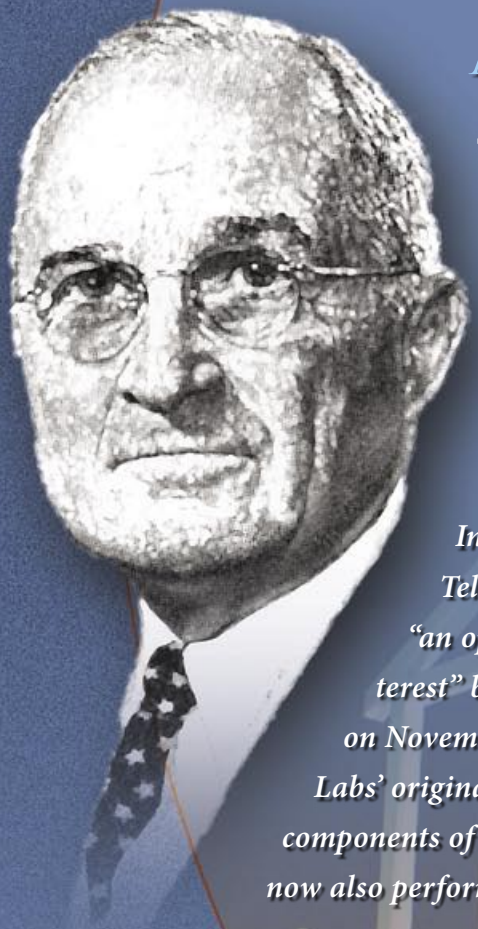
SANDIA

ANNUAL REPORT 2006

Securing a peaceful and free world through technology

Sandia National Laboratories



ABOUT SANDIA

Sandia came into being as an ordnance design, testing, and assembly facility, and was located on Sandia Base, in Albuquerque, New Mexico, to be close to an airfield and work closely with the military. Known as Z Division, part of what's now Los Alamos National Laboratory, Sandia was born out of America's atomic bomb development effort — the Manhattan project.

In 1949, President Harry Truman wrote a letter to the American Telephone and Telegraph Company president offering the company "an opportunity to render an exceptional service in the national interest" by managing Sandia. AT&T accepted, began managing the Labs on November 1, 1949, and continued in the role for nearly 44 years. The Labs' original mission — providing engineering design for all non-nuclear components of the nation's nuclear weapons — continues today, but Sandia now also performs a wide variety of national security R&D work.

Lockheed Martin Corp. has managed Sandia since October 1, 1993, for the U.S. Department of Energy (DOE). Most of Sandia's work is sponsored by DOE's National Nuclear Security Administration, but we also work for other federal agencies, including the Department of Defense and Department of Homeland Security. We work cooperatively with a number of government, U.S. industry, and academic partners to accomplish our missions. Today Sandia employs about 8,000 people and has two primary facilities: a large laboratory and headquarters in Albuquerque and a smaller laboratory in Livermore, California.

SANDIA: LEADING THE WAY TOWARD OPERATIONAL EXCELLENCE

By Thomas O. Hunter
President and Laboratories Director

Sandia remains committed to providing excellent service in the national interest. We will continue our efforts to achieve — excel in mission, excel in operations, and excel in living our values. It is a point of honor that America has placed its trust in this laboratory as a critical instrument of national security for the past 57 years.

As national security demands have changed during those years, we have evolved to meet them. Now, as "transformation" becomes the watchword in the nuclear weapons complex, we are committed to applying our creative powers to that effort. We recognize the need to support the weapons complex both in terms of its business practices and its responsiveness to national security threats we will face in the 21st century.

We take seriously and appreciate the fact that our customers and stakeholders have come to rely on our ability to develop practical solutions to the most complex and challenging problems. We accomplish this because we possess a talented workforce — including some of the nation's best scientists and engineers — and the right tools, and we embrace an enduring dedication to excellence and mission success.

Today we face many challenges. For example, we must strive to fulfill the promise envisioned by the pioneers in nuclear science and engineering. We must bring together fundamental concepts of nuclear weapons, nonproliferation, and nuclear energy production to ensure a flexible, appropriate nuclear deterrent while developing nuclear energy and minimizing the risk of proliferation.

We are poised to move forward in developing cutting-edge science to meet our nation's security needs. The nation's investment in our future includes the $460 million Microsystems and Engineering Science Applications (MESA) project, our Red Storm and Thunderbird supercomputers, and the new Center for Integrated Nanotechnologies. These investments unite Sandia's dedication to operational excellence with many of the best ideas in science and engineering. We take special pride in the success of the MESA project. It is at the core of our vision for the future.

In addition, Sandia continues to establish an enduring Homeland Security mission, lead the advancement of energy technologies, and provide systems engineering solutions for the security challenges facing the nation.

We stand committed to supporting our nation against threats to its national and economic security.

PRESIDENT BUSH VISITS SANDIA

President George W. Bush came to Sandia/New Mexico in early August to sign the Energy Policy Act of 2005, a bill aimed at making America less reliant on foreign energy sources. Accompanied by Secretary of Energy Samuel Bodman, New Mexico Senators Pete Domenici and Jeff Bingaman, and Labs Director Tom Hunter, the president also toured Sandia solar facilities during his visit. He spoke to a standing-room crowd at the Labs' Steve Schiff Auditorium during the signing ceremony. Among provisions of the new policy act are encouragement of more environmentally friendly energy usage and promotion of nuclear, solar, and other alternative energy sources.

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REORGANIZATION REFLECTS NEW VISION FOR SANDIA

Sandia's executive leadership team engineered a major reorganization in 2005, designed to implement the key elements of Director Tom Hunter's vision of the Labs' future. Hunter named three deputy directors to take up a set of newly defined challenges and moved Sandia's main business units (covered in the subsequent pages of this report) into a new alignment with their strategic management groups.

The three deputy directors are charged with supporting Hunter's commitment to:

(1) transforming the nuclear weapons complex;
(2) achieving operational excellence;
(3) creating a model of 21st century engineering; and
(4) developing a cohesive, non-nuclear national security portfolio that complements and extends beyond the primary nuclear weapons mission.

The three deputy directors are also responsible for Sandia's Laboratory Directed Research and Development (LDRD) program. They will direct overall LDRD strategy, budget, structure, and policies through the stewardship of the chief technical officer. (See LDRD on page 21.)

Joan Woodard leads the Labs' Nuclear Weapons Strategic Management Group. Al Romig leads the Integrated Technologies and Systems Strategic Management Group, centered on the Labs' non-nuclear national security efforts. John Stichman provides leadership for Sandia's Laboratory Transformation Strategic Management Group, which provides enabling services to meet the Labs' goals.

Woodard and Romig are points of contact for the Missions Committee of Sandia's Board of Directors and Stichman acts in the same capacity for the Board's Governance Committee.

Nuclear weapons

Woodard, deputy director for Nuclear Weapons, manages Sandia's Nuclear Weapons Program for NNSA, directing strategic planning, budget, staffing, consolidated investments, and program management funds. She is also responsible for the Labs' applied science, engineering, and technology portfolios, and is focusing on developing "Science-Based Engineering for Transformation" as part of the nuclear weapons complex transformation. Finally, she is responsible for the integration of Sandia's vision for microsystems engineering into weapon manufacturing.

Woodard also chairs the Nuclear Weapons Leadership Council, working with the NNSA. She is point of contact for appropriate members of Congress and their staffs.

Integrated technologies

Romig, deputy director for Integrated Technologies and Systems, coordinates and integrates non-nuclear weapon revenue program areas, including strategic direction, staffing, and Work for Others policies. He manages the Integrated Technologies Leadership Council in support of the Labs-wide MESA vision. (See MESA article, page 20.)

Romig's responsibilities include work with the DOE energy program offices, the Nonproliferation Program in NNSA, Department of Defense conventional weapons, Homeland Security, and other federal agencies. Romig also has point-of-contact responsibilities for appropriate members of Congress and staff.

Vision and reality: Computer-generated rendering of Sandia's proposed Microsystems and Engineering Sciences Applications (MESA) Complex and aerial photo showing construction progress. With MESA, Sandia will play a major role in advancing the state-of-the-art in microsystems research and development and in incorporating integrated microsystems into the nuclear stockpile.

Operational excellence

John Stichman, chief engineer and deputy laboratories director, is responsible for Sandia's operational excellence and manages the Laboratory Transformation Leadership Council. In keeping with the concept of top-down integrated laboratory management, he is charged with ensuring that all processes, including engineering practices and standards, are based on a common, Labs-wide information system.

Stichman provides stewardship of technical and operational capabilities. His duties include guiding indirect budget and corporate investments, managing independent and NNSA assessments, Laboratory staffing, salary, and benefits. He bears overall responsibility for fulfilling the MESA vision.

Sandia and the nation face significant challenges today. Sandia's new organizational structure is designed to respond to these challenges and to position the Labs to face the future.

Sandia's Distributed Information Systems Laboratory at Sandia/California enables development and deployment of distributed information systems technologies. The project is a critical element of the Department of Energy's strategy to develop and deploy high-performance modeling and simulation capabilities throughout the complex.

TRANSFORMING AMERICA'S STRATEGIC DETERRENT

Sandia's Nuclear Weapons Program is the Labs' biggest and most enduring mission. We are responsible for the research, design, and development of more than 95 percent of the 3,000 to 6,500 components of a modern nuclear weapon. These components include: security systems, arming, fuzing and firing mechanisms, safety systems, neutron generators, and other nonnuclear components such as energy sources, instrumentation, parachute systems, and aerodynamic design.

We are also responsible for programs to extend the life of warheads well into the future; production of certain nonnuclear components — neutron generators — for the stockpile; stockpile support, including surveillance, field engineering, military liaison, and other activities; and nuclear materials protection in particular technical roles in support of NNSA's transportation system for the shipment of nuclear weapons, components, and materials.

Fundamentally, we are responsible for ensuring that nuclear weapons are safe, secure, reliable, affordable, and fully capable of supporting our nation's deterrent policy indefinitely.

With the end of the Cold War, changes have occurred within the Nuclear Weapons Enterprise. During the 1990s the U.S. stopped underground nuclear testing, closed and consolidated facilities, and established a science-based Stockpile Stewardship Program focused on maintaining the safety, security, and reliability of the nuclear weapons stockpile indefinitely.

Sandia's Red Storm and Thunderbird super computers and a new visualization facility at Sandia/California.

Now, with guidance from the 2002 Nuclear Posture Review, the Nuclear Weapons Enterprise is beginning an effort to transform the stockpile, the nuclear weapons complex, site operations (such as safety and security), and the way it does business. This transformation will usher in a new era in which the stockpile is sustained without testing and by a responsive, affordable infrastructure. This transformation effort will continue as we maintain the existing stockpile, extend its life through life-extension programs, and maintain the capabilities needed to respond to national security needs — including underground nuclear testing, if necessary.

To ensure that the nation's aging stockpile continues to be safe, secure, reliable, and able to meet its requirements as it ages — in essence, to keep it as good as new — Sandia's Nuclear Weapons Program is aligned with NNSA's Stockpile Stewardship Program. The Stockpile Stewardship Program has three major thrusts: directed stockpile work, science and engineering campaigns, and a set of activities that maintains the required technical base and facilities.

Sandia is engaged in all of these activities. It is involved in supporting the existing stockpile through stockpile surveillance, maintenance, and life-extension activities, including the manufacture of limited-life components such as the neutron generator. Sandia is also involved in a robust science and engineering program to maintain critical capabilities that include above-ground test facilities, modeling and simulation activities (including large-scale supercomputing), and fundamental research and development in key areas such as microsystems, pulsed-power physics, radiation sciences, and materials science. Finally, Sandia is engaged in a set of activities associated with its infrastructure that includes the refurbishment of key infrastructure elements, such as the communication system, and the construction of new facilities (such as MESA) that will provide the foundation for future work.

Maintaining today's stockpile

Life Extension Programs (LEPs)

A large part of Sandia's effort is centered on extending the life of nuclear weapons currently in the stockpile. At present, the W76 (Trident submarine missile) and W80 (cruise missile) systems are well along in their respective schedules for refurbishment. In 2005, the W76 LEP reached a major milestone: receiving approval to move to Phase 6.4, where engineering-for-production begins. This approval will lead to the first production unit in 2007. Sandia is also well along with development activities associated with the W80 LEP, with the first production unit likely scheduled for 2009.

The W76 LEP

One of Sandia's responsibilities in recent years has been to update key components in the warheads that go on the U.S. Navy's Trident I and II submarine missiles, which represent a major part of the U.S. strategic deterrent. The warhead, the W76/Mk4, was designed and produced between 1972 and 1987, and was originally intended to have a service life of 20 years. In other words, the most recently manufactured individual warheads would be scheduled for retirement in 2007.

For Sandia, the W76 LEP effort involves replacing two key components — the arming, fuzing, and firing (AF&F) system and the neutron generator — along with other nonnuclear components. The refurbishment was prompted by aging concerns, the nonavailability of replacement components used in original designs, and a desire to modernize nuclear safety features. The LEP will extend the life of the W76 an additional 30 years.

Sandia, anticipating a future need, had begun independently to design a replacement neutron generator for the W76 in the early 1990s. The aim was to increase its resistance to hostile environments, to simplify its manufacturing, and, in general, to increase its lifespan. Subsequently, Sandia began work on life extension of the AF&F system, which among other functions ensures that the weapon will detonate only when intended. One part of this system is the arming and fuzing subsystem, which integrates radar, flight computer, and diagnostics in a single compact assembly. The subsystem redesign met cost goals through use of commercial off-the-shelf parts, new packaging, and automated production.

W76 AF&F System

The redesigned AF&F unit combines advanced fuzing options, modern nuclear safety improvements, and enhanced reliability. Surveillance features built into the unit enable its "state of health" to be determined in the field with minimal intrusion. Working with counterparts at the NNSA's Kansas City plant, Sandia designed and built two versions of prototype firing sets for the W76. The use of simulation and rapid prototyping tools and techniques enabled engineers to advance from paper designs to hardware in less than a year and enabled the evaluation and resolution of design and manufacturing issues before prototypes were actually made.

Increased Cost Emphasis

A major change in the approach to developing the W76-1 was the Navy's requirement that the life-extension program demonstrate a new cultural mindset at Sandia and in the nuclear weapons complex as a whole. While the Cold War approach was to ensure safety, security, and reliability at all costs, life-cycle cost became a key driver in design work, second only to nuclear safety. Sandia's AF&F system work demonstrated that the modified management approach, combined with the adoption of certain critical design tradeoffs, resulted in savings of as much as $750 million.

Lean Six Sigma

One of the tools for assuring that Sandia meets the ambitious goals set by the Navy for the W76 LEP is Lean Six Sigma. Lean Six Sigma is a structured approach to improvement and optimization of complex processes. Statistical tools are used to identify key process parameters, while lean tools are used to optimize and control these parameters to achieve improved output from the processes.

Using Lean Six Sigma, Sandia has eliminated unnecessary activities and processes to speed production and reduce waste. It has reduced costs simply by focusing more on aspects of production that matter most. As a result of the success with Sandia's neutron generator production, Lean Six Sigma techniques are being applied throughout the Nuclear Weapons Program, as well as to other activities at Sandia.

