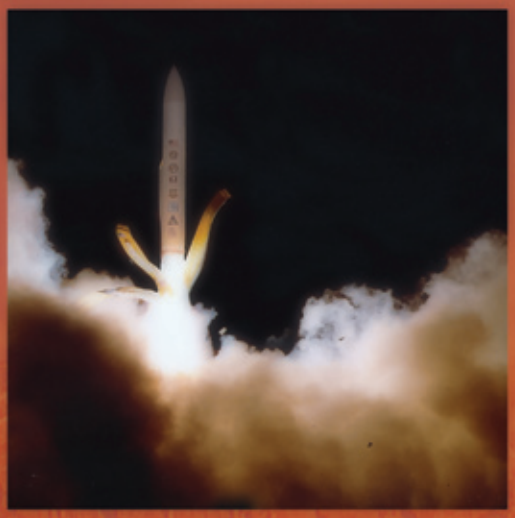
Sandia National Laboratories

Annual Report

2004-2005



Securing a peaceful and free world through technology

Sandia National Laboratories

About Sandia

Sandia was born out of America's first atomic bomb development effort—the Manhattan project—and was known as Z Division, part of what's now Los Alamos National Laboratory. 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.

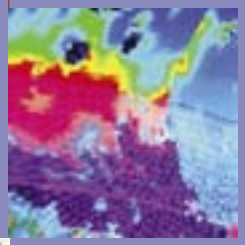
After the war, in 1949, President Harry Truman wrote a letter to the American Telephone and Telegraph (AT&T) Company president offering the company "an opportunity to render an exceptional service in the national interest" by managing Sandia for the U.S. government. AT&T accepted, began managing the Labs on Nov. 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 research and development work.

Lockheed Martin Corp. has managed Sandia since Oct. 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, Department of Homeland Security, and others. 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 laboratory in Livermore, California.

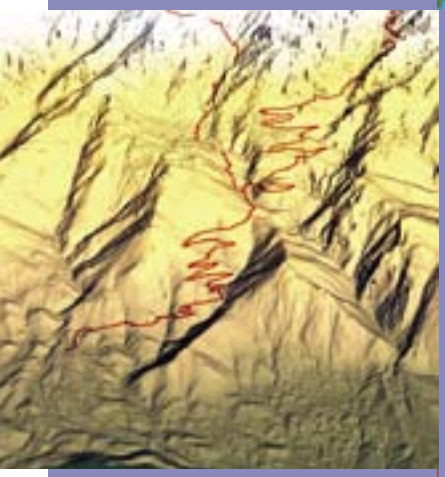
Sandia Overview

National Security is our Business

Sandia National Laboratories applies advanced science and engineering to help our nation and allies detect, repel, defeat, or mitigate national security threats. Our national security mission has grown from responding to the threat of the Cold War to countering a range of threats—some nuclear, others involving chemical, biological, or radiological weapons of mass destruction, and still others that are acts of terrorism.



We develop technologies to sustain and modernize our nuclear arsenal, prevent the spread of weapons of mass destruction, protect our national infrastructures, defend our nation against terrorism threats, provide new capabilities to our armed forces, and ensure the stability of our nation's energy and water supplies. Our science, technology, and engineering program ensures that the nation will maintain national technological superiority and preparedness—keys to national defense, homeland security, and our economic well-being.



We strive to become the laboratory that the U.S. turns to first for technology solutions to the most challenging problems that threaten peace and freedom for our nation and the globe. After the horrors of Sept. 11, 2001, our nation did turn to us. We responded immediately, and continue to respond in a variety of ways. Technologies derived from our national security mission are being used across the nation and around the globe. We are playing significant roles in the Department of Homeland Security and the Department of Defense's transformation efforts.

We not only respond to national security needs as they develop, but try to "think in the future tense" about new types of threats that may develop soon or years down the road—and work to develop solutions before those threats become reality.

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"Members of the independent commission that investigated the September 11th, 2001, terrorist attacks on the United States are pressing for swift action

to safeguard the country from further harm. Days after (the) release of a much-anticipated, 500-page report, September 11 Commission Chairman Tom Kean said the United States remains vulnerable to terrorism... Mr. Kean expressed dismay that, nearly three years after the 2001 attacks, more has not been done to improve America's ability to detect and defeat terrorist plots."

—Voice of America,
July 25, 2004

Answering the Call

A Letter from C. Paul Robinson and Joan Woodard

Science and Engineering for National Security

In the past few years, Sandia has been tasked many times to deliver technologies quickly to address national security needs, and we have answered the call proudly. As threats to the nation's security have evolved, so has the mission of this laboratory. Since its founding Sandia has always worked on many fronts.

Our historic role is the weaponizing branch of the Nuclear Weapons Complex. As a national security laboratory, Sandia continues to focus on our primary mission—maintaining the nation's nuclear weapons stockpile—but the Labs' overall mission has expanded to include a broad range of national security challenges. Our science and engineering foundation has provided the nation with the technological superiority needed to meet those challenges.

Sandia's core vision is "Securing a Peaceful and Free World Through Technology," and our goal is to become the laboratory that the United States turns to first for technology solutions to the most challenging problems that threaten peace and freedom for our nation and the globe.

Sandia's mission has expanded into combating terrorism, aiding homeland security, and supporting our military forces in Afghanistan, Iraq, and elsewhere. New technological advances must be quickly adapted to urgent applications in national security, and here Sandia's rapid prototyping and advanced manufacturing capabilities play a differentiating role.

In strategic planning exercises going back to the mid-1990s, we anticipated we would need to be prepared to deal with new kinds of threats:

- Proliferation of weapons of mass destruction,
- Vulnerability of our nation's infrastructure,
- Modern telecommunications technologies used by adversaries to attack our information and financial systems,
- Terrorism as a real threat to the U.S.,
- Military conflicts likely to be asymmetric and unconventional, and
- A direct relationship between our energy resources and national security.

"We have an obligation to future generations to do everything we can to keep these dangerous weapons out of the world's most dangerous hands."

—Former U.S. Senator Sam Nunn,
co-founder Nuclear Threat Initiative
CNN, January 2003

addition to nuclear weapons. The Armed Forces vision of the "Future Force" relies on bold systems engineering and development on a scale never before attempted—a system of systems that eliminates the fog of war by inverting the structure and operations of the military.

We have focused a substantial portion of our R&D funds to respond to these challenges. We have developed the technology and produced the systems not only for the detection of radiological materials, but also for their real-time characterization. Sandia-developed systems can now differentiate between medical isotopes, fuel- or weapons-grade special materials, and other radiological materials—from a distance, in real time.

America's new nuclear posture recognizes that the nation needs new conventional weapons and warfighting capabilities in

We are applying technologies and a systems approach for developing abundant, safe, and clean energy and water sources as a key part of a national security plan. Energy and water supply are seen by some observers as the driving issues for national security.

"Water promises to be to the 21st century what oil was to the 20th century: the precious commodity that determines the wealth of nations."

—Fortune Magazine, May 2000

Technology changes quickly, but among those things that do not change are the

spirit and values that make Sandia. We continue to create the kind of national security lab that is worthy of the freest nation in the world. There is no question that our work makes a difference. Sandia is doing its utmost to develop science and engineering solutions to national security problems. We do that with many of the best intellectual, scientific, and technical minds this nation has to offer.

"The United States faces a major shortage of scientists because too few Americans are entering technical fields and because international competition is heating up for bright foreigners who once filled the gap, a federal panel warned."

—New York Times, May 5, 2004

We are now well into a five-year program to hire 2,500 new scientists, engineers, technologists, and administrative staff. In the coming years, nearly a third of our current workforce must be replaced due to retirements. This highly educated new group of Sandians will build upon past achievements in exciting and creative ways. We invite you to learn more on the following pages about the many ways Sandia's people are contributing to our national security and America's well-being. This report highlights selected work and activities that we believe are of particular interest to our key public audiences.

For additional information about our capabilities, programs, and technical accomplishments, please see our website at **www.sandia.gov.**

C. Paul Robinson
President and Laboratories Director

Joan Woodard
Executive Vice President and Deputy Director

Special Report:
The State of Homeland Security

Sandia's MicroChemLab™ systems are proving useful in fast, portable detection of harmful agents.

Sandia Leads in Chem/ Bio Protection

The nation's preparedness for a terrorist attack or catastrophic accident involving chemical or biological (chem/bio) agents has been questioned many times in many arenas. So has our ability to prevent or respond to a terrorist attack by conventional explosives.

For nearly a decade, Sandia has been developing sensors, technologies and systems to help the nation rapidly detect dangerous materials, discover threatening activities or emerging epidemics, and mitigate the effects of any chem/bio attack. Working with other national laboratories, universities, government agencies, and commercial partners, Sandia is helping the nation achieve a new level of preparedness.

We are moving rapidly toward applications that protect our major cities. Sandia-built chem/bio protection systems are now deployed in subways, airports, seaports, sports events, and at other large venues. Every part of Sandia contributes to this effort. Our nuclear weapons programs contribute much of the basic science and engineering, as well as rapid prototyping and advanced manufacturing. Many sensor programs came from our nonproliferation and assessments programs.

The MicroChemLab™ is one example of how many advanced technologies are developed into a system that will help

"While observers are sharply divided over how much real progress is being made, the political will and technology now exists—and that's a huge improvement.

On May 12, a simulated explosion in Seattle and the revelation of dangerous germ-warfare toxins in Chicago kicked off a $16 million exercise to test America's first responders and emergency personnel. Thousands of firefighters, police, hospital workers, and others from dozens of federal, state, and local agencies took part. Officials hope lessons learned from the event will help all levels of government better understand how to deflect a terrorist attack using weapons of mass destruction."

—Business Week, May 13, 2004

protect the nation. Until recently, systems for gas-phase chemical analysis required racks of electronic equipment and a laboratory-scale chromatography instrument. Sandia developed a MicroChemLab™ to shrink this equipment to three microfabricated components: membrane preconcentrators, etched gas chromatography channels, and integrated surface acoustic wave modules. All the component parts and all of their linkages have been fabricated on a single monolithic silicon chip rather than of mixed and diverse materials, ensuring that standard microelectronic and micromachining processes can be used.

