ultra-compact, disposable neutron generator could be used in energy exploration and medical applications.

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Sandia Digital Microfluidic Hub
By enabling the interconnection of diverse processing and analysis modules, this droplet-handling router automates complex protocols for preparing microliter-scale molecular biology samples.

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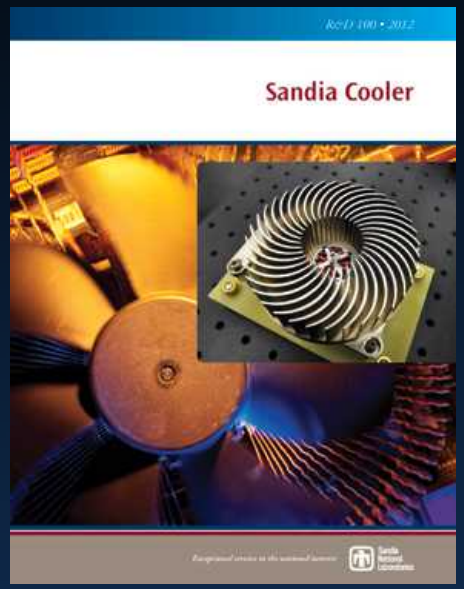

Sandia Cooler
Thirty times more efficient than conventional air-cooled heat exchangers, S
The Sandia Cooler is available for licensing to manufacturers of electronics and solid-state lighting cooling.

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