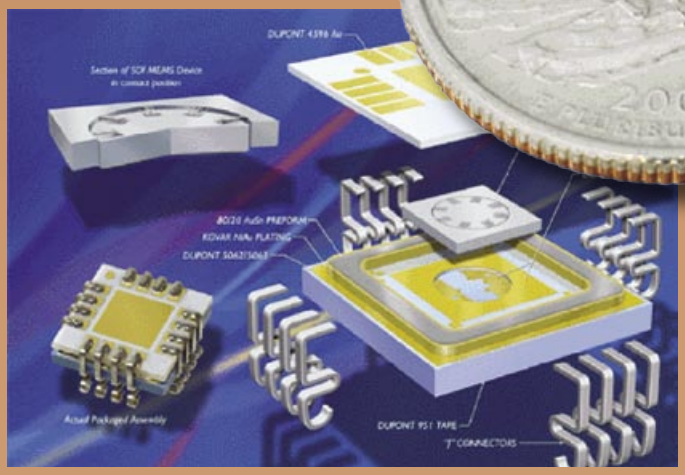
Enterprise transformation for the future

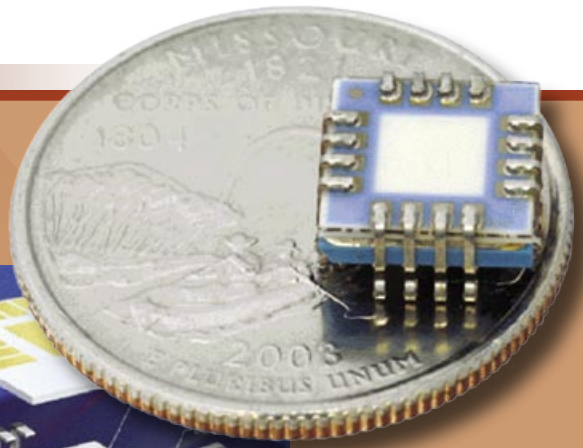
Sandia's strategy around transformation of the Nuclear Weapons Enterprise has four elements:

- transformation of the stockpile
- transformation of the complex

ST&E at Sandia

Post-Cold War Innovation





Sandia's ability to rapidly turn ideas into hardware has been recently demonstrated by the MESA program in the 18-month development of a totally new microsystem, a silicon-reentry switch (SiRES). The switch went from idea to hardware in only 18 months. Within that time, the MESA team developed 31 designs, of which 27 were rejected based on modeling and simulation, while four were fabricated at the MESA facility. While the component ultimately was not selected for the target application because of the difficulty of validating the long-term reliability of an entirely new component type, this activity demonstrates the strength of Sandia's MESA innovation engine.

SiRES, shown here resting on a quarter, went from concept to hardware in 18 months as a demonstration of the MESA program.

- transformation of operations
- transformation of the way we do business

Transformation will enable the enterprise to provide a nuclear weapons stockpile that is affordable, that supports the capabilities-based deterrent concept developed as part of the Nuclear Posture Review, and that is derived from a nuclear weapons enterprise that responds rapidly to changing national needs.

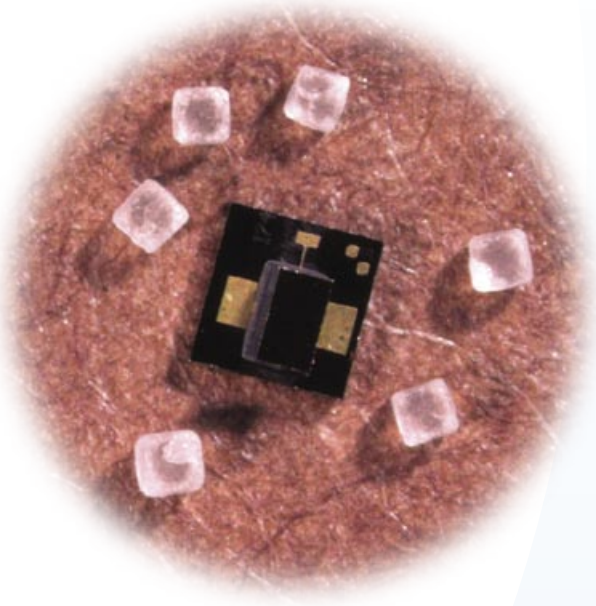
The objectives for enterprise transformation are centered on:

- achieving integrated surety — safety, security, and use control — for weapons systems, components, and materials, under any condition;
- developing a responsive infrastructure where we can achieve new approaches to key elements of maintaining the stockpile;
- creating a Science-Based Engineering for Transformation (SBET) environment to assure system performance through risk-informed decisions based on integrating first-principles engineering and scientific understanding with predictive component and system engineering;
- establishing a measurable increase in the quality and value of Sandia's future capabilities; and
- creating performance excellence in all we do.

Achieving Integrated Surety

In today's world, electronics control the operation of virtually all major systems, including nuclear weapons. However, unlike electronics for commercial applications, electronics for nuclear weapons must be able to survive exposure to the ionizing radiation in space, on the nuclear battlefield, or from the radiation generated by the radioactive material that forms the core of the nuclear explosive package.

Sandia's capabilities in electronic components, microelectronics, and microsystems reside in one organization devoted to the development, optimization, and integration of very small systems. The scale of these components varies by many orders of magnitude. Weapons cables can be three feet long (approximately 6.5 billion atoms long), while the gate insulator in hardened transistors can measure only tens of atoms across. These very small systems are often referred to as integrated, intelligent microsystems — miniature systems that sense, process information (or "think"), actuate other elements, and communicate — all integrated within a single package. To support these needs, Sandia maintains a complete capability, including design, simulation, and testing.



Verifying the desired atmosphere inside hermetic devices becomes much more difficult as package size decreases. Sandia researchers have developed methods and hardware to successfully sample and analyze the internal gas atmosphere of nanoliter packages (shown here with salt gains).

Two large laboratories support these facilities: the Microelectronics Development Laboratory and the Compound Semiconductor Research Laboratory. They are part of Sandia's MESA initiative for new-generation nuclear technology.

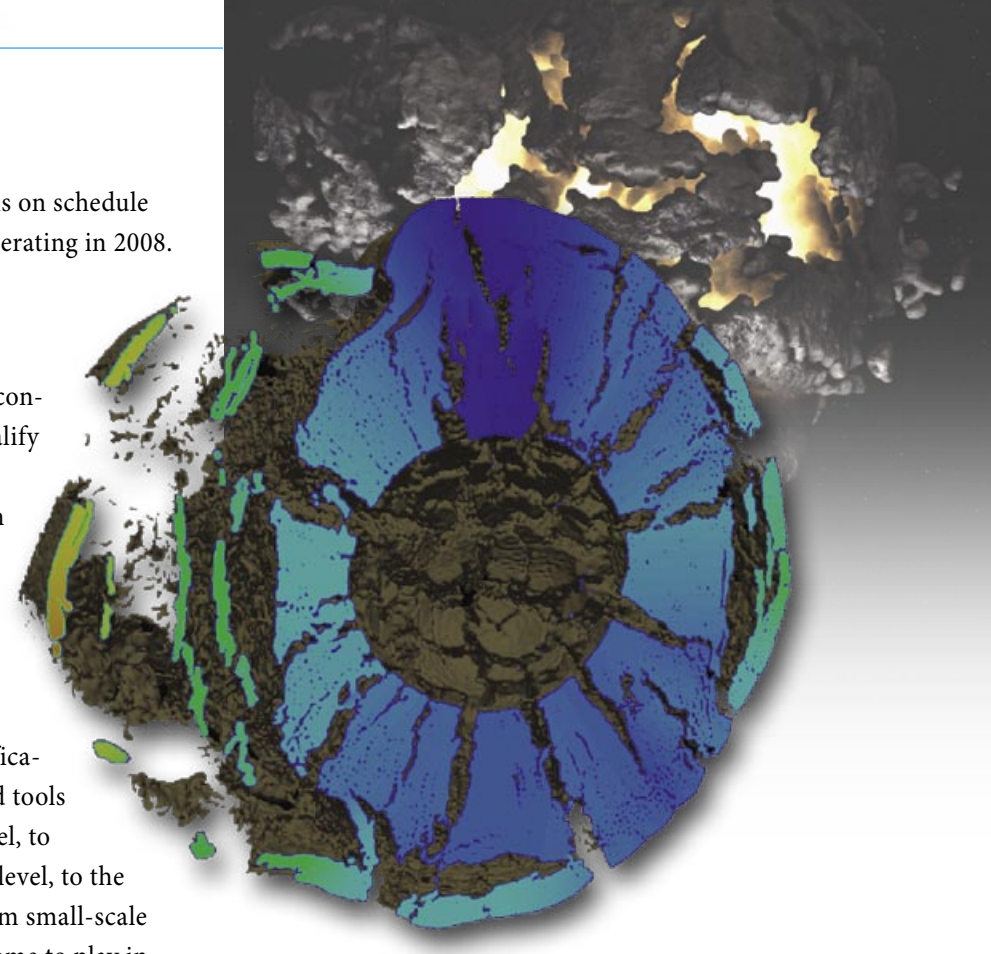
MESA's support of the microsystems engineering effort integrates essential activity for the stockpile life extension process and positions the NNSA to meet new national security initiatives and directives. At the end of Fiscal Year (FY) 2005, the $460 million MESA project

was roughly two-thirds complete, and is on schedule and budget to be fully occupied and operating in 2008.

Science-Based Engineering for Transformation

Modeling and simulation has and will continue to be the critical capability to qualify nuclear weapons without underground testing and is a key part of SBET, which brings together the tools and computer models we need to understand and model (at the physics level) the thermal, fluid, shock, vibration, and other environments in all stages of the research. SBET also integrates the verification and validation of these models and tools at different levels (from the physics level, to the predictive component engineering level, to the systems level). Sandia's capabilities, from small-scale experiments to system-level tests, all come to play in this integrated environment. System-level facilities include the Z Pulsed-Power facility, Tonopah Test Range, and Annular Core Research Reactor.

High-performance computing capabilities at Sandia are key to ensuring that modeling and simulation can achieve its goals. Sandia operates several high-performance computers and collaborates with computing organizations at other weapons labs in modeling, simulation, and other specialties. Sandia's newest high-performance computer, Red Storm, was designed for a peak speed of more than 40 trillion operations per second, enhancing weapons performance and safety through simulation and providing new insights in stockpile stewardship. The "Red RoSE" cluster, which is part of the infrastructure deployed at Sandia in support of the Red Storm environment, includes 264 visualization nodes (workstations). The RoSE clusters are designed to visualize, analyze, and manage the output from Red Storm. Red Storm is housed in the new Supercomputer Annex, a 20,000-square-foot facility providing up to seven megawatts of electrical power. The Red Storm network infrastructure provides 1.2 terabits of switched capacity.



ST&E at Sandia

Asteroid Simulation

Asteroid Golevka measures about 500 x 600 x 700 meters. A radar transmission was reflected from the asteroid and received at Russian and Japanese antenna stations to create the high-resolution solid model for our simulation. In a high-resolution shock physics simulation, we initiated a 10-megaton explosion at the center of the asteroid. The simulation ran for about 15 hours on 7,200 nodes of the Red Storm computer and provided 0.65 seconds of simulated time. The simulation provides realism in crack formation and propagation not seen in lower-resolution models.

Understanding weapons effects requires modeling and simulation as well as experiments. Sandia facilities include the Z accelerator for research in high-energy-density physics, the Saturn hard x-ray source, and the HERMES III gamma ray source. These experimental capabilities are not found anywhere else in the country.

Integrated Stockpile Evaluation

Integrated stockpile evaluation (ISE) is the term that refers to a major transformational effort at Sandia — stockpile evaluation through SBET. In the near term, the focus of ISE is to determine whether new, innovative methods, such as alternative sampling techniques, can be found to reduce the backlog of surveillance work at

Pantex. (Pantex is the DOE nuclear weapons assembly and disassembly facility near Amarillo, Texas.) Researchers are seeking to address the surveillance needs of the existing stockpile with techniques such as predictive simulation, aging characterization, and optimal asset utilization.

Future goals include building "self-test" systems and developing other innovative approaches to stockpile surveillance to meet the responsiveness requirements associated with new small production runs.

Performance Excellence

A fundamental strategic objective for the Labs' Nuclear Weapons Program is excellence in operations, or Performance Excellence. The primary objective for Performance Excellence is to describe, document, operate, and improve a nuclear weapons management system that meets a set of standards. This system will better align and integrate existing systems so we can effectively meet ever-changing customer expectations. Fundamentally, it's about converting customer requirements to customer results and satisfaction.

The "conversion" from requirements to results happens as a result of:

- a quality program measuring customer satisfaction through customer engagements;
- personnel training and qualification;
- quality improvement through corrective actions and the use of Lean Six Sigma techniques;
- an information system for maintaining documents and records;
- work processes for design definition and control, procurement, inspection, and testing;
- management assessments based on a series of management reviews; and
- independent assessments.

Performance Excellence is not an initiative. It is about building a management system that can sustain long-term success for Sandia's Nuclear Weapons Program.

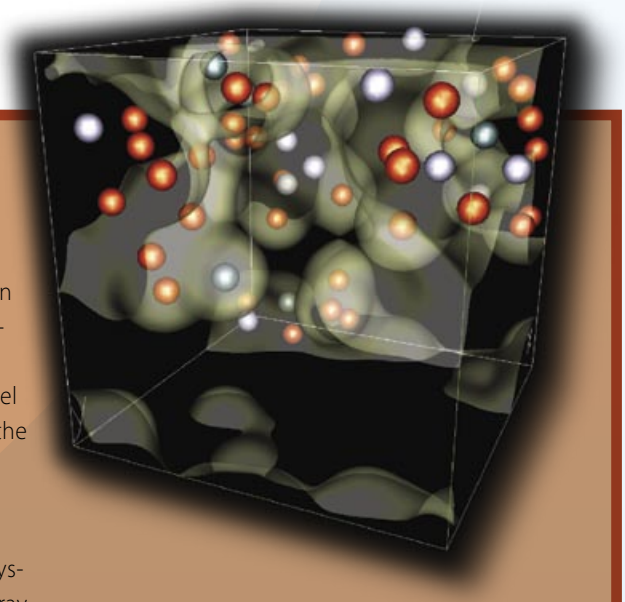
ST&E at Sandia

Pulsed power applications include weapons

Pulsed-power technology, distinguished by the creation of high electrical voltages and currents, is used to generate energetic, high-power particle beams, x-ray sources, and electromagnetic pulses for a wide variety of applications. These include nuclear survivability and hardness testing; measurement of material properties; Z-pinch-driven inertial confinement fusion; and radiation-driven hydrodynamics.

Sandia's pulsed power expertise includes experiments, simulation, theory, and engineering design. Last year, researchers created a new environment on the Z machine to test the resistance of the W76 neutron generator to mechanical impact by accelerating a small metal plate to as much as 76,000 miles an hour in less than one millionth of a second. In addition, researchers performed experiments to help understand the physics and validate computer codes that model the radiation flow from the primary to the secondary within the nuclear explosive package.

The collaboration of computational physics and experiments on Z-pinch wire array implosions has yielded physical insights that are critical to scaling up to higher currents and radiation pulses on the Z machine. The deuterium fuel in Inertial Confinement Fusion capsule implosions at the Z facility now has been heated to temperatures found at the center of the sun (approximately 11 million° C).



Quantum molecular dynamics simulation showing the atomic nuclei and an electron density iso-surface for stainless steel at high energy density. These simulations are being used to calculate the electrical and thermodynamic properties of stainless steel and other materials under the extreme current densities found on the Z machine.

ST&E at Sandia

ST&E LEADS THE WAY WITH LABS' CAPABILITIES

Sandia's Science, Technology, and Engineering program (ST&E):

- provides a comprehensive and integrated understanding of technical laboratory capabilities;
- identifies critical issues to guide investment and disinvestment decisions; and
- contributes to administrative decisions on program, laboratory directed R&D, and diverse infrastructure investments.

Notable infrastructure enhancement includes the construction of state-of-the-art research and development facilities, such as MESA and the Center for Integrated Nanotechnologies (CINT), which will be used to advance micro/nanotechnologies, as well as development of novel, large-scale test facilities such as the Thermal Test Complex (TTC), used for weapon qualification and fundamental studies of fire physics.

Sandia will play a major role in advancing the state-of-the-art in microsystems R&D and in incorporating integrated microsystems into the nuclear stockpile. Integrated microsystems, with their ability to sense, think, act, and communicate, will significantly advance the safety and reliability of weapons systems, and their small size and multiple functions will allow designers to place more features into a smaller amount of space during scheduled weapon refurbishments.