Our derivative Chemical Warfare Agent detectors are working today under demanding real world circumstances at San Francisco International Airport. The MicroChemLab™ Bio Detector System has been used to identify biotoxins such as ricin, staph B, and botulinum. It is now enabling identification of viruses and bacteria using protein signatures. We have demonstrated that the Bio Detector System can be used to acquire unique signatures from viruses, and we developed methods to ensure that these signatures are reproducible and robust.

The MicroChemLab™ chem detector system identifies chemical warfare agents and toxic industrial chemicals.

Last year the Department of Homeland Security (DHS) initiated a project to create a broad-spectrum bioagent detector that is portable and easily concealed. In collaboration with Lawrence Livermore National Laboratory, the BioBriefcase detector will use the Sandia MicroChemLab™ platform with three analysis trains: DNA analysis to identify bacteria and viruses; immunoassays to identify bacteria, viruses, toxins; and protein signatures to identify toxins. The BioBriefcase will collect and detect samples in a stealthy and easily deployed manner, functioning as a portable laboratory, providing quick turn-around between sample analysis and responsive action.

Other advances in chem/bio detection

Basic steps in the detection of natural or terrorist pathogens in water are fast and powerful separation and concentration steps. Sandia scientists have demonstrated a technique—insulator-based dielectrophoresis—that could replace lengthy centrifugation and filtration and can be automated, miniaturized, and scaled up. Using microchannels with etched insulators, the technique separates live from dead bacteria in less than one second, and also differentiates a number of bacteria species.

The AURA (Advanced UV Remote-Sensing Applications) ultraviolet laser-induced fluorescence LIDAR (LIght Detection And Ranging) payload, miniaturized for deployment on an unmanned aerospace vehicle, has successfully detected a variety of biological warfare agent simulants. Sandia also developed a new ground-based system to provide advanced warning of

biological weapons threats and focused on both military and homeland security applications. The system automatically scans a 90-degree wedge of sky once every 30 seconds with ultraviolet laser pulses. Work continues on performance upgrades that support future military needs.

Seaport and border security

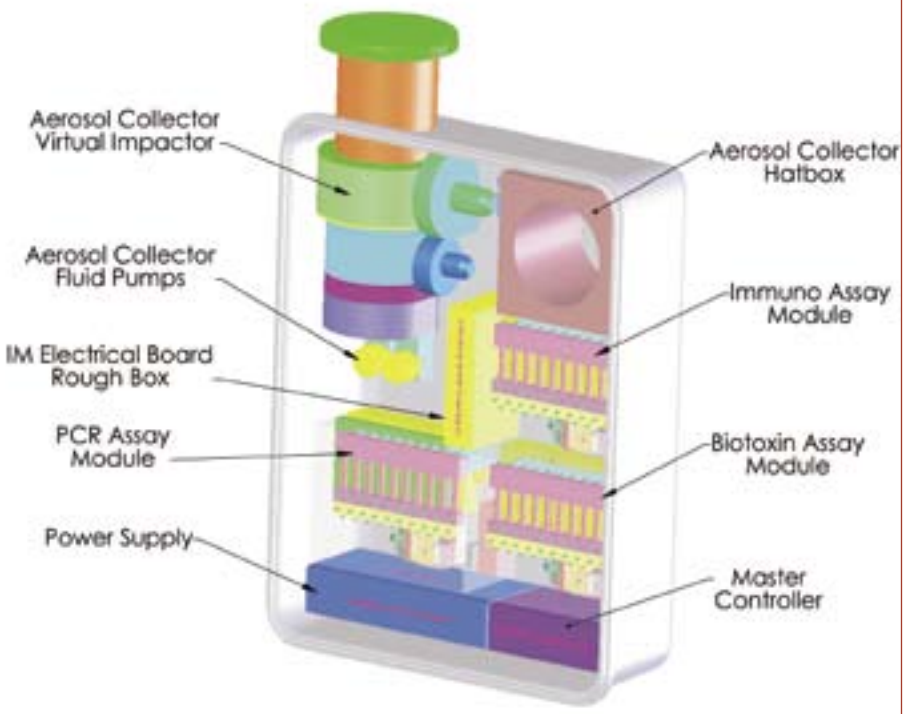
Ships and ports are terrorism's new frontier

"It is one of the most heavily-guarded checkpoints on the border between Israel and the Gaza Strip. Security is so tight at Karni that goods are transferred from trucks parked back-to-back to prevent smuggling.

But despite those precautions, a truck carrying two suicide bombers left the border crossing into Israel at about 2 o'clock in the afternoon of March 14 headed for the deepwater port of Ashdod, about 40 kilometers south of Tel Aviv. By 3:30 pm, the truck had arrived at the port, one of Israel's busiest. About an hour later, the terrorists detonated their explosive devices, killing ten and wounding 18. A local police chief speculated that the real target may have been nearby chemical storage tanks, but that the bombs went off prematurely.

A subsequent investigation solved the mystery of how the terrorists eluded security forces: they had hidden themselves in a secret compartment of a steel shipping container.

—MSNBC, June 21, 2004



Key modules of joint Sandia-Lawrence Livermore National Laboratory BioBriefcase Detector.

Examples abound of the dangers of modern transnational terrorism and the contributions of Sandia expertise in diminishing or eliminating them. From brute force measures such as hefty concrete covers over nuclear material stores in Russia to sophisticated worldwide systems with vast arrays of sensors, Sandia has engineered first- and second-lines of defense. In response to new threats posed by potential terrorist actions against our seaports and border crossings, Sandia is again answering a new call for exceptional service.

Sandia is helping the nation's two largest ports develop the systems and technologies to better secure these vulnerable targets, while minimizing the economic impact on the global web of transportation.

More than nine million shipping containers, and 95 percent of all freight from overseas, enter the nation through our 361 ports. The ports of Los Angeles and Long Beach account for 30 percent of the containers. The port of New York accounts for another ten percent. The top 30 ports account for all but 0.5 percent of containers. All ports are under the stresses of time and money to meet the requirements of the 2002 Maritime Transportation Security Act, which legislated measures to strengthen our defenses.

Sandia is the security consultant, systems integrator, and project manager for the Operation Safe Commerce (OSC)-Pacific program with the ports of Los Angeles and Long Beach. The OSC-Pacific program is an international partnership that involves the public sector (ports of Los Angeles and Long Beach, U.S. Customs, U.S. Coast Guard, and Sandia) and numerous technology providers in the private sector.

Security is monitored from overseas points of origin to final U.S. destinations through the ports of Los Angeles or Long Beach. Sandia analyses support the identification of cost-effective means of addressing the most significant security problems of ports and their supply chains including terrorist attack, illegal immigration, drugs, and nuclear smuggling.

Sandia is deploying its Sensor for Measurement and Analysis of Radiation Transients (SMART) technology to help screen containers. SMART not only detects radiation, but identifies specific isotopes, a critical technological advance in efficiently determining threats. The SMART technology is now being deployed at land border crossings as well as at sensitive facilities.

A miniSAR and other sensors

In Afghanistan and Iraq, Sandia engineered and manufactured systems, such as synthetic aperture radars (SAR), provide extraordinary impact on the conduct of battle. Only a few SARs, deployed worldwide, can quickly and radically change the balance of field operations.

Development of SAR shows how Sandia's strengths are being applied to pressing military needs. SAR is a computed imaging technique, like medical tomography, relying on a "synthetic aperture" created by flying the small antenna above a target area. Sandia's SAR was originally seen as a day/night, all-weather imager. Sandia has made two significant enhancements

to the imaging capabilities of SAR—coherent change detection and interferometric terrain mapping—that demonstrate SAR offers much more than just imagery—information that could not be obtained otherwise.

Coherent change detection enables viewers to detect sub-millimeter changes in a landscape over a period of time. These subtle changes—for example, footprints across grass or leaves rustling in the breeze—could have startling military and nonproliferation applications. Once considered a mapping technology, Sandia has engineered SARs into event recorders.

Interferometric terrain mapping capabilities (IFSAR) enable large areas to be mapped at very high resolutions within a day, with the maps ready by the time the aircraft lands. In addition to providing new capabilities to military planners, SAR could help map—at a precision thousands of times greater than today's maps—vast areas of the Earth that are virtually uncharted today, with a clear benefit to civilian applications such as aviation, flood control, and agriculture.

Through breakthroughs in IFSAR design, Sandia has furthered the development of completely automated terrain-mapping systems. An aircraft-based system developed for the Army, known as Rapid Terrain Visualization (RTV), can map 30-square-nautical-miles per hour, providing height data every three meters with 0.8- meter relative height accuracy—more detailed and accurate than any previous real-time system.

RTV has proven valuable closer to home, too. Recently, data collected and processed by the system have been provided to the Albuquerque Mountain Rescue Council, a volunteer search and rescue group, for two recent missions in the Sandia mountains. The RTV maps used in both missions significantly enhanced on-the-spot knowledge of the terrain, thus helping to determine the safest, most efficient routes to the subject, demonstrating a real potential to help save lives.

Sandia's engineering excellence is now pushing SAR into new realms. Once installed in sizeable aircraft, now carried by drones, the microSAR of the future, using micro- and nanotechnologies, could be carried by very small aircraft or by microsatellites. Sandia's SAR technology will be applied by General Atomics to a lighter, more reliable, and easier to maintain version of the Lynx radar system for the U.S. Army Communications Electronics Command. Lynx uses SAR to provide all-weather reconnaissance capabilities, including tracking ground-moving targets

Sandia's Rapid Terrain Visualization technology has aided members of the Albuquerque Mountain Rescue Council, like Bill Scherzinger, in two recent rescues.

A primary application for miniSAR will be aboard small unmanned aircraft like this one.

such as vehicles or human beings. According to General Atomics, the Lynx II version will deliver photographic-like images with 4-inch resolution at up to 19 miles away.

Critical infrastructure Protection

Great blackout of '03

"The biggest blackout in US history left millions without power across a huge swath of the sweltering Northeast and southern Canada yesterday, jangling the nerves of many Americans who at first feared terrorists had struck again.

The outage stranded commuters in subway trains, triggered urban gridlock, shut down nuclear power plants, and forced powerless neighbors into city streets to gather around car radios for the news that this time it was simply a mammoth malfunction."