Through its core facility in Albuquerque and gateways to both Los Alamos and Sandia, CINT provides open access to the tools and expertise needed to explore along the continuum from scientific discovery to the integration of nanostructures into the micro and macro world. Operations in the new core facility are scheduled to begin in April 2006. The CINT "jump-start" user program, which concluded last year, launched its science program by attracting more than 250 proposals, from which 89 projects were approved. These projects involved 43 universities, 27 states, three private-sector companies, and four foreign countries.

The TTC is part of a major revitalization of Sandia/NM's test capabilities. Completed in fall 2005, the TTC serves two functions: to support qualification of nuclear weapon systems and subsystems in abnormal thermal environments and to provide state-of-art capabilities for large-scale fire research. The facility has been designed to study quiescent large-scale combustion events as well as to assess the effects of wind. Novel diagnostics development and application are also possible at the TTC, and the facility will serve as the nation's fire phenomenology validation test bed. This facility offers one-of-a-kind capabilities and positions Sandia as a technical leader in the fire science and technology community.

Computer generated images of CINT (left), MESA (center) and an aerial view of Sandia's TTC. Both CINT and MESA took major strides toward completion in 2005, while researchers moved in to the TTC, part of a major revitalization of Sandia's test capabilities.

LDRD: A case study in innovative research

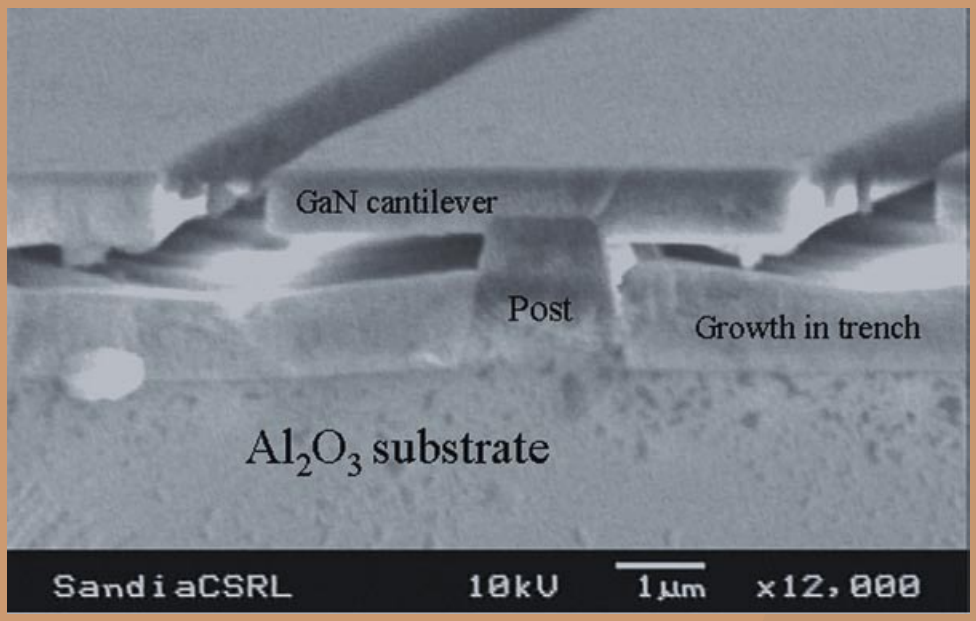
It was a perplexing problem for researchers in solid-state lighting. The output of light emitting diodes, or LEDs, was limited by energy losses at defects, or dislocations, in the crystal lattice of the diode material, gallium arsenide (GaN). The dislocations resulted from a mismatch in the atomic spacing of the GaN lattice and a sapphire material, used as a base for growing the gallium compound.

Describing the problem and setting out a three-year funding plan, Sandia's Laboratory Directed Research and Development (LDRD) Program challenged researchers to address this issue. Out of this "Grand Challenge" came a novel way of growing GaN, called cantilever epitaxy, which created large areas that are nearly free of vertical dislocations.

In August 2004, the work was recognized by a 2004 R&D 100 award from *R&D Magazine* as one of the most promising new technologies in the field. In addition to furthering scientific understanding of GaN physics and growth chemistry, the cantilever epitaxy approach offers new possibilities in reduced-energy lighting in general applications and in specific ones, such as reduced-weight aircraft navigation and cockpit lighting. The LEDs also show promise in chemical and biological detection applications for homeland security and sensors for analysis of threat from ballistic missiles.

This "Grand Challenge" through Sandia's LDRD Program is one example of how the Labs' world-class science, technology, and engineering efforts define its value to the nation. These capabilities must remain on the cutting edge because the security of the U.S. depends directly upon them.

It's a not-so-unusual story for LDRD. In fact, 60 percent of the Labs' R&D 100 award winners since 1992 were supported by LDRD. And like many LDRD projects, the fundamental level of the LED effort resulted in a benefit to multiple sponsors.



A scanning electron microscope image shows a cantilever epitaxy growth on top of the sapphire post. This Sandia-developed process for growing gallium nitride on an etched sapphire substrate may help light up the world with brighter green, blue, and even white high-efficiency light-emitting diodes.

Sandia's LDRD Program provides the flexibility to invest in long-term, high-risk, and potentially high-payoff research and development activities that stretch the Labs' science and technology capabilities. LDRD also promotes creative and innovative research that attracts exceptional research talent across many disciplines.

LDRD funding — the "seed corn" for the future of the Labs — is intended to invigorate and extend Sandia's expertise within disciplines identified to be core technical competencies. Although it uses only five percent of the Labs' budget, LDRD's impact in terms of intellectual property reaches well beyond that amount. More than 40 percent of the Labs' technical advances, 30 percent of its total income from patent licenses, and almost 40 percent of issued patents come as a result of the LDRD Program.

Sandia's three deputy directors (see Reorganization on page 4) decide the LDRD Program's budget, structure, and policies. Rick Stulen, Sandia's vice president for Science and Technology and Research Foundations and chief technology officer, is responsible for stewardship of the program. He administers LDRD and interprets policy direction from the deputy directors to create an overarching LDRD strategy with a portfolio mix of projects aligned with Labs goals.

ST&E at Sandia

NATIONAL SECURITY TECHNOLOGY AT THE CUTTING EDGE

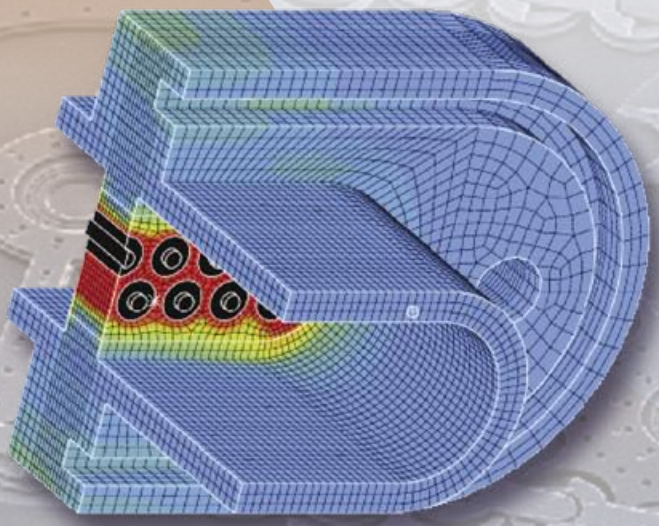
Sandia maintains strong fundamental programs in science, technology, and engineering (ST&E) to underpin and build critical R&D capabilities that support its national security mission. Our ST&E stewardship is focused in five foundational areas:

- Computational and Information Sciences
- Engineering Sciences
- Materials Science & Technology
- Microelectronics & Photonics, and
- Pulsed Power

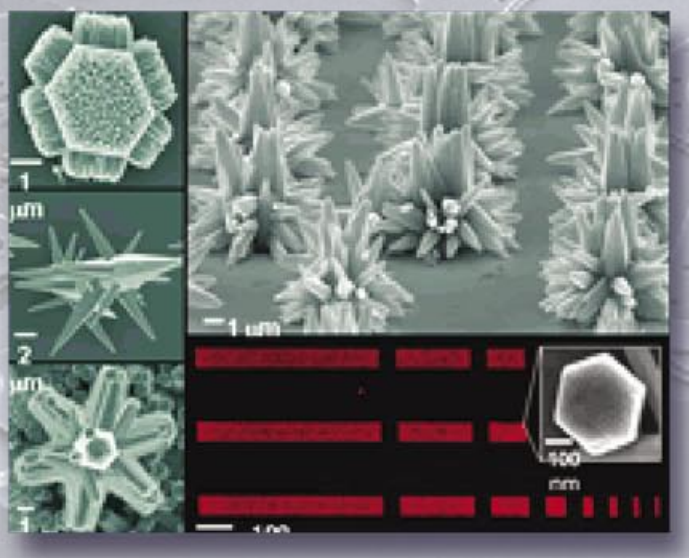
We will continue to enhance our science-based stockpile stewardship role through the 21st century in order to transform all aspects of the work of the nuclear weapons complex, including design, manufacture, qualification, annual stockpile evaluation, and daily surveillance functions. This role includes the use of exotic radiation machines and high-performance computing to model and simulate the environments that nuclear weapons must endure, from vibration and fire to thermonuclear effects.

Sandia's stockpile management responsibility extends to a nuclear weapon's arming, fuzing, and firing system; gas transfer system; and associated cables, valves, pads, foam supports, and miscellaneous parts. It also extends to the electronics that keep the nuclear weapon safe and ensure that it works as required, which is why it is imperative that the electronics we purchase meet the Labs' high, science-based qualification standards.

The Sandia-operated MESA microfabrication facility also does its part in helping the Labs' meet the demanding requirements of nuclear systems by producing the essential components unavailable through commercial industry. Continued innovation in assuring the performance and reliability of nonnuclear materials in the stockpile has become a key mission of the Labs' ST&E organization.



This high-fidelity simulation of a 15-pin hermetic microminiature connector shows the stress generated in the housing by glassing operations. Simulations, like this one, support changes in manufacturing processes to improve product yield. This two-minute simulation took about 24 hours to do a decade ago.



The red arrays at the bottom of this composite photo are made up of many hexagonal zinc oxide rods (shown in inset) coated with quantum dots, which glow red when illuminated with the proper wavelength of light. The intricate zinc oxide structures — on the order of only a few nanometers — left column and in the top photo were assembled in solution on patterned substrates at Sandia.

DEFENDING THE NATION THROUGH ADVANCED TECHNOLOGIES

The Department of Defense (DoD) chose Sandia to build a conventional earth-penetrating warhead (EPW) because of the Labs' expertise in high-speed flight system design, precision navigation, guidance, control capabilities, and penetrator technology. The project integrates an Army TACMS (Tactical Missile System) booster with a maneuvering reentry vehicle designed, developed, and tested by Sandia. The White Sands Missile Range test, conducted in 2004, demonstrated the feasibility of the first high-speed, precision-guided EPW delivered from a deployed tactical missile system.

TACMS-P (penetrator) is a prime example of the projects undertaken by Sandia's Defense Systems and Assessments (DS&A) organization. DS&A coordinates special projects for the DoD and other entities to defend against weapons of mass destruction, defeat hardened deeply buried targets, combat terrorism, and support related missions. DS&A's principal customers are the DoD, the intelligence community, and the nonproliferation technology community in the DOE's National Nuclear Security Administration. A multiplication of capabilities has emerged as the result of microsystems engineering, advanced modeling/simulation, and other technologies.

Weapon systems superiority

DS&A's purpose is to help the nation maintain the conventional weapon systems superiority that is critical in fighting terrorism and equipping the armed forces for future conflicts. A large part of its operational approach is connected with the development of advanced technologies and systems that transform the military into a more effective, agile force while enhancing personnel survivability. In brief, Sandia's defense expertise lies in finding targets, deciding what to do about them, and executing an attack, when appropriate. Finding the target might rely on unattended ground sensors, or "darts," like the semi-autonomous sensors built by Sandia and deployed in the jungles of Vietnam in the 1960s. Target location may be enabled by an unmanned aerospace vehicle carrying a synthetic aperture radar imaging system that Sandia has put into a package of just over 25 pounds capable of making high-resolution images through weather, at night, and in dust storms. The attack might then be carried out with a rapid-response, autonomous, precision-attack system such as TACMS-P.

Sandia systems and technologies also contribute to national security through remote sensing and verification using space-based payloads and platforms. In 2005, Sandia delivered the twenty-third and last Defense Support Program satellite to Cape Canaveral. This satellite provides advanced radiation detection payloads that are key to the nation's capability to detect surface and atmospheric nuclear detonations. Sandia also delivered the second next-generation Global Burst Detector payload for integration with the second Block IIF Global Positioning System spacecraft. A suite of sensors, designed and produced by Sandia and Los Alamos National Laboratory, performs nuclear event monitoring.

This 2004 test of an integrated earth-penetrating warhead (conventional) met range, accuracy, and penetration objectives.

Sandia is also supplying the next generation Integrated Correlation and Display System as the ground element of the U.S. Nuclear Detonation Detection System. This system processes data from sensors aboard Global Positioning System and Defense Support Program satellites and consists of one million lines of code and hardware located at seven facilities.

With its focus on advanced conventional technology for the defense department, DS&A regularly finds itself supporting challenges set by the U.S. Strategic Command (STRATCOM). These include military space operations; global strike; information operations; global missile defense; combating weapons of mass destruction; and intelligence, surveillance, and reconnaissance. Each of these, with the exception of nuclear responsibilities, is supported in some way by DS&A's associations with the armed forces.

The organization is also alert to the need for advanced technologies that will detect, locate, characterize, defend against, and, when necessary, destroy the increasingly sophisticated weapons being developed and used by unfriendly and rogue nations and by transnational terrorist organizations.

Through DS&A and other Sandia groups, the Laboratories combines its resources to help give the president

Intercepting a ballistic missile

Several times a year, residents of western Kauai, Hawaii, are treated to the early-morning fireworks display of a rocket rising from a Sandia-operated launch site into the Pacific sky. It is very likely that the rocket is being launched in support of the Missile Defense Agency's development of interceptors that will stop ballistic missiles before they reach U.S. territory. This is sometimes described as the problem of "hitting a bullet with a bullet."

Kauai Test Facility (KTF) is located on the U.S. Navy's Pacific Missile Range Facility, the world's largest instrumented, multidimensional testing and training range. Situated among the dunes of Kauai's dry and sunny western beaches, the range's job since the 1960s has been mainly to prepare and launch targets — simulated missiles, warheads, or decoys — that DoD systems must find and destroy.

In one recent test, Sandia launched an Aries medium-range target missile westward over the Pacific Ocean shortly after dawn. Downrange, the Aegis cruiser USS Lake Erie was waiting and watching with SPY-1 detection and tracking radar. Two minutes after the Aries launch, its missile tubes opened and an SM-3 missile emerged, seeking out its prey. In another two minutes, the cruiser's missile collided with the target booster from KTF, smashing it with non-explosive, kinetic energy. The anti-missile missiles are intended for intercepts above 80-100 kilometers as part of the sea-based missile defense system.

Such exercises are, if not actually routine, a well-practiced job for Sandia's DS&A crew. Sandia has run the range since the 1970s, through the days of the Strategic Defense Initiative and the Ballistic Missile Defense Organization to the present, gaining a growing reputation for expertise in designing and launching special-purpose rocket systems. Sandia has also proven its ability to build its own launch systems, though the private sector provides Aries, Castor, and others that are regularly used by Sandia.

KTF operations are managed by DS&A's Integrated Military Systems group, which supports the defense department's ballistic missile community in flight tests of advanced reentry systems. Work commissioned by the DoD three decades ago proved a catalyst for development of a center of excellence for advanced mechanical design, flight test support, miniaturized instrumentation, earth-penetrating weapons, navigation, guidance and control, hypersonic vehicle design/materials, missile defense, and rocket test design and services. These include scores of proof-of-principle demonstrations of advanced and exploratory missile defense, reentry, rocket, aided-navigation, and guided-flight systems. The KTF and Tonopah Test Range in Nevada, also operated by Sandia, are the only full-scale flight test facilities in the DOE complex.

Resources at KTF are available for assembling, testing, launching, uplink command, receiving telemetry, and recovering instrumented rockets, rocket payloads, and remote air and ship-borne instrumentation platforms. The Navy's Pacific Missile range provides flight safety, radar tracking, world time reference, telemetry reception, communication, and weather data.

and secretary of defense what STRATCOM terms "a unified resource for greater understanding of specific threats around the world and the means to respond to those threats rapidly."

DS&A is composed of a number of program areas that support the DoD and other federal agencies with advanced systems projects. Here's a sampling of these projects:

- ***Intelligence, Surveillance, and Reconnaissance*** – builds on Sandia's success in remote sensing and synthetic aperture radar to provide science, technology, and engineering capability in battlefield intelligence, surveillance, and reconnaissance.

- ***Remote Sensing and Verification*** – Sandia completed a Critical Design Review milestone on its most complicated satellite system to date, clearing the way for fabrication and deliveries in early 2006. This system provides a Sandia-unique solution to critical national needs, combining large-format focal plane arrays, reprogrammable integrated circuits in radiation environments, precision pointing and control, and other technologies.

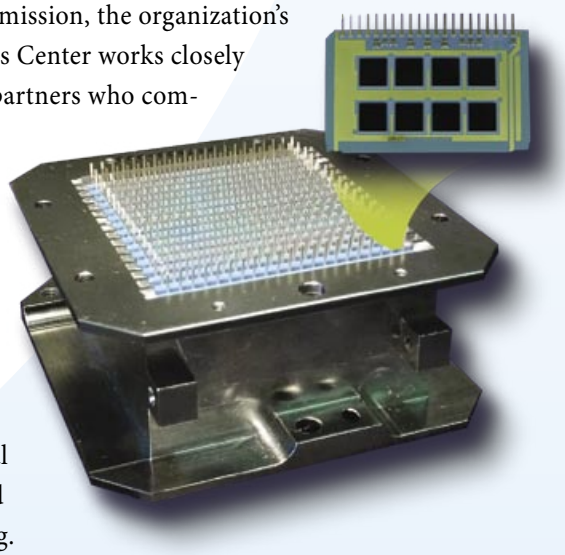
- ***Energetic Systems*** – specializes in development of high-energy systems such as electromagnetic launchers for ship-borne aircraft and munitions, drawing on Sandia technologies and expertise developed over the last two decades.

- ***Information Operations*** – addresses growing national security challenges in information system security and surety. This program is investigating new approaches that would insert trusted detection systems at various points within an information system to detect anomalies and intrusions by sophisticated adversaries such as well-financed terrorists and nation states. Sandia's Information Design Assurance Red Team seeks to improve system integrity, privacy, and data security for the Next Generation Secure Computing Base.

- ***Intelligent Transformational Systems/Robotics*** – develops new intelligent systems technologies, drawing on experience in designing, developing, and delivering complex micro- to macro-sized automated systems, and adapting machine intelligence technique to projects such as the use of computer game methods to train Special Forces soldiers in adaptive thinking, negotiation, conflict resolution, and leadership within cross-cultural settings.

Since its launch into space six years ago this March, this multispectral thermal imager (MTI) — the first full satellite and sensor system designed and built by Sandia — has captured data for various government agencies and advanced the state of satellite technology.

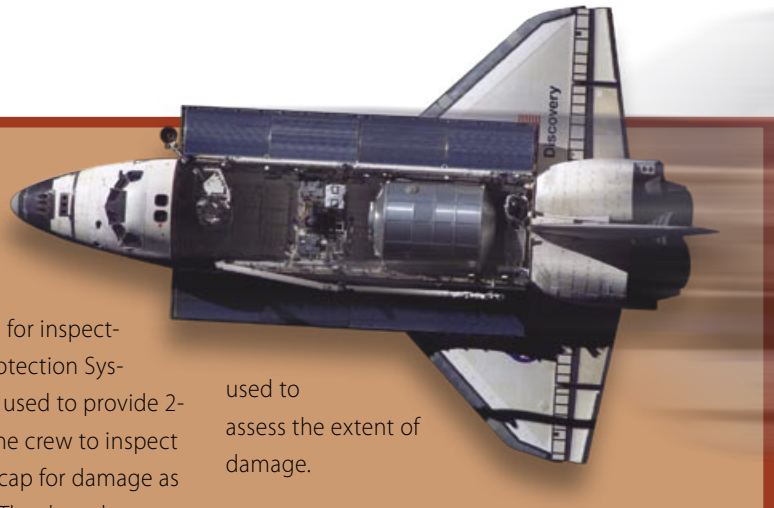
In carrying out its mission, the organization's Industrial Relations Center works closely with a number of partners who commercialize Sandia's technology in products manufactured for the DoD. Agreements include collaborations with (among others) Northrop Grumman, General Atomics, Lockheed Martin, and Boeing.



S&TE at Sandia

This microsystem combines sensing and electronics integrated into a package. Each of 16 chips on each multi-chip module provides continuous conversion of photodetector signals over 14 octaves of dynamic range. Sixteen modules are integrated into a single housing. With this array, Sandia has achieved 10,000 times greater on-orbit processing power, reduced size and weight by a factor of 2,000, and cut power consumption by a factor of 1,000.

Sandia aids in NASA's "return to flight" ride



The Space Shuttle *Discovery* was launched from Kennedy Space Center July 26, 2005, the first shuttle flight since the *Columbia* tragedy of February 2003. Sandia had been instrumental in analyzing the cause of the accident that destroyed the *Columbia*, helping confirm that it was caused by foam that detached from the external tank and impacted the wing-leading edge on takeoff. When foam debris was observed again during the launch of *Discovery*, the Labs' technology proved essential.

Sandia's projects in NASA's "return to flight" effort ranged from providing sensor technology to supporting real-time operations at mission control. Sandia studied the vibrations caused during the rollout of the space vehicle and developed a nondestructive inspection method. The effort that captured the most attention in the mission, however, was Sandia's Laser Dynamic Range Imager (LDRI).

The LDRI is the primary tool for inspecting the shuttle's Thermal Protection System during missions. It was used to provide 2- and 3-D video imagery to the crew to inspect *Discovery's* wings and nose cap for damage as small as a 0.020-inch crack. The data also went to NASA engineers to determine the health of the heat shield.

Designed to satisfy the recommendation that shuttle crews have a way to inspect the orbiter after launch, the LDRI was mounted on *Discovery's* Orbiter Boom and Sensor System, a 50-foot-long robotic arm extension. Simply described, it is an intensified black and white television camera with a 3-D laser imager mounted on a pan-and-tilt unit. It uses a modulated infrared laser illuminator and receiver to image and spatially locate each point in the scene, at the rate of seven and a half images per second. Intensity data are used to detect damage, and the geometric data are used to assess the extent of damage.

The LDRI began scanning the orbiter after the robotic arm was deployed on day two of the flight, focusing on inspection of tile, gap filler, and the port wing. It soon discovered loose gap fillers, thin fabric stiffened with a ceramic material used to plug gaps between the shuttle's tiles. One piece was sticking out 1.1 inches. The other projected at an angle from six-tenths to nine-tenths of an inch.

Sandia's orbiter inspection sensor housed in the payload bay (above) and being used to reach out toward the shuttle wing to scan tiles (left).

Geometric data collected by the LDRI allowed NASA to model the effects of the protruding

filler, and to conclude that overheating might result on reentry if the pieces were left in place. Astronaut Stephen Robinson then removed the protruding gap fillers during an unprecedented space walk. *Discovery* subsequently touched down at Edwards Air Force Base August 9, 2005, following successful reentry.

NASA has requested the Sandia-developed sensor be on the next space shuttle mission.

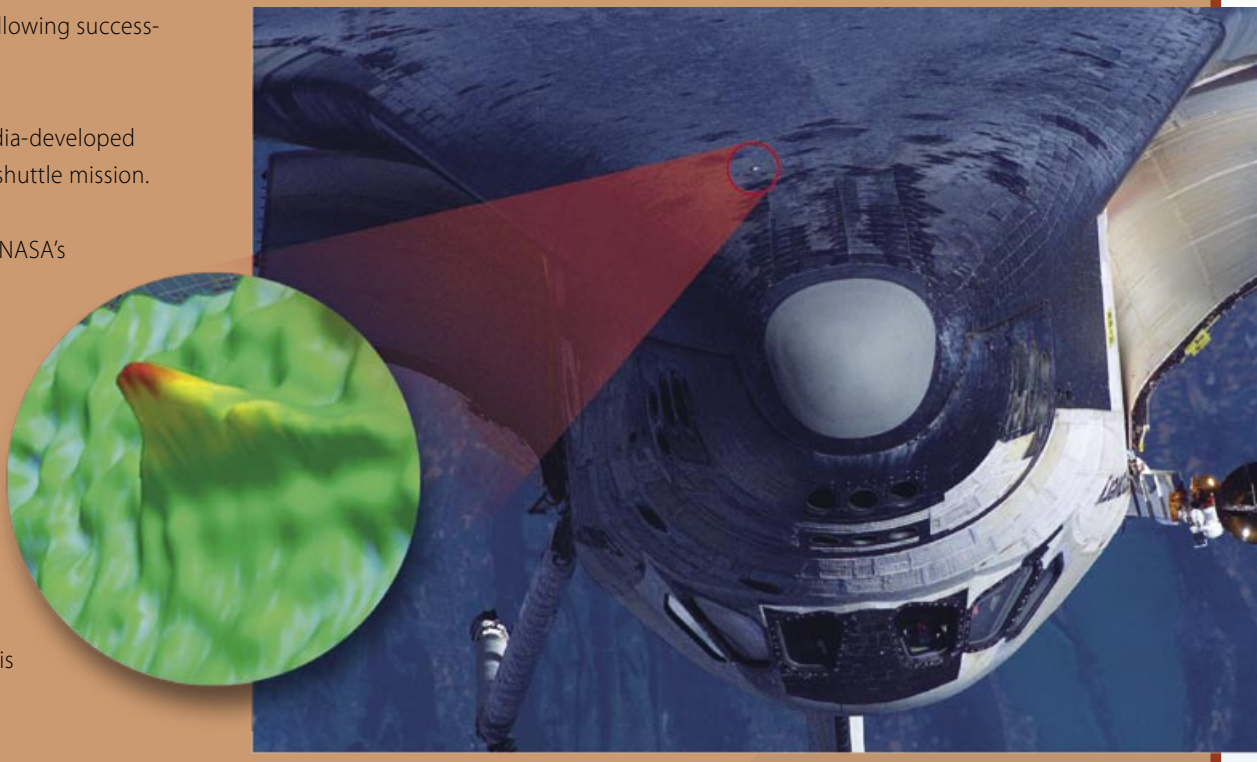
Other Sandia involvement in NASA's shuttle program included:

- Contribution to peer reviews of NASA's development of computational tools to support rapid damage assessments. These tools would be used to decide whether the orbiter can safely return or if some in-orbit repair is needed.

- External membership in NASA's Engineering and Safety Center's Flight Sciences "Super Problem Resolution Team." This team was formed shortly after the *Columbia* accident to oversee safety issues in any of NASA's flight programs.

- The Debris Transport Review, which focused on NASA's development of tools to model external tank foam or ice buildup that could detach during ascent and strike the orbiter. NASA has used these tools to redesign parts of the external tank.

- The Boundary Layer Transition Review, which centered on heat transfer effects during the reentry trajectory, when the environment around the orbiter transitions from laminar to turbulent flow, risking higher than normal integrated heating on the orbiter during reentry.



Extruding gap filler shown as LDRI data (in circle) from Sandia sensor. (NASA photo)

- Assisting in designing tests and instrumentation to measure the dynamic environment of rollout and moving the shuttle from the Vehicle Assembly Building to the launch pad, which led to better understanding of the fatigue that results from vibration.

- Testing sensors that were placed on the leading edge of the orbiter's wings, thus validating a Boeing model that predicts accelerometer data collected during ascent and impacts on wing- and spar-leading-edge materials.

- Refinement of ultrasonic nondestructive inspection method (hardware, techniques, and standards) to support a pre-flight shuttle certification process, which focused on methods for certifying the flightworthiness of orbiter wing-leading edges.

In the next shuttle mission, STS-121, *Discovery* is scheduled to supply the International Space Station and carry out testing of inspection and repair hardware, as well as evaluate operational techniques and concepts for conducting on-orbit inspection and repair.

ACG: HOW SCIENCE AND TECHNOLOGY RELATE TO HUMANITY

Science and technology, research, and development are wondrous parts of modern-day society. But how do they relate to people — those who use them and those who are, or could be, affected by them in positive or negative ways?

Such questions, part and parcel of what are called complex systems, are the province of a unique Sandia organization, the Advanced Concepts Group (ACG). In a collegial setting, social scientists mix with physical scientists and engineers to examine complex problems and draft systems solutions for broad challenges that generally involve social and political conflict and that can be helped or hindered by technology.

The ACG's small, select, and changing membership (generally appointed for two- to three-year assignments) deals in ideas and concepts that appear to be appropriate for Sandia participation. These are ideas that others will eventually own and bring to reality, perhaps 10 to 20 years in the future. Its white papers and presentations are designed to refine ideas and convince others to take ownership.

Various types of discussion groups are designed to extract new ideas and new solutions — sometimes actionable, nearly always thought-provoking — from subjects that move quickly from the broad view to more discrete sets of prickly problems.

Brainstorming, fests, and futuristic discussions

As a safeguard against insular thinking, the ACG regularly organizes "fests" that bring in other specialists — from science-fiction writers to corporate R&D chiefs — for a day or two of futuristic discussion. More fre-

quently, Friday brainstorming sessions take on subjects that range from the increasing cost of geriatric care and the future of nuclear weaponry, to the huge challenge of filtering, managing, and acting upon intelligence.

Liaison with the Sandia mainstream is accomplished through a variety of means: meetings with top management in the Laboratory Leadership Team, participation in strategic planning for key strategic units, and occasionally funding special projects.

- One of the major investments, named TALON, is a concept for precision situation awareness in the attack on enemy targets or protection of "soft" targets through the use of networked sensors that collect, filter, share, and report information on the environment of interest. TALON could be used in locations ranging from the battlefield to airports and other centers of high-density civilian traffic.

- Another is a software-based system that analyzes routinely prepared reports of human symptoms by area and flags those locations where the epidemiological data indicate a possibility of inadvertent infection by agents being prepared to conteract terrorist attack.

On the international front, which through globalization is increasingly connected with U.S. security, the ACG plans and promotes ideas for peaceful international cooperation — an area that has been supported for more than a decade by the Cooperative Monitoring Center and other units in the Labs' Energy, Resources, and Nonproliferation organization. This thrust supports the philosophy that, rather than concentrating on one or two parts of a problem, national and international security issues should be considered as systems in which the eventualities must be prevented, dealt with, and terminated, and the locus of conflict restored.

Root causes of conflict

ACG's global-security emphasis more often tends to be aimed at reducing the causes of conflict rather than dealing with a conflict that has deteriorated into warfare. The group was instrumental in promoting the establishment of an initiative for the safety, security, and

ACG leader Gerry Yonas speaks at opening ceremonies for the Bi-National Sustainability Laboratory at Santa Teresa, New Mexico, near the U.S.-Mexico border. The lab's goal is to reduce stresses and achieve border stability and transparency.

sustainability of water resources and a separate Bi-National Sustainability Laboratory (BNSL) concept that fosters cooperative, sustainable economic development in neighboring states as part of a strategy to reduce stresses and achieve border stability and transparency. BNSL programs may first be set up on the U.S.-Mexico border before being "exported" to areas where binational cooperation serves the interests of both participating states.

ACG members consider they have scored a success when one of their ideas is accepted sufficiently that it becomes an initiative within some other organization, preferably inside or at least outside of Sandia. The overriding desire, however, is to stimulate the Labs' existing expertise. In fact, the ACG team considers that much of its business is concerned with thinking about thinking, and that its "coin of the realm" is infecting other people with ideas. For Sandia, this group adds up to a resource with an unusual talent for finding and using a wide range of resources.