—Boston Globe, August 15, 2003

The National Infrastructure Simulation and Analysis Center (NISAC) has become a key element in the national effort to protect critical infrastructures such as electrical power grids, natural gas and oil systems, and telecommunications. NISAC, a Sandia-Los Alamos partnership, was congressionally chartered and is being incorporated into the DHS. To identify and resolve critical vulnerabilities, NISAC is developing models and simulations of critical infrastructures, their interdependencies, and the downstream consequences of attacks. Before and following the 9/11 terrorist attacks, Sandia conducted wide-ranging risk assessments on behalf of many national agencies. Sandia security experts have traveled the country developing and applying security assessment methodologies and other risk-management tools for the nation's dams and power systems, government buildings, chemical plants, water supplies, and other potential targets. For example:

A look at our power grid from space.

- We assessed management systems and security practices of the U.S. Bureau of Reclamation, the nation's second largest producer of hydroelectric power. The analysis led to the integration of the latest supervisory-control and data-acquisition technologies at six hydroelectric projects, including Hoover, Shasta, and Grand Coulee dams. The program is now in its second phase, providing similar input for five additional dam sites. About

10 percent of America's electricity needs are provided by hydroelectric power.

- A classified assessment of nuclear power plant vulnerability was conducted in less than four months. The multilab team was engaged by the Nuclear Regulatory Commission (NRC) to carry out analyses to better understand the consequences of specific terrorist threats on nuclear plants. Two ongoing, plant-specific vulnerability assessments are refining insights gained in the initial study.

- For years Sandia has lent its systems analysis abilities to the national power grid. Labs' researchers in New Mexico and California study the security of communications between control systems, the distribution of power generating facilities and how it could be improved, and system vulnerabilities. Potential attacks on the system have long been recognized to have implications to the economy and national security.

- On request, Sandia assessed the potential impact terrorist attacks on numerous NNSA, DoD and NRC facilities. The assessment team was responsible for developing the methodology to quantify the structural response and consequence of any fires that might ensue. This endeavor brought to bear unique technical expertise, state-of-the-art computational tools, and experimental infrastructure to address a problem of national importance.

- A Sandia-Los Alamos team produced a state-of-the-art vulnerability assessment of commercial aircraft attacks on two nuclear power plants for the NRC. The project analyzed the ability of aircraft to strike specific plant locations, resulting structural and fire damage, effects on critical safety systems and core melting, the resulting health consequences, and options to mitigate the damage.

The Information Operations Red Team and Assessments program performed numerous cyber system assessments, evaluations, and vulnerability experiments for a range of prototype-through-operational systems. Customers include civilian government agencies, the DoD, industry, and critical infrastructure assets including electricity, communications, water, oil, and gas.

Sandia researchers are developing information security practices to meet the next generation of Internet security threats. The research team developed Standard Agent Architecture II/Agent-in-a-box, which has brought revolutionary advances in agent and information security. The Advanced Information System Lab's intelligent agents provide a dynamic defense for domains, a significant contribution to national security that also represents substantial commercial value for the multibillion dollar cyber security industry.

Standards and controls are vital to the predictable and secure flow of electrical power. Our programs include technologies for automatically diverting or shutting down electricity flow from grid-connected systems when an electric distribution line shuts down—an important breakthrough that encourages distributed energy systems development.

"Fundamental capabilities in Science, Technology and Engineering are an ever-more critical foundation of our nation's prosperity and security. We are in a new unstable global environment, and it will be essential for Sandia to provide solutions to the nation's most press-

ing problems. The challenges are too complex to be solved by linear extensions of our existing knowledge and too urgent to await the serendipity of the usual innovation process. As in the past, meeting these challenges requires extensive strategic partnering with the university and industrial communities and, when appropriate, other government agencies and institutions. Add a sense of urgency as catastrophic weapons and measures fall into the hands of terrorists."

Pace VanDevender
Vice President
Science, Technology, and Engineering

Making Over-the-horizon Concepts Real

A strong science, technology, and engineering heritage extends into the future

The confluence of hypothesis and unparalleled experimental facilities has been augmented by still-growing computational capabilities in many areas but especially in modeling/simulation. Sandia's traditional science and engineering processes are accelerated by ever-more powerful computing capabilities; so too are our computing capabilities strengthened and refined as we progress and tackle larger problems.

Mary Crawford tests the output of an ultraviolet light-emitting diode developed by a team that set new records for wavelength/power output.

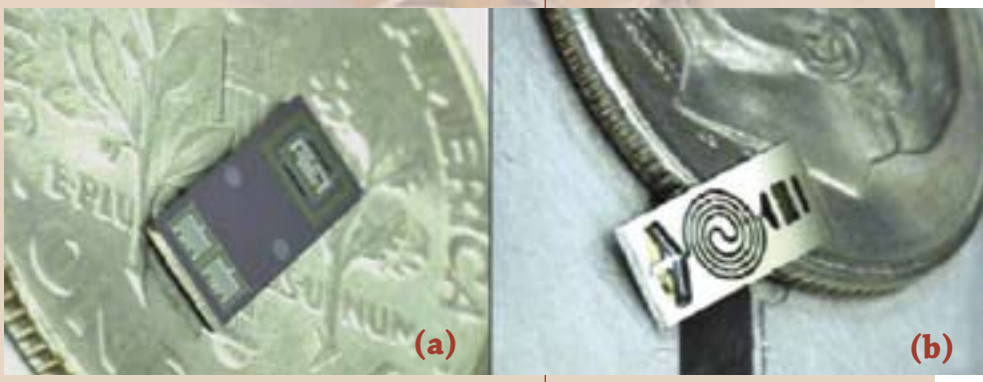
Wars for domination of the world plagued civilization for nearly 4,000 years until 1945, followed by the decades-long Cold War. Today, the threats to the nation's security and well-being are far different but equally dangerous. The science, technology and engineering programs at Sandia remain rooted in our primary mission as stewards of the nuclear deterrent to wars of global domination. We are committed to producing advances of the same magnitude to end the newer scourge of terrorism, with fundamental benefits for the nation and the world. These order of magnitudes advances occur across the spectrum of science and engineering. They may involve single scientific steps that work their way up to revolutionize whole processes, or they may be large, engineered systems with a worldwide impact. Increasingly, they are computed solutions for previously intractable problems.

Our Grand Challenges inspire our scientists and engineers to make real concepts that are currently over the horizon of today's technologies. These challenges, in fields as diverse as atmospheric studies, energetic materials, nuclear and fusion energy, and reliability studies, attract new talent and partnerships across the nation.

The impressive technical achievements of miniaturization and integration in the MicroChemLab™ demonstrate the cross-lab coordination that will occur

in the future Microsystems and Engineering Sciences Applications (MESA) complex. Production of the integrated MicroChemLab™ advances the concept of integrated microsystems by demonstrating how microscale components can be fabricated together into a single silicon chip. The state of the art of high pressure liquid chromotography was substantially advanced through a recent CRADA with Waters Corporation.

Sandia has also signed an Umbrella CRADA with HP's Imaging and Printing Group (IPG), one of HP's four business groups. IPG includes printer hardware, digital imaging devices such as cameras and scanners, associated supplies, and accessories. Their business involves many of the same technologies that are core to Sandia, including microfluidics, chemistry, materials science, and photonics. The CRADA will directly benefit Sandia's homeland security and defense missions.



Front side (a) of monolithically integrated MicroChemLab™ compared to a U.S. dime. Etching visible on the back (b) defines fluidic channels, release holes, and the spiral gas chromatograph column.

IPG hopes to leverage Sandia technologies to develop new business markets in the life sciences arena, in particular health sensing solutions, to develop new products in display devices/technologies.

Technological advances in national security—the province of chemistry, physics and mechanical engineering for most of the 20th century—now occur at a far more complex and, obversely, fundamental level. For example, to build robust microsystems, Sandia scientists and engineers soon recognized that nanoscale phenomena came into play, and had to be understood

Nanotechnologies at Sandia will be developed at a new facility, the Center for Integrated Nanotechnologies, or CINT, in a joint program with Los Alamos National Laboratory. CINT will have four areas of expertise: photonics lattices and quantum clusters; complex, self-assembling nanostructures; the mechanics of behavior at the nanoscale; and importation of biological principals and functions into nano- and microsystems.

Sandia played an integral role in helping NASA understand the underlying cause of the shuttle Columbia accident. Sandia staff conducted computational analysis and experimental studies to confirm that foam from the external tank impacted and severely damaged the wing leading edge on takeoff. More than 35 Sandians contributed to the investigation in the areas of computational fluid dynamics, aerothermodynamics, thermal analysis, impact analysis, and materials characterization. Sandia's simulations of the foam impacting the wing leading edge (illustrated here) showed the potential for significant damage, and were later confirmed by full-scale impact tests.

and exploited. Nanotechnology, in turn, required an understanding of the ways biological creations assemble and disassemble. More than ever, multidisciplinary and cross-disciplinary research will be critical to generating new insights and discoveries occurring at scientific boundaries. Following are just a few highlights from recent work at Sandia.

Understanding fundamental phenomena

Fundamental work in material sciences resolved a long-standing mystery of how the centuries-old process of annealing metals works. Annealing removes damage and defects from a shaped piece of metal, leaving tough, ductile, perfect crystals behind. Using advanced computer models, Sandia researchers performed the first full-physics simulations of a shaped aluminum substructure. They found that one in a million tiny, pre-existing crystallites grows quickly and large, supplying the nucleus for recrystallization into a cellular structure. These observations provide the basis for a new, physically based understanding of this pervasive metallurgical process.

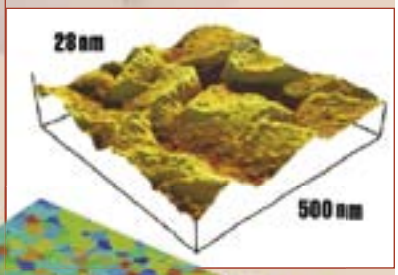
The researchers also discovered that the cell models, when plotted to a mathematical curve, compare to patterns in the expanding universe. The team is now applying their results to annealing in aircraft aluminum and automotive steel. More realistic annealing models can help industries cut costly time and prototypes from their design schedules. Eventually, engineers may use these models to control sheet metal forming in factories around the world.