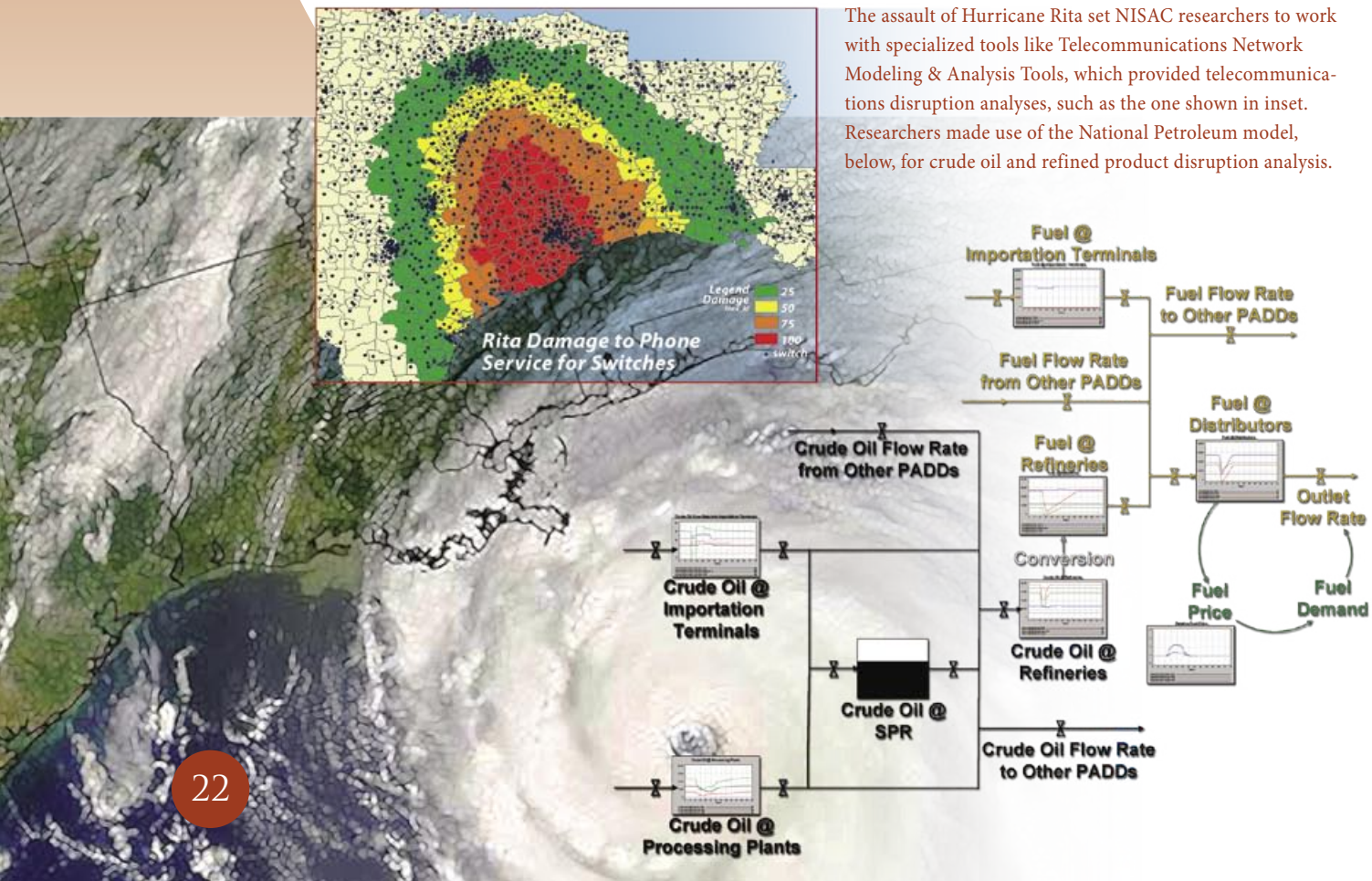
NISAC ANALYSIS SUPPORTS DISASTER PLANNING AND RESTORATION

How would the U.S. economy — and overall security — be affected if one or more key rail bridges were lost? Would public health be at risk if shipments of chlorine — a potential weapon in the hands of terrorists — were stopped during periods of heightened alert? If a specific dam failed, how many people and businesses would be hurt?

Questions such as these arise frequently as the Department of Homeland Security (DHS) and other federal agencies work to build a comprehensive strategy to protect basic infrastructure elements against terrorism and natural disasters. Because resources are limited and the potential for damage immense, the stakes are too high to leave the answers to guesswork.

Yet determining the myriad and interrelated consequences of a catastrophic event is a complex enterprise — far beyond the scope of conventional analysis. Extending conventional analysis to create sound, scientifically defensible approaches for understanding the interrelationships between complex infrastructures — and their failures — is the core mission of the National Infrastructure Simulation and Analysis Center (NISAC). A program in DHS's Infrastructure Protection, Risk Management Division, NISAC is a core partnership between Sandia and Los Alamos National Laboratory.

Researchers at NISAC focus the two labs' modeling and simulation expertise to analyze critical infrastructures and their interdependencies, vulnerabilities, and complexities. By building these capabilities, analysts have developed unique expertise in how infrastructures work and interact. DHS queries NISAC on issues concerning infrastructure policy analysis, investment and mitigation strategies, consequence metrics, understanding of interdependency effects, and exercise support — all aimed at optimizing protection, saving lives, and limiting damage should disaster strike.



The assault of Hurricane Rita set NISAC researchers to work with specialized tools like Telecommunications Network Modeling & Analysis Tools, which provided telecommunications disruption analyses, such as the one shown in inset. Researchers made use of the National Petroleum model, below, for crude oil and refined product disruption analysis.

Understanding Hurricane Katrina

Core modeling and simulation developed over the past five years enables NISAC analysts to respond quickly when needed — as was the case as Hurricane Katrina bore relentlessly toward the Gulf Coast region. Activated by DHS two days before Katrina's landfall on Monday, August 29, 2005, NISAC gathered a variety of data — including storm data from the National Hurricane Center, flood maps, infrastructure asset locations and capacities, and information on regional conditions — and ran computer simulations to determine Katrina's potential impact on infrastructures.

Before the storm hit, NISAC analysts were able to forecast:

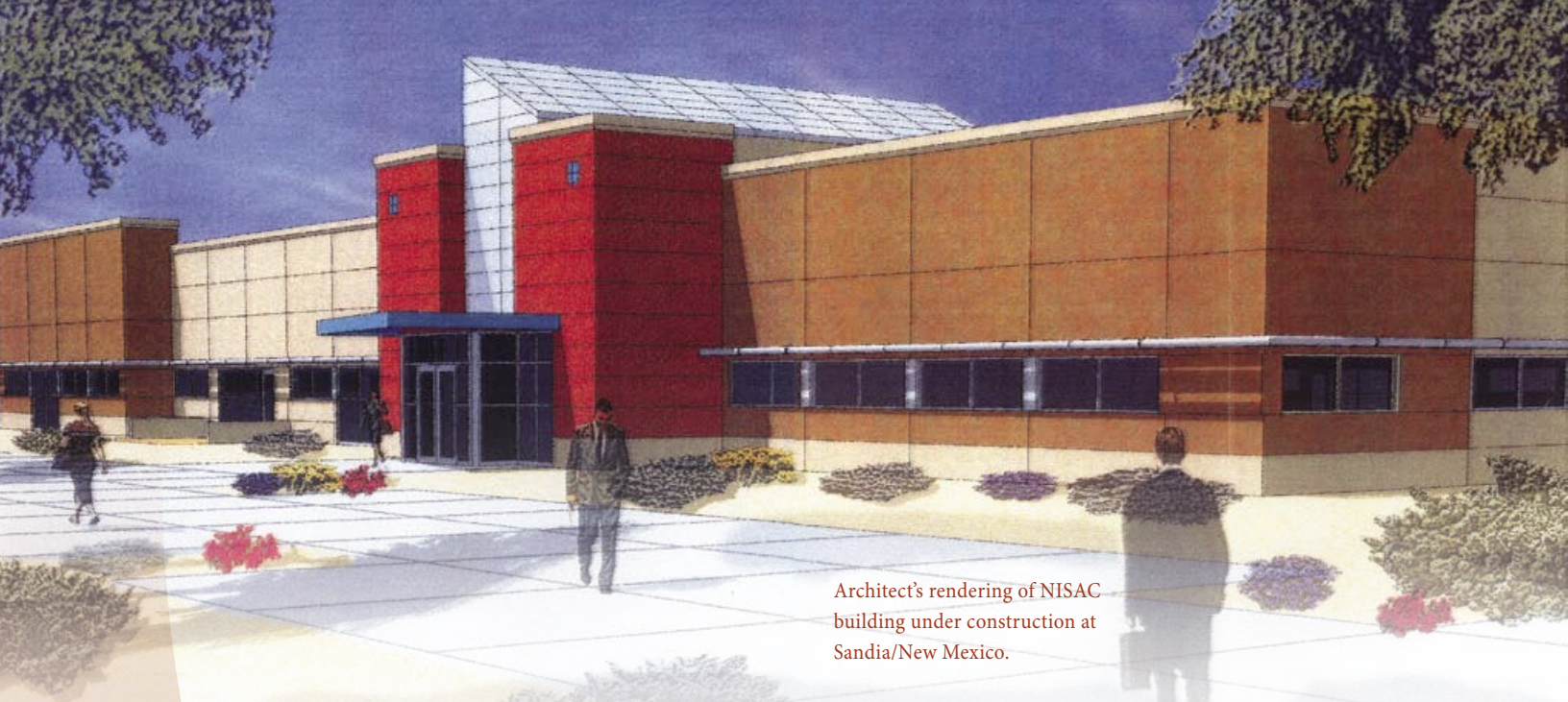
- Direct economic impacts of the storm could total $10-$14 billion, while the total impacts to Gross Domestic Product (GDP) could range from $18-$25 billion (excluding property losses). Severe flooding or levee breaching could increase GDP impacts by 30-40 percent at a minimum.
- Electric power outages could affect 2.6 million customers (in reality, 2.5 million customers experienced outages) and restoration could require up to four months.
- Stored crude oil supplies were sufficient to limit the consequences of disruption, although it was noted that speculation and unexpected occurrences could lead to uncertainty and volatility in the price of crude oil and refined products. It was also noted that the potentially affected region contained 14 percent of the nation's refining capacity and 10 percent of the nation's crude oil importing capacity, including the majority of supertanker traffic.
- Transportation of commodities would be affected, which led NISAC to identify supply chains that would be interrupted and alternative sites for offloading goods.
- Up to 98 chemical facilities would be affected and require one to four weeks for recovery.
- Twenty-two water treatment facilities would be damaged, as would related pumping and sewage facilities.

Perhaps even more important, NISAC identified the cities and populations — numbering more than 2.6 million people — in areas of most likely damage and identified the threat to New Orleans from levee breaching. Specifically, after reviewing the literature on hurricane flooding in the region, analysts noted that any storm rated Category 4 or greater would likely lead to severe flooding or levee breaching that could leave the New Orleans metro area submerged for weeks or months.

Helping the nation respond and prepare

As the nation grappled with the difficult task of rebuilding this vital region after the storm and flooding, NISAC analysts continued to provide near-daily reports on the implications of infrastructure damage for recovery operations. More focused economic analyses, for example, showed possible declines in GDP of $32 billion (0.4 percent of total GDP) in the year following Katrina and of $82 billion over the three subsequent years, with projected direct and indirect losses of from $300-$400 billion. In other work, NISAC:

- Simulated the potential magnitude and distribution of fuel shortages and the potential for shortages or price increases in winter heating fuels and natural gas,



Architect's rendering of NISAC building under construction at Sandia/New Mexico.

- Estimated electric power restoration times,
- Identified damaged rail lines and affected commodities,
- Forecasted that industry spare parts reserves could compensate for the probable loss of 20-40 percent of major telecommunications switches, and
- Identified agricultural commodity flows through ports at the mouth of the Mississippi and possible alternate transportation strategies.

For 2005, NISAC has completed 21 hurricane-related reports for DHS, including two Katrina pre-event and 10 Katrina post-event reports, four pre-event reports on Hurricane Rita, two pre-event reports on Hurricane Wilma, and one pre-event report each for Hurricanes Dennis, Emily, and Ophelia. NISAC also contributed to three DOE hurricane reports. Findings were provided to the Federal Emergency Management Agency and the Homeland Security Operations Center, DHS Secretary Chertoff, and the White House.

These reports will help policymakers and those on the ground examine consequences and recovery over the longer term. However, the 2005 hurricane season illustrated a national need for improved planning, preparedness, and response to catastrophic events. NISAC is making plans to advance its capabilities and is currently compiling high-risk scenarios, focusing on natural disasters, accidents, attacks, and inherent infrastructure stresses.

DHS funds new NISAC building

In recognition of the importance of secure and high-performance infrastructures to overall security, NISAC funding has increased substantially over its five operating years, from the initial $500,000 in 2000 to the current $20 million budget. Further, DHS will be funding the construction of a new building to house NISAC researchers. Located at Sandia New Mexico, this facility will be the first DHS-owned building at a national laboratory.

In the words of Senator Pete Domenici (R-NM), "This building, which we have been planning for the past several years, will house a program that has important implications to the national security of this country. Our nation cannot be secure without sufficient understanding of the infrastructures that make our economy and facilitate modern life."

Focusing on real-world needs

Sandia's Homeland Security organization, led by California site Vice President Mim John, developed a detailed set of 10-year objectives, five-year goals, and one-year milestones in 2004 as a guide into the future. The long-term goal is to "establish through high impact, national contributions a major business unit in homeland security for Sandia, sponsored principally by the Department of Homeland Security (DHS) but with a diverse portfolio encompassing other agency sponsors (developed in partnership with other Sandia organizations), the industrial sector, and state and local governments."

By focusing on real-world needs and partnering with industry, Sandia continued its homeland security efforts in:

- Defending against weapons of mass destruction
- Protecting our borders and securing transportation
- Protecting the nation's physical and information infrastructures
- Mitigating attacks

Activities at Sandia's National Infrastructure Simulation and Analysis Center (NISAC) represent only part of the organization's impact in 2005. (See NISAC on page 22.) Other highlights include:

Department of Homeland Security Secretary Michael Chertoff visited Sandia in May 2005, to learn about Sandia's technical contributions to homeland security efforts. DHS is currently working with Sandia on several fronts in the war on terror.

- DHS Secretary Michael Chertoff made his first visit to a national lab by touring Sandia/California in May, where he joined Senator Pete Domenici (R-NM) and Representative Heather Wilson (R-NM). "There is a tremendous contribution [to homeland security] to be made here," said Chertoff, adding that the energy, the dedication, and the creativity at Sandia "truly are remarkable."

A handheld BROOM scanner displays building floor plans and collected sample information. Barcodes and other relevant sample data are recorded for later transfer to the BROOM database.

- In the spring, Sandia unveiled a software-based tool called BROOM — short for Building Restoration Operations Optimization Model — to assist in sample gathering following a release of biological warfare agents in a public facility. In conjunction with the National Institute of Occupational Safety and Health, Sandia conducted a successful exercise to test BROOM.
- Sandia finalized and published Guidelines to Improve Airport Preparedness, a 100-page document prepared in collaboration with Lawrence Berkeley National Laboratory expected to aid security managers of airports and other transportation facilities in reducing the risk of chemical and biological attacks.
- A DHS-funded study by Sandia researchers revealed that inaccurate sampling of biological pathogens can be deadly and that today's anthrax sampling methods need improvement.
- Several projects are currently under way focusing on the nuclear material and improvised explosive device threats. Researchers are investigating detection technologies and developing techniques focused on public transportation systems and venues, as well as follow-on countermeasures.

Near year's end, the organization made structural changes to bring relevant work being performed for other sponsors under the same management, reflecting our desire to offer our sponsors higher value.

NATIONAL SECURITY WITH INTERNATIONAL DIMENSIONS

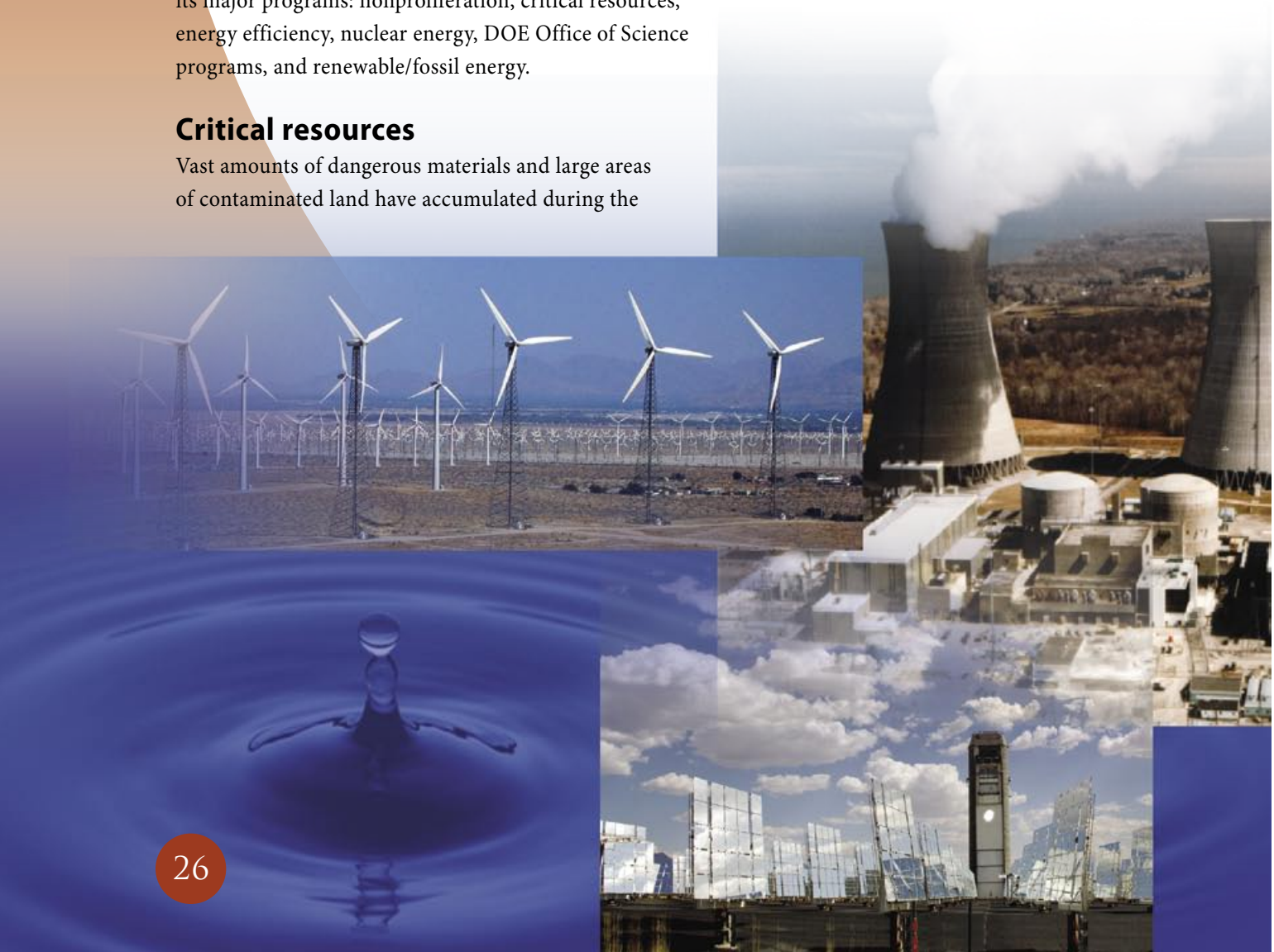
The Energy, Resources, and Nonproliferation (ERN) organization supports Sandia's national security mission by developing and applying technologies in wide-ranging areas — nonproliferation, energy surety, and water — enabled by fundamental science and global engagement in partnership with other national laboratories, academia, and private industry.

While much of the work in these areas is focused within the United States, the ERN has international dimensions. For example, the need to curb the proliferation of weapons of mass destruction makes it necessary to locate and track the shipment of radioactive and other weapon-capable materials. ERN manages the lion's share of Sandia's international projects through one or more of its major programs: nonproliferation, critical resources, energy efficiency, nuclear energy, DOE Office of Science programs, and renewable/fossil energy.

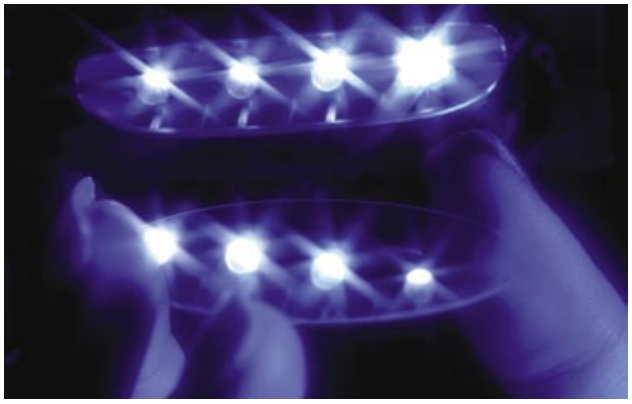
Critical resources

Vast amounts of dangerous materials and large areas of contaminated land have accumulated during the last four or five decades, a legacy of the Cold War and the rapid development of energy resources. Dealing with this legacy to reduce the risks it presents is one of society's most pressing problems. Yet disposing of materials that cannot be reused, storing and recycling materials that can be put to use, and cleaning up contaminated areas must be done safely, efficiently, and openly. In dealing with issues related to materials and waste management, and environmental quality, the Critical Resources Program builds upon the capabilities of a long history of successful work in waste disposal and environmental cleanup.

Over the years, Sandia has developed efficient techniques and instruments for these tasks, often working



in cooperation with regulatory agencies, citizen groups, scientific oversight groups, and other stakeholders. The program is supported primarily by two internal groups, the Nuclear and Risk Technologies Center and the Geosciences and Environment Center.



Lighting the future

A prime example of the Labs' contribution to the quest for more efficient lighting lies in the use of microtechnology to fabricate light emitting diodes (LEDs) that are 50 percent energy efficient throughout the visible spectrum. This feat was achieved in a collaborative project with Lumileds Lighting of San Jose, California, and the University of New Mexico. Tests with a Lumileds chip showed that including a photonic lattice boosted device efficiency from 12 percent to 18 percent. Incandescent light sources convert only about five percent of their electrical input to visible light, and fluorescent lighting converts only about 25 percent of its electrical energy to light.

Solid-state lighting is still more efficient and, though it is relatively more expensive to install, lasts 10 times longer (in its application in single-color traffic lights) than incandescent or fluorescent lighting. Sandia continues to invest in semiconductor materials, nanoscience, and novel device designs and packaging. It is generally believed that, as costs become competitive with other light sources, LEDs could capture most of the lighting market by 2025.

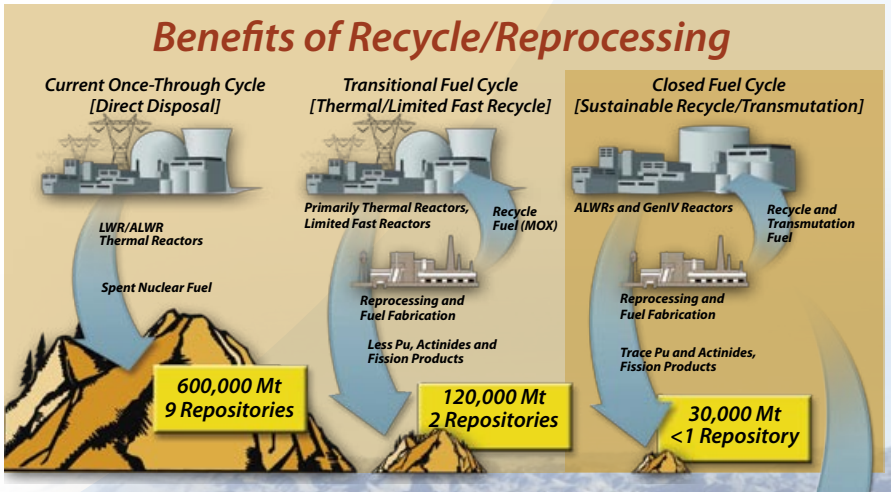
Energy for 1000 years

Sandia supports the philosophy of growing sustainable nuclear power while reducing availability of attractive nuclear materials to potential proliferators by using Sandia's systems capabilities in nuclear technology, nuclear materials and waste management, and nonproliferation to support continued and expanded use of nuclear power worldwide. Sandia is now cooperating with six other DOE national labs and nine Russian scientific nuclear organizations in the implementation of a joint declaration predicting that, "with government encouragement and the right regulatory and economic conditions, nuclear energy could supply a substantial part of U.S. and Russian energy needs and 30-40 percent of the world electricity demand by 2050."

Sandia, working with a six-lab consortium, has developed a Nuclear Energy Vision that calls for new fuel cycle technology capable of generating 50 percent of U.S. electricity by 2050 using reactor options that are twice as efficient as today's concept. The Vision also calls for:

- supporting the export of long-lived (30-year core) reactors for smaller markets based on a cradle-to-grave supply concept,

- minimizing what is currently viewed as waste by at least 90 percent by recycling everything of value and transmuting what is left,



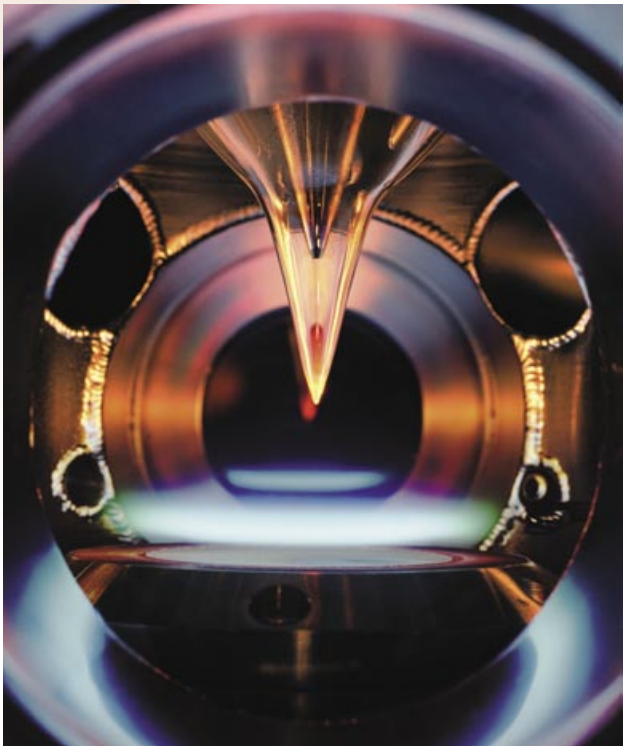
Improving the nuclear fuel cycle, first with recycling and then reprocessing, can dramatically minimize the tonnage of nuclear wastes destined for repository disposal.

- enabling sufficient fuel supplies to provide a significant fraction of the world's energy needs for 500-1000 years, and

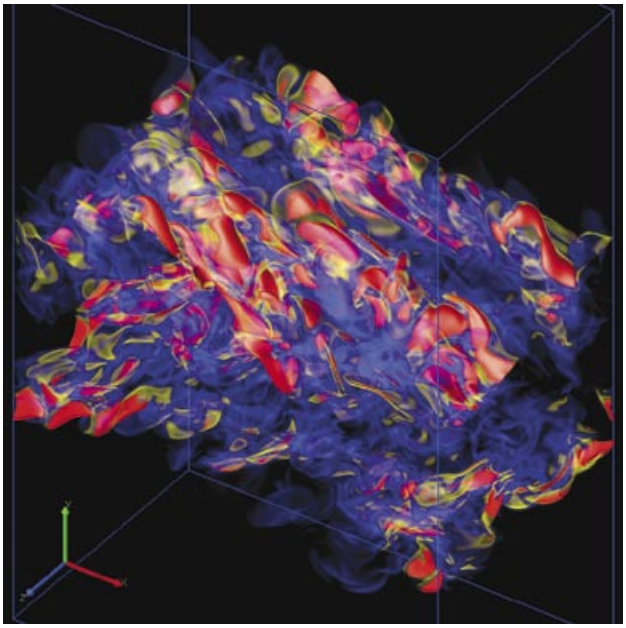
- assuring safety, security, and real-time transparent operations through the incorporation of smart manufacturing process controls along with parallel, real-time, overt assessment of process data for continuous proliferation risk management.

Office of Science

Sandia research sponsored by the DOE Office of Science includes work in fusion energy sciences, scientific computing, basic energy sciences, and biological and environmental sciences. A major achievement was the recent discovery of a new class of transient chemical compounds, called enols, in flame during experiments at Lawrence Berkeley Laboratory's synchrotron light source. This discovery will permit greater fidelity in the modeling of the combustion process. In the area of advanced scientific computing, scientists are modeling cell wall dynamics. For its part, geosciences research runs from nuclear waste repository design and fossil energy exploration and production to geologic sequestration of carbon dioxide.



The newest Office of Science facility is the joint Sandia/Los Alamos National Laboratories Center for Integrated Nanotechnologies (CINT), an international center of excellence in nanoscience that provides fundamental understanding for applied science programs for DOE. CINT offers an environment in which academic researchers can gain access to the labs' nanotechnology. More than 60 nanotechnology research projects are already under way through this program. For example, CINT scientists and their collaborators are using "quantum dots" to create logic circuits that build themselves and more energy-efficient light sources. Invisibly small clusters of atoms, quantum dots are the new engineering building blocks for future electronic devices and solid-state lighting. These small clumps of matter (about 100 atoms) have unique properties that reflect the nature of nanoscale quantum physics. (See Nanotechnology on page 31.)



(Above) Sandia combustion researchers used a supercomputer at Lawrence Berkeley National Laboratory to perform the world's largest 3-D direct combustion simulation of a turbulent carbon monoxide-hydrogen flame. The 10 terabytes of simulation data will be used to understand interactions to design more fuel-efficient, cleaner-burning engines.

(Left) Researchers at Sandia's Combustion Research Facility were part of an international team that has detected a new class of compounds, called enols, previously unknown in flames. The breakthrough could lead to soot reduction, decreases in pollutants, and improved fuel cells.

Energy mixes for the future

Since the mid-1970s, Sandia has been charged with developing commercially viable energy technologies based on solar, wind, and geothermal resources. With the establishment of the Combustion Research Facility (CRF) in 1980, the Labs became a DOE-designated user facility for the automotive industry, later extending to the fields of space heating and cogeneration. Sandia is also committed to the development and implementation of key science and technology and systems that will enable the start of a long-term transition to a hydrogen-energy economy (especially through improved hydrogen storage materials). A combustion engine that will increase fuel economy by as much as 50 percent could be made available to consumers within the next five years through a new approach that would combine the advantages of gasoline and diesel engines.

The CRF is broadly engaged with DOE and industry through DOE's FreedomCAR & Hydrogen Fuel Initiative on the pathway to fuel-cell-powered vehicles and a hydrogen economy across a broad front of scientific research and technology development. Sandia researchers are looking at projects ranging from hydrogen production by nuclear, solar, biomass, and fossil sources to use in advanced vehicle power supplies, including fuel cells and new hydrogen-combustion engines. Sandia is also part of the international partnership that supports DOE's Nuclear Hydrogen Initiative.