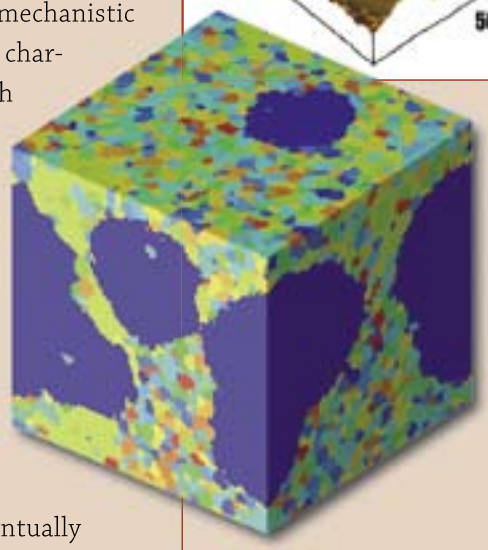
Understanding corrosion is fundamental to understanding why materials fail. We have adopted a novel approach using engineered defects and newly developed analytical techniques to unravel the mysteries of how localized corrosion initiates in aluminum. We are generating mechanistic information by comparing the characteristics of nanometer-length scale degradation processes in synthesized protective oxide structures with those in actual alloy systems. This knowledge is critical to developing predictive models of materials aging.

Quantum computing, which uses phenomena at the quantum level of physics, could eventually replace today's digital computing. The innovative materials used in these systems are so pure that the electrons remember their phase over distances of up to 100 microns. Thus they behave more like waves than like particles, and can exhibit wave interference effects, anticrossings of energy levels, and novel collective effects where the positions of individual electrons become correlated with their neighbors to form ordered, collective states.

Another fundamental discovery could lead to revolutionary quantum computing devices with logic, storage, and wiring elements that actually build themselves. Stress in mixed silicon/germanium films, grown under precisely controlled conditions, causes the spontaneous formation of remarkable nanoscale quantum dot molecules in square fortress-like shapes with highly uniform sizes. Furthermore,

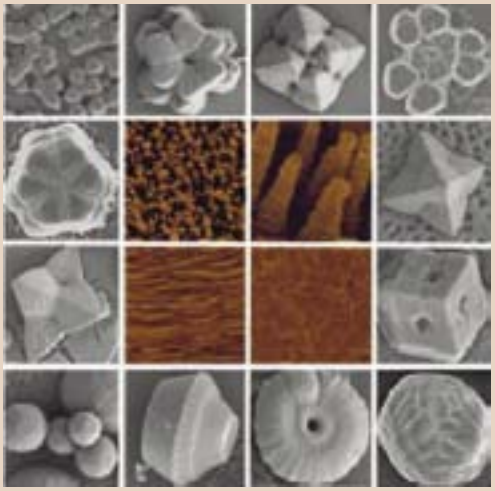
Understanding aluminum film corrosion with an atomic force micrograph.





The universe in a bent piece of metal. In a computer simulation, a few crystalline cells (dark blue) grow at the expense of their neighbors as annealing begins. When annealing is over, the substructure will be entirely consumed. The small cells in this picture are about one-fiftieth the diameter of a human hair. Their spacing pattern compares with that of expanding galaxies following the Big Bang.

a focused ion beam can selectively seed the self-assembly process, demonstrating the potential to create complex nanoscale circuits exactly where wanted.



Bio-inspired diatom-like and seashell-like zinc oxide (brown) and silicate (gray) crystals.

We have devised a general, environmentally benign, chemical-synthesis approach to build complex nanostructures that are strikingly similar to those observed in biominerals (seashells and diatoms). The key to this new approach is to control nucleation and growth events and crystalline surface chemistry. We hope this new class of nanomaterials will lead not only to applications in microdevices, sensing, energy storage and conversion, and catalysis, but will also add to our understanding of how complex biomaterials are formed.

Biological advances fight terrorism and infant leukemia

At the biological interface, motor proteins are molecular machines that enable many materials-assembly and actuation functions in living organisms, including cell division, transport of subcellular structures, and muscle contraction. Sandia is exploring the use of these active proteins to assemble and reconfigure nanomaterials in artificial systems. As a first step toward creating programmable nanomaterials, we have demonstrated that the motor protein kinesin can transport inorganic materials such as gold nanoparticles and quantum dots in lithographically patterned microfluidic channels.

Sandia scientists, working with the University of New Mexico Cancer Center, have made a significant advance in the understanding of the molecular biology of infant leukemia. By using specialized machine learning techniques, they studied and classified a large collection of microarray data of infant leukemia tissues into three distinct categories. The first two categories, environmental exposure and viral exposure in utero, were expected. However, they showed that there was another category, whose genetic markers indicated a strong correlation with abnormal stem-cell activity. This was a completely unexpected result, and the complete classification of the different types of cancers is an important step toward developing treatments tailored to an individual. This work has led to numerous patents and more importantly, has led to a large number of collaborations around the country in the field of microarray analysis.

Computational capabilities merge modeling/simulation with traditional science methodology

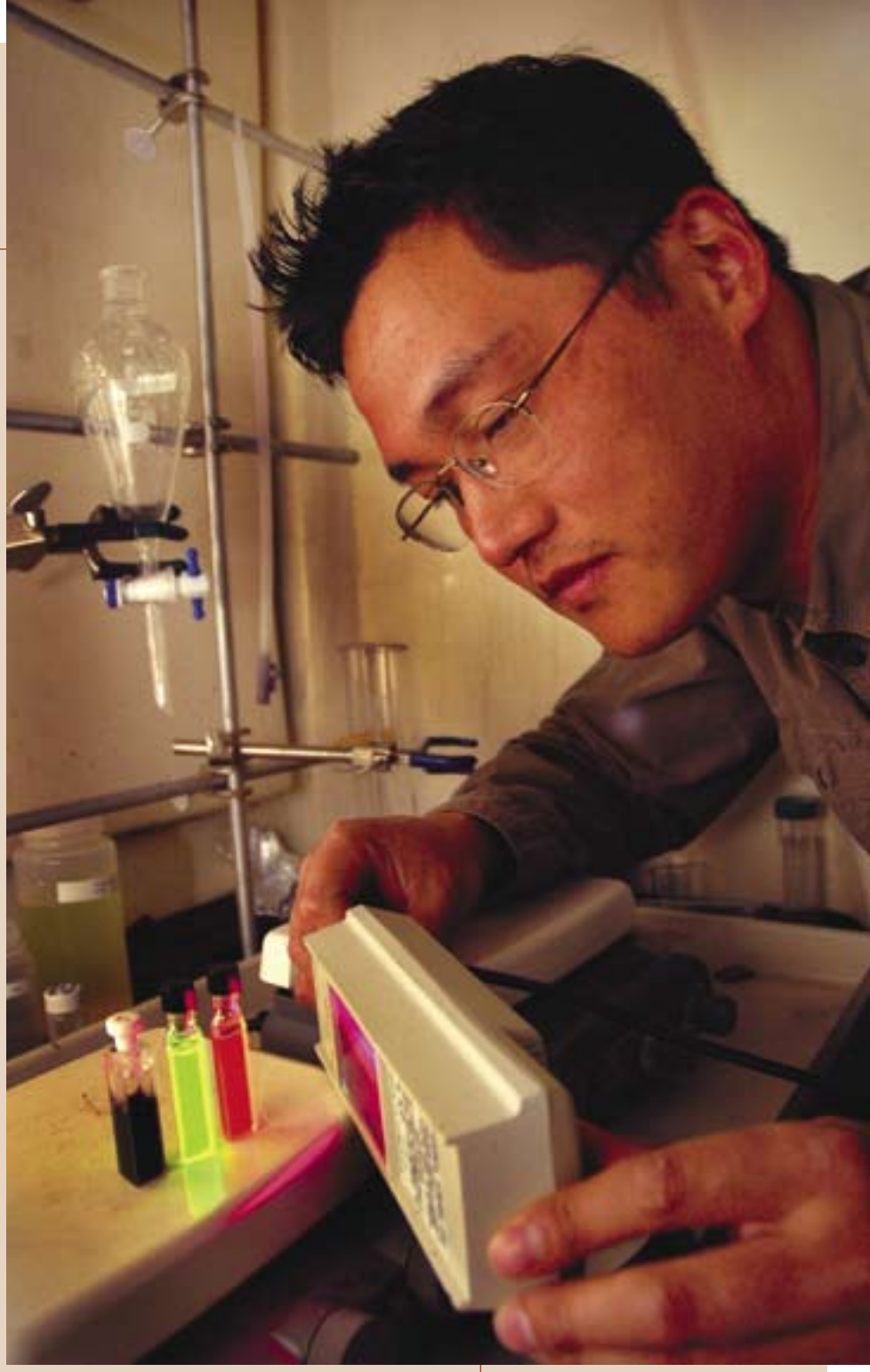
Our computational programs include the building of the 40-teraops (40 trillion operations/second) Red Storm computer; the secure and ultra-fast networking needed for collaboration within Sandia and with other labs; the visualization systems to help comprehend vast data sets, and inno-

vative and powerful software to fully use this computational power to solve real-life problems. These programs are creating and deploying the new architectures required to double computational capabilities every two years. In California we dedicated the Distributed Information Systems Laboratory, which will enable classified and unclassified local and distant collaboration, and significantly reduce development times.

Supercomputing is revolutionizing the way we approach science, and engineer and manufacture all kinds of products. Sandia's contributions, recognized by three Gordon Bell awards—the highest computer science award—are integrating the traditional theory-and-experiment methodology with high-performance computational modeling/simulation to accelerate technical progress. An example of how these enhanced computing facilities help our nation is a Memorandum of Understanding between DOE and the Environmental Protection Agency (EPA) that established an EPA-funded effort focused on leveraging Sandia capabilities to advance the biological, environmental, and computational sciences for EPA's missions. EPA will benefit from Sandia's capabilities for resolving remote sensing and gene expression array data and for speeding-up EPA's Computational Model of Air Quality.

Biotechnology for understanding and bettering quality of life includes national security

Our biotechnology programs are developing basic science and technology for understanding biological processes and harnessing these processes for national security applications. At our California site, researchers have made significant and unique contributions to the science of structural proteomics. Starting from a bare-wall 'bio' capability a little over three years ago, they are unraveling the complexities of membrane protein structures. This positions Sandia to play an important role in defense against biowarfare agents, particularly as protein-based receptors can be tuned to detect specific toxic molecules.



Hongyou Fan observes fluorescence by nanocrystals in water solution. The dark vial holds gold nanocrystals; the orange and green vials are semiconductor nanocrystals.

Work is under way to identify and learn how to exploit key strategies used by living systems to develop materials whose assembly and disassembly can be programmed or self-directed. This may lead to new nanomaterials that can be programmed for assembly, reconfiguration, healing, and disassembly. Just as the ability to direct and bound processing on the microscale via semiconductor lithography has enabled scores of electronic advancements, the ability to pattern and direct biochemically relevant molecules will open new horizons in engineering at the molecular scale.

The successful demonstration of multilevel patterning of DNA, phospholipids, proteins, and cells has been the first step toward achieving this molecular scale organization. This work supports sensor designs ultimately based upon single molecular responses.

New materials for environmental extremes

As weapon systems advance and material performance requirements are pushed to extremes, we must develop new materials to match these environmental extremes. In many cases, components can survive only if the environmental loads can be shared with a secondary, synergistic structure. Some highlights:

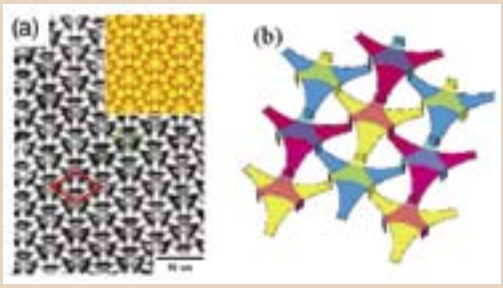
- We developed new materials with exceptional toughness that absorb energy from extreme environments and distribute impact forces broadly, preventing catastrophic failures in new weapon applications.
- We have made significant improvements in ultra-high-temperature ceramics for use in advanced thermal protection systems. These materials melt above 3,200°C and are strong and resistant

Sandia's Red Storm computer was under construction in late 2004.

Sandia's $37.9-million Distributed Information Systems Laboratory in California will enable development and deployment of new technologies for the nuclear weapons complex. The lab is a critical element in a strategy to develop and deploy high-performance modeling and simulation capabilities.

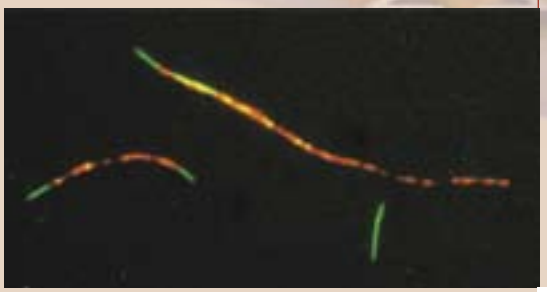
to thermal shock. These materials are needed to manage the 2,000°C temperatures expected from atmospheric heating of maneuverable, hypersonic vehicles that are proposed for a number of defense, surveillance, and space missions.

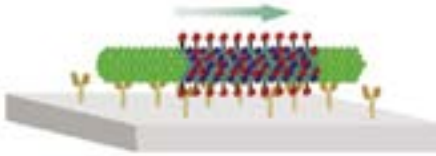
- Electronic and mechanical parts often contain interfaces between dissimilar materials. These interfaces often crucially affect overall materials strength of a part. We have discovered a new structure for these interfaces, with perfect metal on both sides separated by a single layer of specially arranged metal atoms. This structure promises to provide an extremely strong shear-resistant bond.



(a) An experimental scanning tunneling microscope image of the nanoscale dislocation array with a theoretical (yellow) simulation of the structure. (b) A schematic of the perfect array of nanoscale dislocations that are interwoven to lock the two bulk metals together.

- Friction and wear are major concerns in the performance and reliability of micromechanical (MEMS) devices. While many friction-reducing materials are available, it is difficult to apply uniform coatings to the intricate three-dimensional (3-D) structures typical of MEMS devices. We have developed a novel coating process, called atomic layer deposition, which uniformly coats shadowed surfaces, such as gear hubs and teeth with wear-resistant or lubricating films.



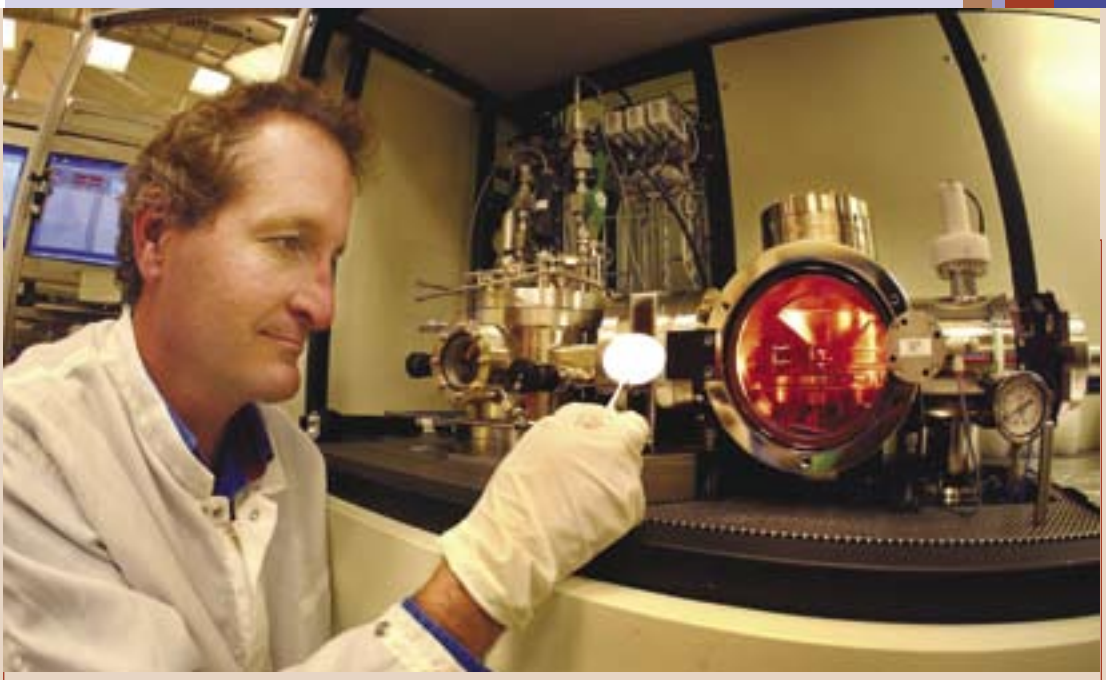


A simplification of a self-assembled monolayer containing the motor protein kinesin propelling a microtubule shuttle carrying nanoparticle "cargo." The image is from a fluorescence microscope movie of the transport by kinesin of quantum dots.

New technologies in photonics and electronics for lighting efficiency, fighting terrorism

In past research, Sandia's photonic lattice showed the ability to bend light with no loss of efficiency. Now a microscopic tungsten lattice—a filament fabricated with an internal crystalline pattern—has the potential to transmute infrared energy into the frequencies of visible light. This would raise the efficiency of an incandescent electric bulb from five percent to greater than 60 percent, greatly reduce the need

Martin de Boer (right) and Alex Corwin investigate friction at the microscale.



Andy Allerman is growing new UV LED materials that operate at shorter wavelengths, making it possible to build miniaturized devices that can detect biological agents, perform covert communications, purify water, cure polymers and other chemicals, and decontaminate equipment.

for excess electrical generating capacity, and reduce the costs of electrical lighting. The advance also opens the possibility of increased efficiencies in thermal photovoltaic applications.

Our breakthrough in deep ultraviolet solid-state, light emitting diodes (LEDs) has led to large increases in output. These LEDs have been used in demonstrations of bio-agent detection and a non-line-of-sight communication system. Further development could enable water purification, decontamination, and thin-film curing.

Each crystal for terahertz lasers takes approximately 17 hours to grow in a 175-step process on this 10-foot-long, seven-foot-high, molecular beam epitaxy machine.

With the Massachusetts Institute of Technology, we have achieved world-record long-wavelength lasing from quantum cascade lasers. We have generated wavelengths as long as 141 microns (frequency >2 TeraHz) and record operating temperatures in this regime (137K pulsed and 93K continuous operation). TeraHz spectroscopy has potential for rapidly identifying chemical and biological agents and for imaging applications. Sandia is one of only three laboratories worldwide that has demonstrated the sophisticated compound semiconductor growth required for these structures.

Z Machine produces first confirmed fusion neutrons

We continue to leverage Sandia's and other leading institutions' expertise and successes in pulsed power, high energy density physics, and material dynamics for the nation's pressing issues in weapon science, thermonuclear fusion energy, and national security applications of high-power and high-power/density beams.

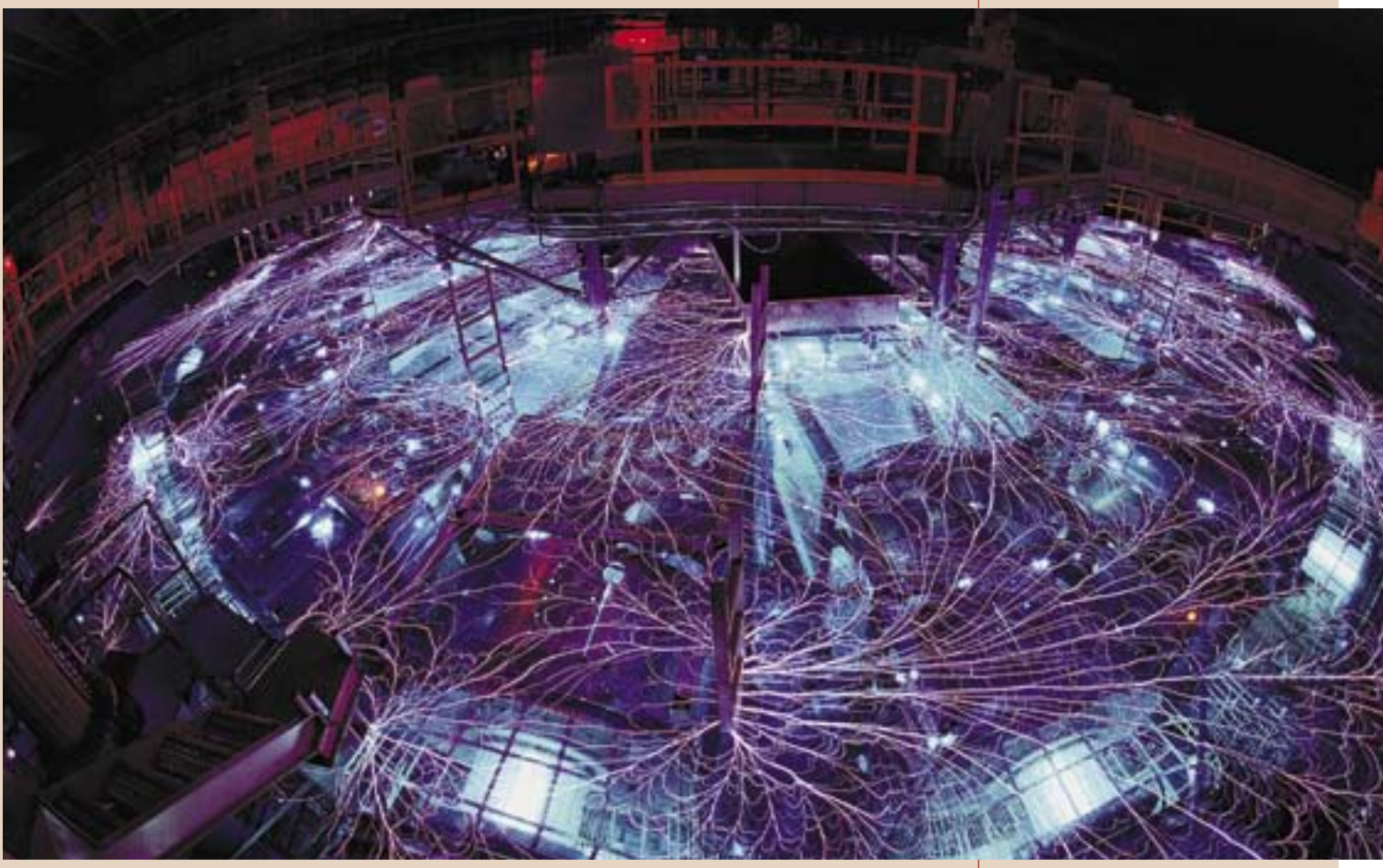
Inertial confinement fusion (ICF) capsule implosions in the Z machine have produced the first clearly measured neutrons