Labs' engineers are leading the Center of Excellence for metal-hydride-based hydrogen storage and are partnering with General Motors to engineer state-of-the-art, integrated, metal-hydride storage systems that permit advanced prototyping for vehicle designs. Additionally the Labs are investing more than $2.5 million per year in discretionary funds to develop:

- advanced materials for hydrogen separation,
- new high-temperature materials for fuel cells, electrolysis membranes, and electrodes,
- new methods for thermochemical water splitting using clean nuclear and solar energy, and
- new computational tools for dynamic modeling of novel fuel-cell systems, systems for co-production of hydrogen and electricity, and systems for CO_2 sequestration.

Sandia researcher with medal hydride sodium alanate, a material that can absorb and store hydrogen. General Motors and Sandia are partnering in a four-year, $10 million project to design and test metal hydride materials for hydrogen storage.

Nonproliferation

Sandia's nonproliferation organization is committed to "reduce the vulnerability of the United States to the proliferation and use of weapons of mass effects" and to "provide performance and vulnerability assessments of

both U.S. and foreign technical capabilities along with the development of associated tools and technologies." This set of responsibilities calls for capabilities ranging from the assessment of commercially available access control technology to the development of sensors and sensor suites and the design and construction of surveillance satellites.

Air Marshals Arshad Chaudhry (Pakistan) and Kodendera Cariappa (India) discuss aerial monitoring options in a program at Sandia's Cooperative Monitoring Center.

Sandia nonproliferation professionals:

- boosted security measures and monitor weapons-grade material in Russia,
- helped manage a regional technology-for-peace organization in the Middle East,
- partnered with the Arab Science and Technology Foundation to revive science and technology in Iraq, and
- provided expertise to increase security at Olympic events.

People representing opposing sides in global hot spots come to Sandia's Cooperative Monitoring Center to augment their treaty-making skills and to get acquainted with new technical means for monitoring treaties. Sandia nonproliferation personnel also cooperate with counterparts in nations as diverse as Tanzania, Haiti, Greece, Egypt, and Lithuania. They identify radioactive materials that can be used in "dirty bombs" and protect them from theft with technologies ranging from motion detectors to fiber-optic seals.

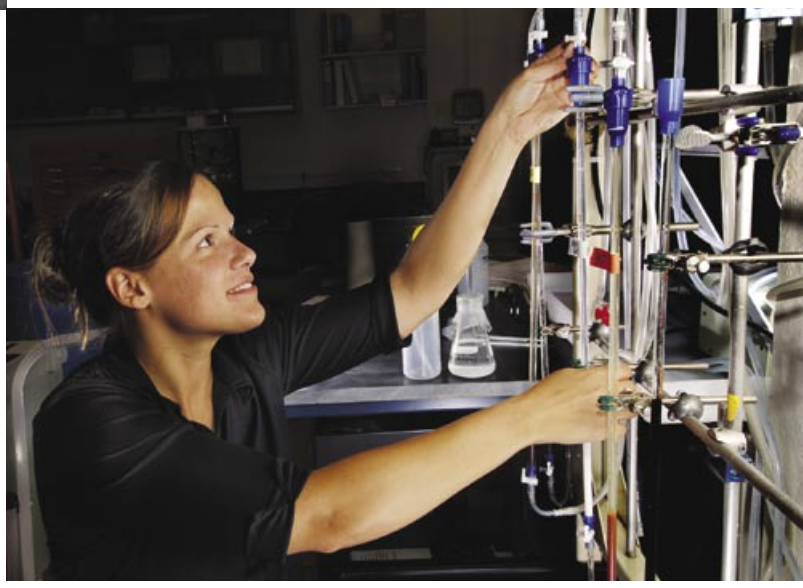
Water: conflict or cooperation?

Water can be a source of conflict or a platform for cooperation. Increasing scarcity implies the possibility of future instability and conflict but also represents the opportunity for countries to develop joint approaches. Sandia's strengths are growing as a water research and development institution, providing technology applications and solutions for the U.S. and the world.

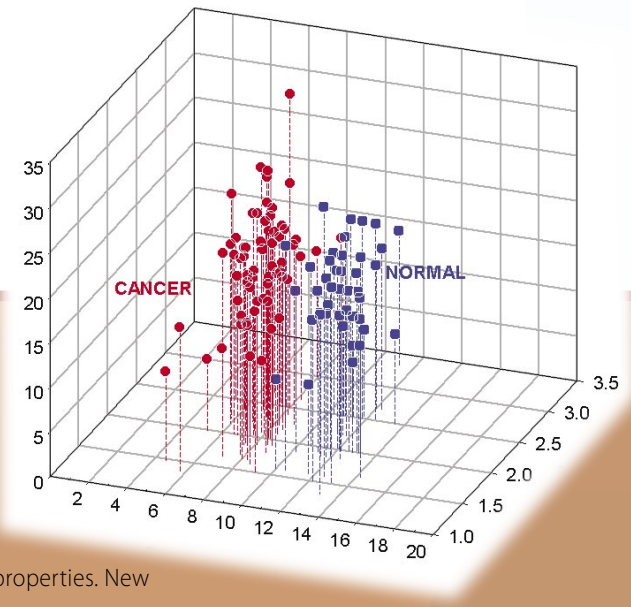
Current aims are to:

- produce revolutionary water treatment technologies that enable advanced-concept desalination and low-cost removal of contaminants,

Sandia researcher works on a laboratory project to determine how best to remove arsenic from drinking water — a problem faced by many in the U.S. desert Southwest and abroad.



- incorporate sensing technology into a real-time water quality monitoring network for water infrastructure systems,
- develop strategies and technologies in water infrastructure security that will enable cost-effective management of risks related to terrorist attacks on U.S. water systems,
- use integrated systems-level models for cooperative decision making in multiple settings, including local, state, multi-state, and international settings,
- facilitate the understanding of energy and water and other interdependencies, and
- develop improved technologies to enable the solution of interdependency issues.

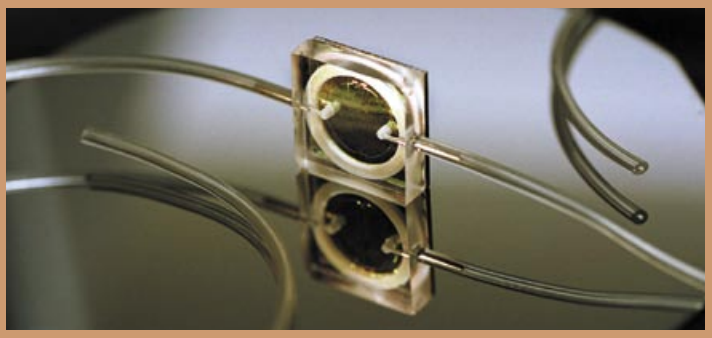


Transparent cells (or other biological material) have indexes of refraction that affect the laser output intensity, wavelength, and other characteristics. Different cell types produce different spectral characteristics from the laser, as this graph shows.

Nanotechnology: small scale, large potential

The field of nanotechnology is developing rapidly at Sandia and other R&D laboratories around the world. Great potential exists for this new class of materials; however, many challenges need to be met before its practical benefits are fully realized. These include manufacturing at the nanoscale, integration of nanoscale materials and devices with more conventional technology, and computer modeling that allows nanotechnology to be engineered reliably into useful applications and products.

Sandia activities in this field are included, with numerous others, in the Labs' new MESA facility and CINT (see page 20).



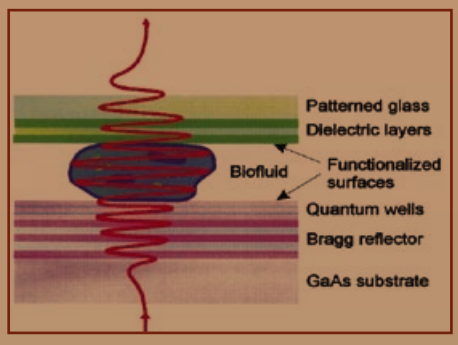
The BioCavity laser is based upon the Vertical Cavity Surface Emitting Laser, a Sandia-developed technology. A completed device with tubing to allow the flow-through of samples is shown here.

Nanotechnology is creating an entirely new class of materials and devices with unique and potentially useful properties. New applications are expected to emerge as new tools are developed to "see," "touch," and measure the behavior of individual nanostructures, and as experimental techniques are complemented with advanced computational tools.

The Sandia-originated Vertical Cavity Surface Emitting Laser (VCSEL) incorporates a nanomaterial that uses layered structures to produce highly efficient, low power-consumption light sources. Structures of this type are now used in optical communications, image scanning, laser pointing and surveying, printing, and computing.

In the field of nanocrystals, electrons can be used to modify the properties of semiconductor quantum dots or "Q-dots," which may be developed as fluorescent tags to follow biological processes in real time. Q-dots produce a wide range of colors, allowing many individual biological processes to be tracked simultaneously.

Molecular self-assembly, extensively used in biological systems, is well suited for the production of nanoscale 3-D structures. Self-assembled nanoengineered films are used to provide a several-hundred-fold increase in detection and identification sensitivity for Sandia's MicroChemLab, or µChemLab.



The laser cavity is fabricated with a space (a microfluidic channel) to allow the passage of whole cells or other biological material, as illustrated here.

PARTNERING: KEEPING PACE WITH LIKE-MINDED INSTITUTIONS

As part of Sandia's dedication to operational excellence, its scientists and engineers maintain a continuing relationship with other organizations involved with DOE's NNSA manufacturing programs, assuring that they are acquainted with new procedures and materials that may assist in assuring that all products from the complex are top quality and cost-effective.

Because the best science, technology, and engineering cannot be developed in seclusion, Sandia collaborates and partners with a variety of like-minded industry, government, and academic institutions. For example, Sandia has a long history of helping commercial computer-aided-design (CAD) companies improve their tools. This work is driven by Sandia's need to better meet demanding DOE requirements of predictability, reliability, and improved productivity.

Applicon partnership

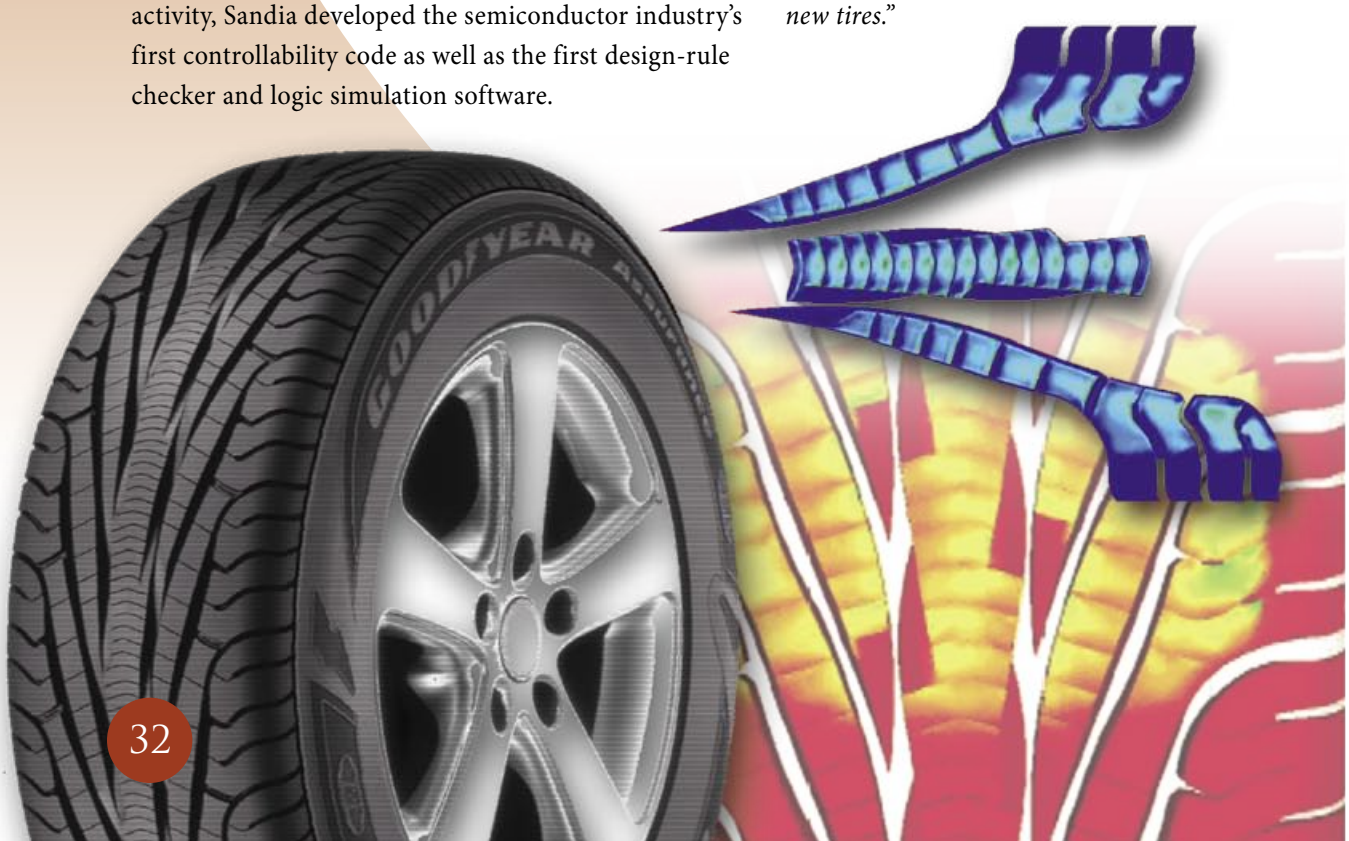
In partnership with Applicon during the 1970s and early 1980s, Sandia developed codes for integrated-circuit layout, beginning with the user command interface and continuing through analysis and design — and even to the code that drove the output plotters. As part of this activity, Sandia developed the semiconductor industry's first controllability code as well as the first design-rule checker and logic simulation software.

Sandia continues to collaborate with the software automation industry in developing software for identifying needs and developing custom manufacturing execution systems for low-volume, high-product-mix semiconductor production. The tools that Sandia helped develop over the years are fed back into continuing to ongoing DOE programs.

Goodyear partnership

In another example, Bob Keagan, chairman, CEO, and president of Goodyear Tire, had this to say about Sandia's drive to partner with others:

"Part of our R&D strategy is to partner with others — like Sandia National Labs — to take advantage of technological capabilities without significant incremental investment. Our success here was validated once again in this area, as Goodyear and Sandia were recently honored by the prestigious R&D Magazine *for our work on Assurance TripleTred™ as one of the year's top 100 technology innovations. The work on TripleTred replaced our need to — as has been the case for many years — build, test, and repeat with a powerful set of simulation tools for design, prototype development, and performance evaluation on new tires."*



FY2005: A RECORD YEAR FOR SANDIA

Sandia achieved records in Fiscal Year 2005 for total revenue, total expenditures, and total employment levels. At the same time, Sandia's business operations continued to improve the Labs' financial processes, setting as a highest priority the stewardship of taxpayer dollars.

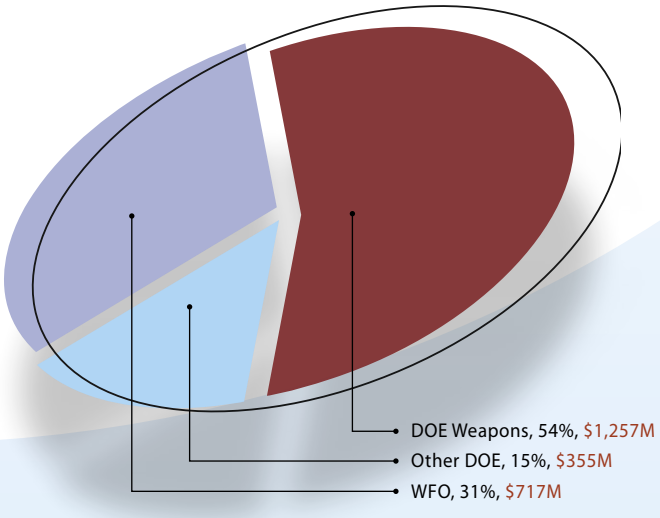
At the end of the fiscal year, Sandia counted:

- $2.329 billion in total budget,
- 8,821 employees,
- 188,327 acres of land,
- 1,185 buildings with 6.5 million square feet of space,
- 22 leased buildings totaling 313,000 square feet, and
- 13,500 total workers (estimate from all sites, counting limited-term employees, staff augmentation contractors, students, and post doctoral appointments).