and X-ray images of imploded fuel symmetry. We confirmed that deuterium fuel reached temperatures found at the center of the sun (about 11 million degrees C.). Capsules have been imploded to less than 1/2000 of their original volume, implying a radiation-drive symmetry that scales to within approximately a factor of two of high-yield fusion requirements. Uniform 3-D compression is an essential step in creating controlled nuclear fusion.

We completed a unique concept for using Z-pinch fusion technology to generate electrical power. Using advanced manufacturing technology, critical components are remanufactured every 10 seconds to support a high-yield fusion pulse generated by a driver based on Sandia's Z accelerator technology. This radically different, yet simpler, approach to fusion energy will compete with other fusion concepts.

A Sandia team, with assistance from Ktech and Bechtel, has developed a containment system that can shocklessly compress materials to greater than 1.5 million atmospheres of pressure (one-third the pressure at the center of the earth) using Z, then hermetically seal the chamber in 10 microseconds. Six shots have demonstrated the system's reliability to contain hazardous materials, including highly radioactive ones. This system enables revolutionary dynamic materials studies.

Sandia's Z pulsed-power generator, the most powerful X-ray generator on Earth, has become nationally recognized for dynamic materials research.



Sandia Supports Innovative Small Businesses

The New Mexico Small Business Assistance program allows Sandia to use a portion of its gross receipts taxes paid each year to provide technical advice and assistance to small businesses in the state. During 2003, Sandia received $1,796,000 million in tax credits, 64 percent of which went to small businesses in rural New Mexico and 36 percent to small businesses in Bernalillo County, where Sandia's main facility is located. Technologies and technical assistance come from virtually all areas of Sandia's expertise. Following are some examples of this assistance:

- **Applied Thermal Systems and Beer Engineering** perform research and development in the areas of systems engineering, complex robotics, automation systems, networks, and software development. Sandia's assistance has provided the two companies valuable experience with the capabilities and limitations of commercially available robots through work on a pick-and-place robotic work cell project.

- **Enterpulse, Inc.** is a research and development company in pulsed power specializing in automotive ignition, specifically spark plugs. Sandia assisted in the development of a new spark plug that has the potential to be 10,000 times more powerful than current spark plugs. This assistance allowed Enterpulse to overcome a major hurdle in development and expedited the fabrication process.

- **Fast Ditch™** in Vallecito is in the commercialization stage of producing a unique corrugated plastic liner for earthen ditches to reduce the loss of water that occurs with unlined ditches. Based on burn testing provided by Sandia, new liners will be designed to minimize the surface area of the ditch that is exposed to weed burning.

Nickel Brand Software in Moriarty helps bridge the gap between historical (hot iron branding) and current animal identification methods. Working with the Space Alliance Technology Outreach Program, Sandia has demonstrated a recognition software that is compatible with scanners and hand-held computers for ease-of-use on the range.

The Cumbres & Toltec narrow gauge steam railroad remains a major tourist attraction in Northern New Mexico long after its working life would otherwise be over. Recently Sandia researchers helped the Cumbres & Toltec repair shop with some critical metallurgical analysis. The railroaders needed to know the composition and other properties of certain metals before doing any welding for restoration and repairs.

- **Last Chance Water Company** in Otero County is a water management company representing landowners of the Salt Basin. The company manages water resources and establishes the water supply available to potential markets. Sandia is assisting in the identification, quantification, and characterization of a new and renewable water source within the state.

- **New Mexico Chile Taskforce** in southern New Mexico is a partnership of chile growers, producers, and researchers created to apply science and technology to improving productivity and ultimately enhance New Mexico growers' competitiveness in a global market. Sandia has provided a remote system to evaluate efficiency of automated chile cleaning and destemming machines now under development.

- **PEMCO** in Farmington is one of only five companies in the United States that provides repair and refurbishment services for well drilling and servicing rigs. Partnering with NM Manufacturing Extension Partnership, Sandia has helped PEMCO meet current industry standards and requirements for management and manufacturing practices and techniques. That translates to about $150,000 in annual cost savings.

- **STAR Cryoelectronics** in Santa Fe develops, manufactures, and markets ultra-sensitive Superconducting Quantum Interference Device (SQUID) sensors and advanced PC-based SQUID control electronics products worldwide. With Sandia's assistance the company modified a process and eliminated defects that were causing device failures.

Sandia also provided assistance through the Small Business and the Mentor Protégé program to 12 of the 40 start-up companies included in this year's *Albuquerque Journal's* Flying Forty—an annual list of New Mexico firms producing the most revenue or greatest revenue growth. The companies include: Emcore, Ktech, CVI Laser, Holman's, Optical Insights, TMC Design, MesoSystems Technology, Team Specialty Products, Optomec, Stolar Horizon, Management Sciences, and TPL.

Partnering for a Strong America

Sandia's industry and university partnerships are key to our mission of providing cost-effective scientific and engineering solutions to meet national needs in nuclear weapons and related defense systems, homeland security, energy security, and environmental integrity—and to address emerging national challenges for both government and industry.

Since its inception in the early '90s, Sandia has executed more than 580 CRADAs, 930 non-federal entity agreements, 940 commercial licenses to Sandia-developed intellectual property, and more than 2,800 small business assistances.

CRADAs and other types of Partnering

Umbrella CRADAs continue to be the preferred contractual instrument for implementing strategic and enduring relationships. At least 15 such agreements have been executed with industrial partners and recently Sandia signed CRADAs with Toyota, FM Global, Catalytic Distillation Technologies, and American Superconductor Corporation.

Sandia's relationship with Lockheed Martin, the Shared Vision program, serves as a model for strategic partnerships. This highly successful collaboration is applying technologies and systems developed by both organizations to the challenging defense and security threats of our changing world. Shared Vision projects in microelectronics and photonics, sensors, situation and decision support modeling, cognition, nanotechnology, biotechnology, anti-tamper devices, and logistics support have offered applications for both government and industry.

Award-winning partnerships

The R&D 100 Awards, which annually recognize significant advances in technology, are a measure of Sandia's success in developing technologies that impact the nation's security and prosperity. Since the award's inception, Sandia has won 70 R&D 100 awards. This year, Sandia was involved with two award-winning technologies.

One award is for a new process of growing gallium nitride on an etched sapphire substrate, called cantilever epitaxy, which promises to make brighter green, blue, and white LEDs—solid state lighting. The cantilever epitaxy program at Sandia was part of an internal three-year, $6.6 million Laboratory Directed Research and Development Grand Challenge. Funding also came from a grant from the DOE Office of Building Technologies for a collaborative project with Lumileds Lighting, a joint venture between Agilent Technologies and Phillips Lighting.

The second award was for the creation of the software framework and library Trilinos. Trilinos is part of a broad effort on the part of national laboratories, industry, and academia to establish high-fidelity computational modeling and simulation as an approach to engineering and scientific understanding so it becomes an equal partner with the most basic approaches of theory and experiment. Trilinos provides a common enabling solution to one of the most difficult problems in creating

Christine Mitchell looks through a substrate that was made for the new cantilever epitaxy growth process.

these simulations: How can one solve the massive and complex systems of equations required, and do so in a way that "scales" all the way from laptop computers to the most powerful and complex parallel computers in the world? Trilinos offers what is probably the largest and most complete scalable solver capability in the world, and it is available to the public.

A commitment to university programs

University partnerships are a critical element in achieving the goal of making Sandia the laboratory that the U.S. turns to first for technology solutions to the most challenging problems that threaten peace and freedom for the nation and the globe. Sandia has traditionally contracted for university research to expand its science and technology base to assure the performance of its nuclear weapons, but many partnering opportunities exist in other Sandia mission areas.

Today, Sandia partners with key universities to achieve three major objectives: conduct world-class science, hire world-class scientists and engineers, and develop strategic collaborations in focused research areas. In Fiscal Year 2003, Sandia invested about $21 million in joint research projects with universities. We worked with 109 universities and had about 500 active contracts with them. Sandia also devotes about $15 million a year for graduate student support and university and science outreach.

Two Massachusetts Institute of Technology postdoctoral students have been selected as the first recipients of the President Harry

S. Truman Research Fellowship in National Security Science and Engineering at Sandia. Truman Fellowship candidates are expected to have solved a major scientific or engineering problem in their thesis work or have provided a new approach or insight to a major problem, as evidenced by a recognized impact in their field.