Sandia's revenue for FY2005, $2.329 billion, represented an increase of $20.3 million from the previous year. The bulk of Sandia's income, 69 percent, came from the Department of Energy — 54 percent for weapons work and 15 percent for other DOE programs. The remaining 31 percent came from "Work for Others" customers, comprising other federal agencies, state and local governments (including universities), and private companies partnering with the Labs.

FY05 actual revenue by source: $2,328.6M

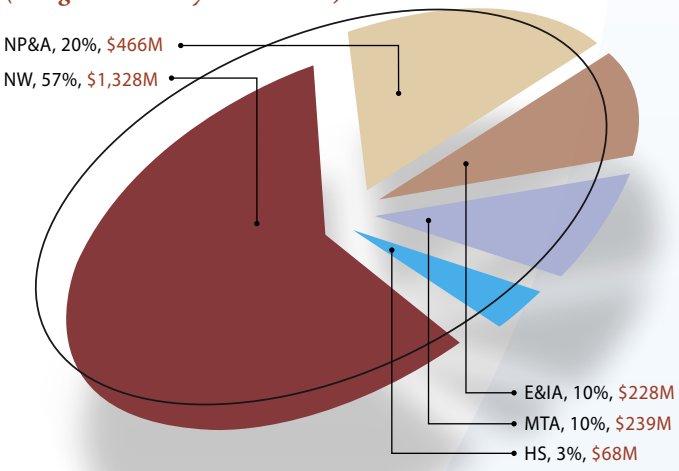
(Budget Authority in Millions)



The total revenue provided by Sandia's customers is allocated to five mission organizations, or business units, within the Labs. These organizations conduct the missions assigned to Sandia by our customers. The Nuclear Weapons unit continues to be the largest, using 57 percent of the revenue. The remaining four units share 43 percent of the revenue as shown here:

Application of FY05 SNL revenue by Strategic Business Units: $2,328.6M

(Budget Authority in Millions)



NW, nuclear weapons; HS, homeland security; MTA, military technology and applications; E&IA, energy and infrastructure assurance; NP&A, nonproliferation and assessment.

Another way of looking at the division of Labs revenue is to categorize it by (1) operations and maintenance, (2) capital equipment, and (3) construction. This table shows this division of revenue for the past two fiscal years:

Total revenue by category

(Budget Authority in Millions)

Total Revenue by Category	FY04 Actual	FY05 Actual	% Change
Operations and Maintenance	$1,995.2	$2,100.1	5.3%
Capital Equipment	$110.0	$76.4	-30.5%
Construction	$203.1	$152.1	-25.1%
Total SNL Revenue	$2,308.3	$2,328.6	0.9%

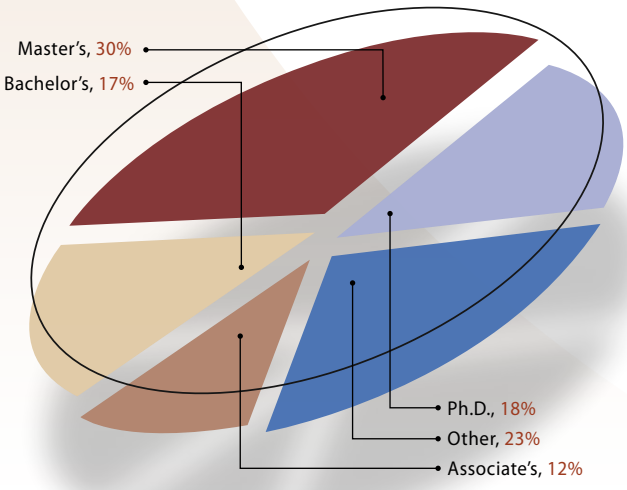
Editor's note: The division of funding by business units shown above reflects FY05 business units, which were changed for FY06 in a reorganization (story on page 4).

The decrease in capital equipment between FY04 and FY05 was the result of completion of the acquisition of Sandia's new Red Storm computer in FY04. The decrease in construction revenue is due to the completion of several construction projects in FY04. These include: the Distributed Information System Lab in Sandia/California; the modernization of communications infrastructure; and the first phase of a revitalization of test capabilities at Sandia/New Mexico. In Amarillo, Texas, at the Pantex facility, Sandia also completed construction of the Weapons Evaluation Test Lab.

Sandia's staffing story was also a positive one in FY05. Total Sandia full-time equivalent employee numbers climbed from 8,294 in FY04 to 8,821, an increase of 527 employees. Sandia's Human Resources group continues to work with line organizations to ensure a stable and sustainable work force, with highly qualified staff for Sandia's future.

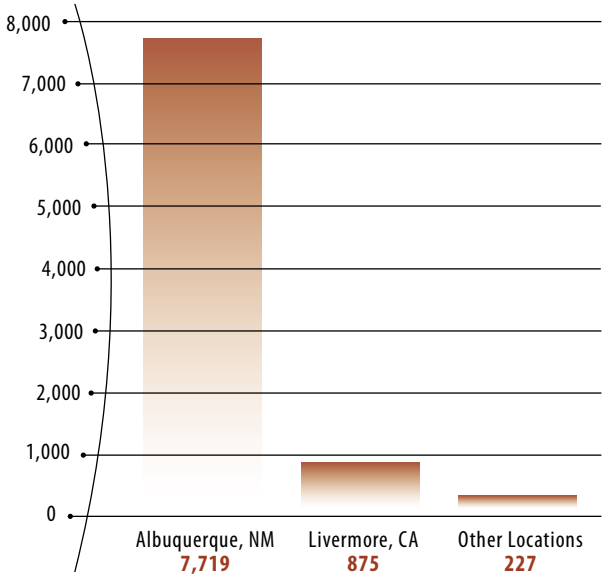
Here's a look at Sandia's regular workforce by education level. These numbers show the Labs' commitment to continuing education and to hiring the best and brightest engineers and scientists available for the national challenges we face.

SNL's FY05 workforce by degree



Although most Sandia employees work in Albuquerque, New Mexico, or Livermore, California, others are scattered among dozens of sites in the U.S. and abroad.

FY05 employees by location



The total economic impact of Sandia's annual budget — calculated at three times the total of the money Sandia spends for salaries and purchases — amounts to $6.8 billion* in New Mexico. As a national laboratory with many highly specialized needs, Sandia must secure some products and services nationally, but we support local New Mexico and California companies whenever possible. The Labs also believe in working with small businesses that provide many vital services and products. Last year, Sandia spent $428 million with small businesses.

In addition to the dollars-and-cents impact, Sandia's economic activities affect the number of jobs available. Beyond Labs employees, other jobs are supported or created by Sandia's need for goods and services. Re-spending by individuals and businesses providing goods and services also creates jobs. The result is a total impact of 34,225 jobs* in New Mexico.

*These calculations are not available for the California site.

WORKING WITH THE COMMUNITY

Sandia engages with the communities where it works in New Mexico and California. Here are some examples:

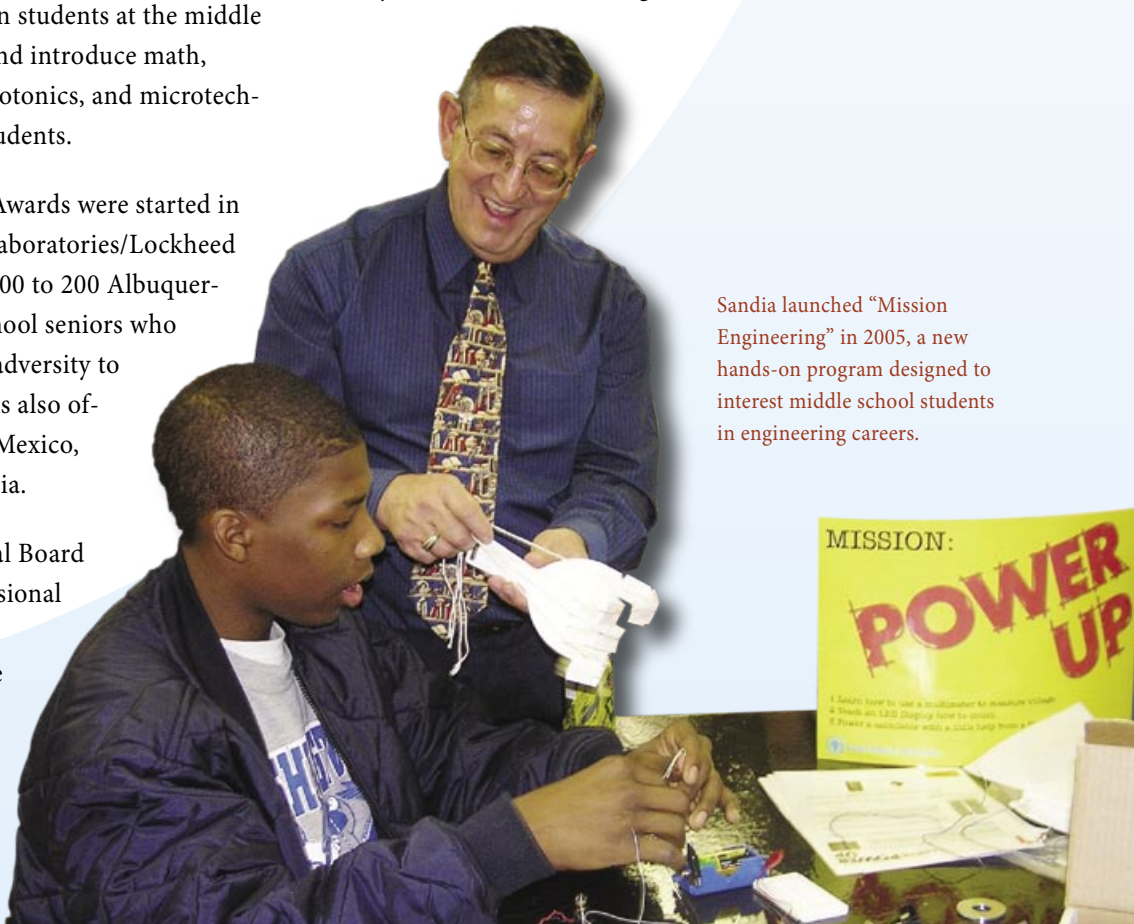
- Sandia helps numerous New Mexico businesses and civic organizations address community needs such as water and air quality, arid land issues, safety, and security. Sandia completed its fourth year of providing technical assistance to nearly 300 small businesses in New Mexico in FY2005 through a tax credit program passed by the New Mexico Legislature.

- Sandia's commitment to education focuses in the areas of leadership, student engagement and achievement, professional development, continuous improvement, and focused corporate gifts and grants. Our management and staff have provided leadership as chairpersons in organizations supporting education.
  - Our efforts in elementary school focus on making science fun and in engaging children and their families. Sandia continues to host Family Science Nights during the school year in New Mexico and California.
  - Other programs focus on students at the middle and high school levels and introduce math, science, engineering, photonics, and microtechnology to a variety of students.
  - Since the Thunderbird Awards were started in 1994, Sandia National Laboratories/Lockheed Martin has given $247,400 to 200 Albuquerque area at-risk high school seniors who overcame some type of adversity to graduate. The program is also offered in Carlsbad, New Mexico, and Livermore, California.
  - Sandia supports National Board Certification and professional development for science and math teachers at the middle and high school levels, and recognizes outstanding science teachers with annual "Excellence in Science Teaching Awards."
  - Additionally, Lockheed Martin on behalf of Sandia donated more than $2 million to nonprofit organizations in support of educational initiatives and programs during the year.

- Since 1993, Lockheed Martin has donated more than more than $16 million to local cultural, educational, and human services groups, emphasizing Sandia's engagement with its communities.

- Employees are encouraged to volunteer their time to a variety of organizations and causes, and they respond enthusiastically by becoming role models and partners in community programs and contributing to youth education.

- With a record contribution of $3.17 million, Sandians at Livermore and Albuquerque have now surpassed the $3 million mark in giving to local United Way and other charitable agencies for the first time.



Sandia launched "Mission Engineering" in 2005, a new hands-on program designed to interest middle school students in engineering careers.

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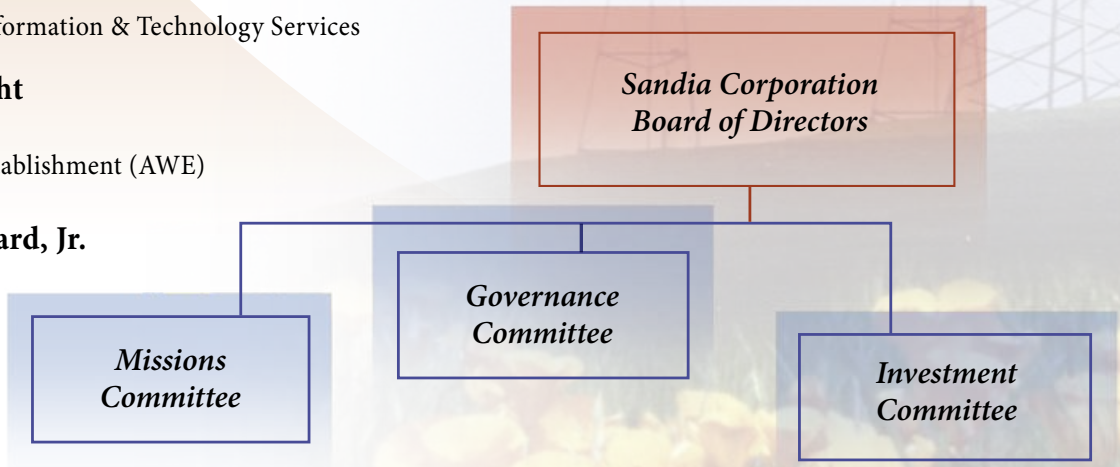

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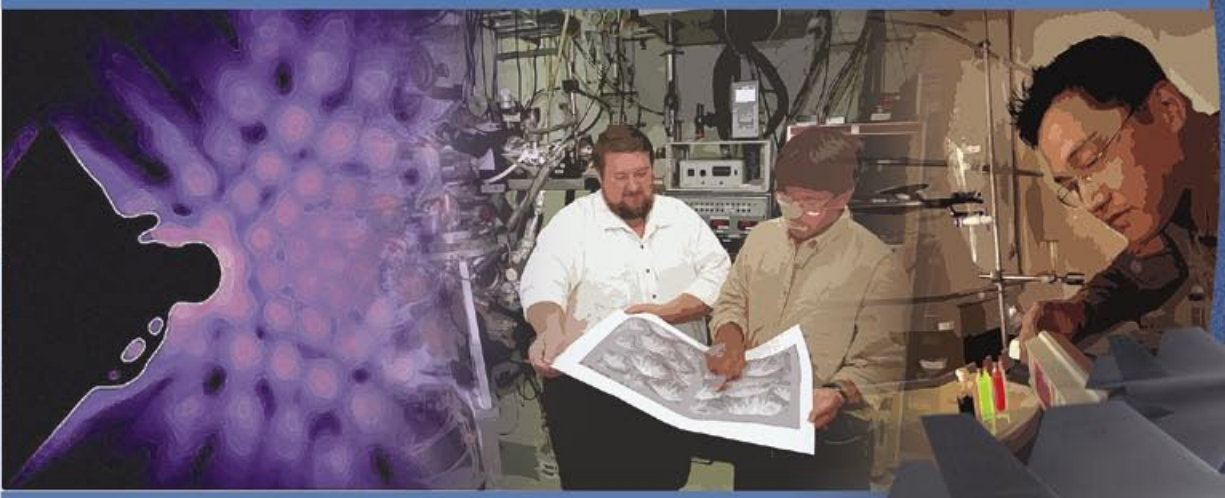

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