The Sandia Campus Executive Program provides a framework for Sandia to focus our research goals and helps us create the 21st-century workforce needed to perform the technical jobs crucial to fulfilling our national security mission. Sandia executives, acting in the role of ambassadors, are paired with top university officials (usually deans of engineering) at schools that have synergistic research interests and capabilities with Sandia. The campus executives and their teams visit their assigned universities once or twice each

year, serve on university advisory boards, and attend special events. They actively support placing students in the numerous Sandia programs. Sandia partners with universities on numerous research projects, some also involving other government or industrial partners.

Since its inception in 1998, the SS&T Park has been widely recognized as a model for public/private partnerships around the country.

Sandia Science & Technology Park

The Sandia Science & Technology Park (SS&TP), a 200-acre, technology community located adjacent to the Labs in Albuquerque, continues to grow. Sandia serves as the anchor to the park, offering companies access to scientists, engineers, technologies, and cutting-edge facilities. Among the past year's success stories:

- Ktech Corporation and its 170 employees, a Sandia strategic partner, moved into a new 84,300-square-foot building in the park.
- Sandia's Controller and Pension Plan Management Center moved into a new 25,457-square-foot building, Innovation Center, in the park.
- Sandia's SS&TP program office won both a Sandia Employee Recognition Award and a Gold President's Quality Award for mangement of the park.
- Heel, Inc. opened a new 52,546-square-foot building, housing corporate offices and production facilities. The firm currently employs 70 people, with growth potential to 150 by 2010.
- New Mexico Senator Pete Domenici spoke at a ceremony marking a major upgrade to the park's fiber optic network. The Department of Commerce's Economic Development Administration presented a check to the park for $750,000 at the ceremony to purchase networking and switching equipment for the network.

Improving the quality of our nuclear deterrent

"Traditional deterrence rests on our ability to launch a devastating counter-strike against any country that uses weapons of mass destruction against America, its allies, or deployed forces. Such measures worked against the Soviet Union, whose leaders were rational and risk-averse, but they may not deter rogue states whose leaders are indifferent to their people's welfare. Iraq, Iran and North Korea do not need long-range missiles to intimidate their neighbors; they want long-range missiles to coerce and threaten more distant countries in North America and Europe. The United States has adopted a multi-faceted approach to counter this threat so that rogue state leaders cannot hope to blackmail America from protecting its interests, including commitments to its allies. Our first line of defense is to maintain a robust conventional and nuclear deterrent."

—William S. Cohen,
former U.S. Secretary of Defense,
Essay 2003, Terrorist Watch

Kevin Eklund examines nose cone of B61-11 weapon

"Sandia, with its unique heritage and capabilities, is leading revolutions in the theory and practice of science, engineering, and manufacturing to meet transformational challenges. Only the most advanced and failsafe technologies, processes, and validated systems fulfill our responsibilities to the nation to ensure the safety, security, and reliability of our nuclear arsenal. For the future we are investing in new technologies, such as microsystems, as the cornerstone of 21st-century weapons development. Ultimately, our nuclear

deterrent is supported by the scientific and technological capabilities of Sandia's people to develop engineering solutions with the highest degree of confidence for our national security problems."

Tom Hunter
Senior Vice President
Defense Programs

The U.S. nuclear weapon stockpile requires exact engineering and the integration of nuclear weapons with their delivery systems. Sandia has a key role in assuring that the nation's nuclear deterrent remains strong through its efforts in maintaining the nuclear stockpile and in advancing technologies that can be implemented in the current and future nuclear arsenal. Our role as the system integrator for the complex includes the very important role of assuring that our systems are sure (safe, secure, and reliable). Our emphasis on weapon surety spans activities associated with surveillance through development of new technologies and strategies to expand the scope of surety to meet current and future threats.

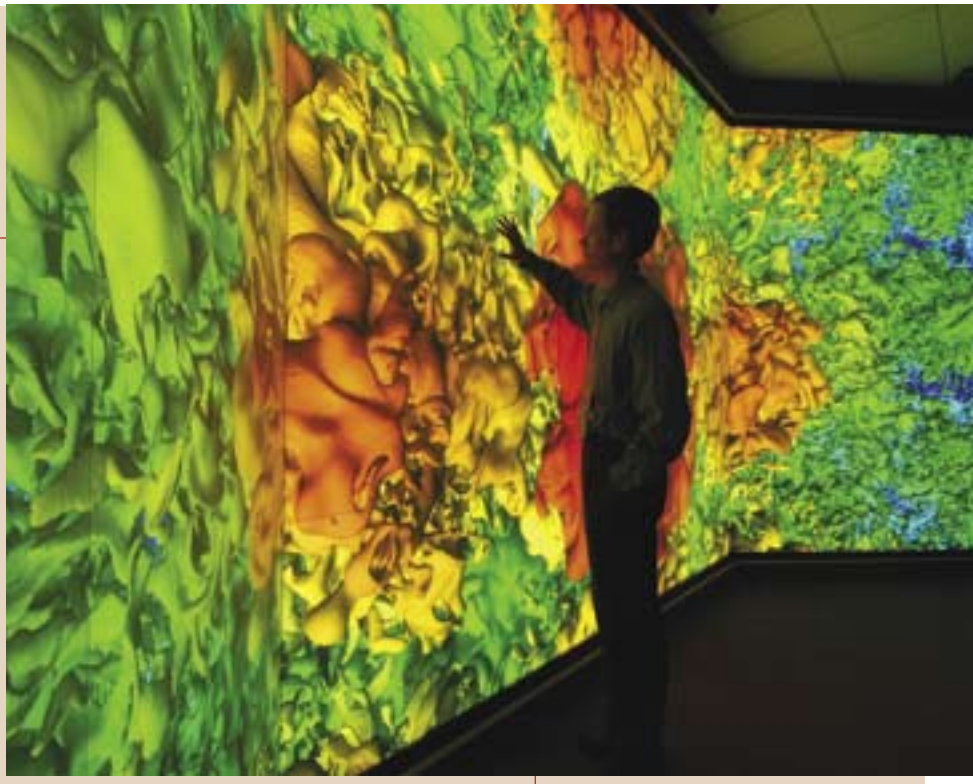
Tom Hunter speaks at spring kickoff for Sandia's $118-million Test Capability Revitalization project. Among projects started in 2004 is a state-of-the-art Thermal Test Complex to support fire science research.

Sandia, in collaboration with two NNSA physics laboratories, is sustaining the nation's capability to maintain existing nuclear deterrence capabilities or to develop--should U.S. policy dictate--new nuclear deterrence options for national defense. Our focus remains on the non-nuclear components and subsystems. Sandia researches, designs, and develops more than 90 percent of the components of all modern nuclear weapons. This past year, we investigated enhanced surety options that would supplement deliver-system performance for cruise missiles. Additionally, the desire to hold at risk hardened, deeply buried facilities has required Sandia to explore technologies that may be needed in the future to survey the very severe mechanical and shock loadings associated with penetration events. These studies have included developing approaches to ruggedize arming, fuzing, and firing subsystems. As part of these efforts, we have improved our understanding of penetration mechanics, have explored new materials options for penetrator systems, and have evaluated alternative delivery systems, such as cruise missile platforms.

With our large-scale testing facilities, validated modeling/simulation capabilities, and advanced manufacturing technologies, Sandia is uniquely equipped to handle these multi-discipline challenges.

Improving our test facilities

Our laboratory and large-scale testing facilities are unparalleled, and we are investing to maintain and improve them.



Rob Leland studies a complex materials interaction shown as a computer simulation in Sandia's visualization corridor. Computer modeling and simulations like this one are becoming integral to understanding all types of complex phenomena in science and engineering.

Construction of the first phase of the $118-million Test Capabilities Revitalization (TCR) line-item construction project is under way. These facilities are needed to support the development and qualification of non-nuclear weapons components for the nuclear arsenal. TCR includes facility enhancements and new diagnostic acquisitions; these state-of-the-art capabilities are slated to be fully operational by 2009.

Phase 1 of TCR will revitalize the Aerial Cable Facility (ACF) and construct a state-of-the-art Thermal Test Complex (TTC). The TTC will support ongoing fire-science activities needed to better understand the performance of engineered systems when subjected to accidental fire conditions. Revitalization of the ACF will be completed in time to support critical weapon surveillance. TTC will support the W76 and W80 life-extension qualification efforts. We are creating an infrastructure to support our new instrumentation and data demands. Safety, security, and data acquisition and control will all be improved in the new design. The improved quality of the data enhances confidence in the tests.

Phase 2 of the project, scheduled to begin in 2005, involves revitalizing the 29-foot and 35-foot centrifuges, the 10,000-foot sled track, the mechanical shock facility, the vibration and acoustics facility, and building a new 67,000-square-foot Experimental Sciences Complex, which will provide laboratories for experimental discovery, phenomenology quantification, and model validation.

In the past year, Sandia made many significant improvements in everything from exploiting basic scientific discoveries to improving quality at every level from component manufacturing to systems engineering. Management excellence, a Sandia hallmark for decades, is built on continuous improvement of all processes, from technical business practices to contributions to efficient worldwide command and control systems.

Improving our assessment capabilities

Sandia Director C. Paul Robinson recently conveyed to the Secretaries of Energy and Defense his ninth annual assessment of, and confidence in, the continued safety and reliability of the U.S. nuclear weapon stockpile. The two secretaries integrate assessments from several sources into an annual stockpile certification statement to the President. Our technical staff supports these actions with thorough work throughout the year to maintain the stockpile and to assess its continued capability. Sandia's Independent Surety Assessment teams and Annual Assessment Peer Review teams provide red team review of the assessments and have provided ad-

ditional action to strengthen our technical basis supporting these assessments.

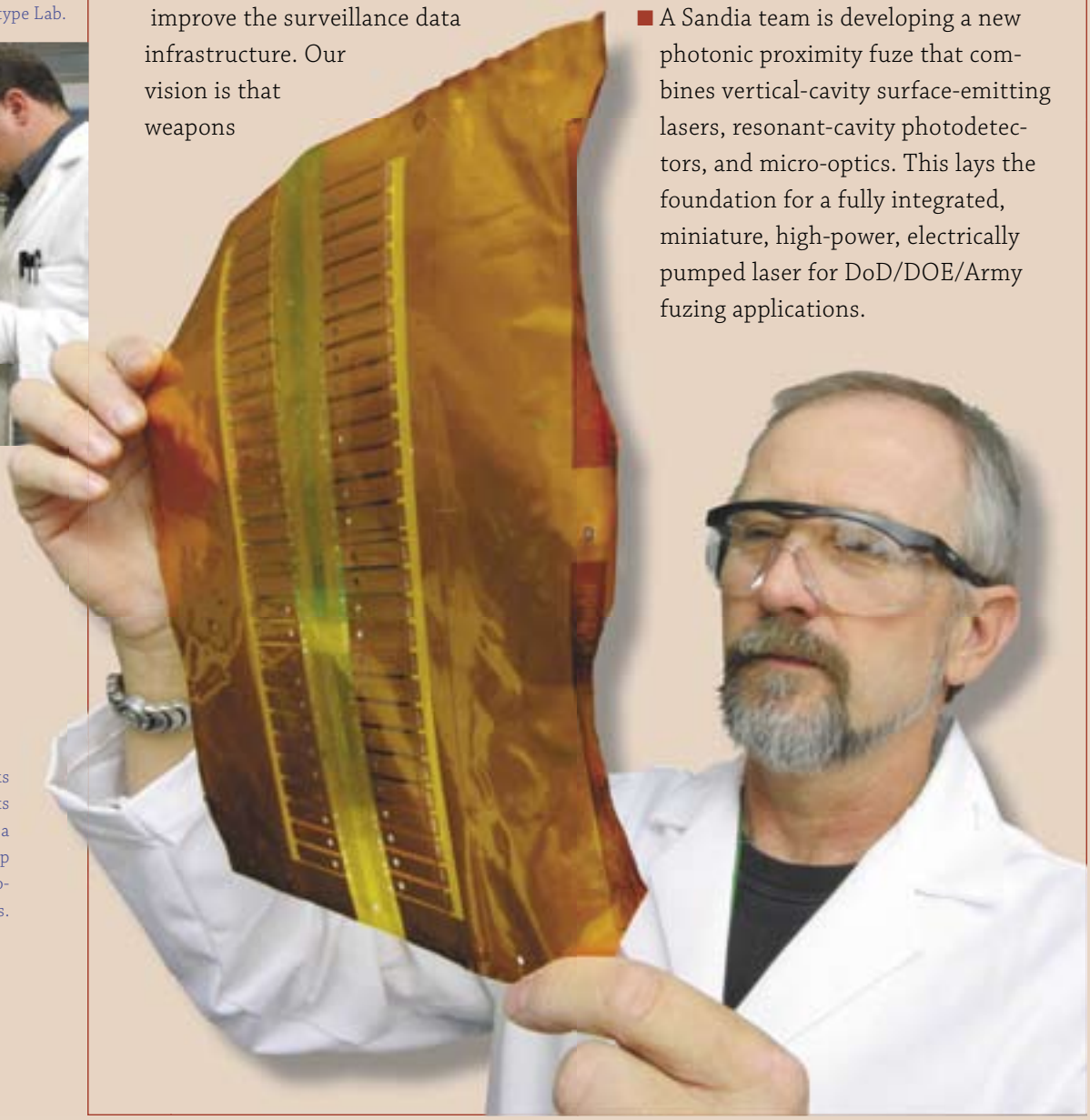
In order to bring efficiency to our nation's nuclear weapons program, Sandia strives for shared designs, components, and test parameters, as well as improvements that impact the entire arsenal rather than one system. Below are highlights of these efforts.

- We began a three-year program to improve the surveillance data infrastructure. Our vision is that weapons engineers will have timely access to accurate, easily understood, and complete data to analyze the health of the stockpile.

- Sandia successfully tested the first wideband data link during a flight test of a W87 reentry vehicle, providing an unprecedented amount of data. This vehicle was the most sophisticated yet developed for a flight test at Sandia.

- A Sandia team is developing a new photonic proximity fuze that combines vertical-cavity surface-emitting lasers, resonant-cavity photodetectors, and micro-optics. This lays the foundation for a fully integrated, miniature, high-power, electrically pumped laser for DoD/DOE/Army fuzing applications.

Todd Barnett inspects printed circuit board layers during the fabrication process at Sandia's Electronic Prototype Lab.



Jerry Inman checks flexible foil circuits used as part of a process to develop new weapon explosive devices.

In a tunnel 962 feet below the surface of the Nevada Test Site, Gene Ormond, a member of the Nevada Projects Team, prepares the cathode cover of the Sandia-designed, high-intensity flash X-ray system for weapons certification.

- Many photonics developments have been spurred by the pursuit of optical ordnance, especially safing, arming, and firing mechanisms, as well as switches. Optical actuators cannot be confused by electronic countermeasures or triggered inadvertently by stray electrical pulses such as lightning. These miniature parts are more robust in hostile environments than the conventional parts they will replace.

- Sandia's Code Management System (CMS) revamps all command and control systems for nuclear weapons to the highest encryption and security standards. The CMS for the weapons in Europe was completed in 2001, and CMS is now being tailored for the weapons in the continental U.S.

- Sandia conducted experiments that showed how mission surety is improved using Mission End-to-End Command and Control, which enables the weapon to intelligently respond to unexpected threats and take commands from humans via satellite communications.

- Nuclear weapons must withstand the many severe stresses. The Advanced Radiographic Technologies program has successfully developed and is deploying a twin-axis flash x-ray radiographic probe underground at the Nevada Test Site for sub-critical experiments. The advanced accelerator and X-ray sources developed for this mission are being extended in close collaboration with the United Kingdom's Atomic Weapons Establishment (AWE), Bechtel-Nevada, and Los Alamos to address both NNSA and AWE future radiographic needs.

- We have successfully demonstrated a novel microsystems-based acceleration switch that can sense the unique environments associated with weapon re-entry. The Environmental Sensing Device is fabricated with advanced processes developed or refined at Sandia. More than 20 prototype units have been

successfully fabricated, packaged, and tested. The project represents a development effort that could result in the first Sandia-designed microsystems device introduced into the enduring stockpile.

- A partnership between Sandia and the NNSA's Kansas City Plant has successfully created science-based processes, models, and methodologies that will allow commercial off-the-shelf microsystems components to be used in War Reserve applications with high confidence.

- We led a joint effort with the DOE and the Air Force to finalize the System 2 interface specification, which defines the digital interface between aircraft and nuclear weapons. Unique analog devices are replaced by military standard digital messages. Weapon designers can now implement advanced operational concepts. The aircraft benefits from standard electrical interface signals and test equipment.

- Sandia is also responsible for most areas of testing systems and training military personnel how to handle weapons safely and securely. Often overlooked, these responsibilities ensure the surety of our systems and the readiness of our armed forces.

Examples of Sandia's work on stockpile maintenance are in the recently completed B61 modifications, judged an outstanding success by NNSA and DOE managers. Sandia completed several alterations on B61 weapons that enhance the safety, security, and reliability of these retrofitted weapons. In addition, a high-fidelity trainer was provided to the Air Force to allow training with the full range of new features without the safety or security risks of using real weapons.

Finally, Sandia completed development of and initiated production activities for the B61 spin motor replacement. The spin rocket motor rapidly spins the bomb after it is released in order to stabilize it. The new motor will significantly reduce the production and maintenance costs of building, stocking, and replacing motors over the life of the system, as well as reduce the risks of handling the explosive device.

Improving stockpile evaluations

Beyond surveillance and maintenance, the Sandia Stockpile Evaluation Program is focused on maintaining a timely, cost-ef-

Patricia Bonham with Sandia's Command Disable System Tester, now in use at the Pantex Plant near Amarillo, Texas for weapon testing. Sandia engineers designed and built the tester.

fective program that minimizes defect detection time and maximizes data collection, retention, and accuracy.

A core function of the program is to evaluate weapon system attributes, design, and production to ensure that Sandia appropriately addresses the surety and quality of nuclear weapons. Every year, weapons are randomly selected for annual testing from each of the nine enduring stockpile systems. Eight of the weapons systems are typically sent to Sandia's Weapons Evaluation Test Laboratory at the Pantex Plant near Amarillo, Texas, where they undergo more than 700 tests on automated test beds. Test beds replicate the configuration of a weapon as closely as possible. A new generation of testers can conduct tests of three different weapons systems, rather than one, reducing operational and maintenance costs while expanding the scope of the tests.

Refurbishing and Sustaining Weapon Systems

All of Sandia's weapons stewardship activities follow exacting processes and demand uncompromised results. The W76 and W80 Stockpile Life Extension Programs challenge Sandia to develop technical innovations and employ new modeling, simulation, and testing tools and capabilities. New designs are in development for the electrical systems, neutron generators, gas-transfer systems, and several new structural components. Notable activities for critical weapon systems are summarized below.

W76 Activities: The W76-1 SLEP team successfully completed its third year of development engineering on the arming, fuzing, and firing (AF&F) system. The refurbishment of the W76 not only extends the life of the current system, but also incorporates significant improvements in weapon surety.

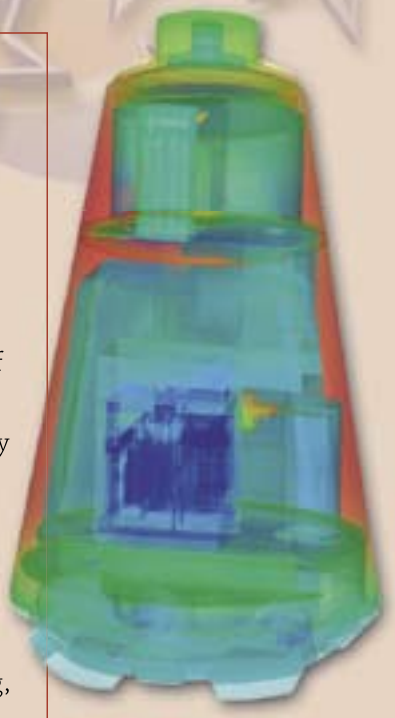
The Navy conducted the first flight test of a W76 with the AF&F system. Early data indicate that the system performed exactly as intended. The AF&F system engineering team has been able to integrate radar, flight computer, and diagnostics in a single compact assembly. The design is meeting aggressive cost goals through use of commercial parts, innovative packaging, and automated production processes.

W80 Activities: The W80-3 SLEP refurbishment extends the life of the current warhead and incorporates significant improvements in weapon surety. The W80 refurbishment also represents an in-depth collaboration with the Advanced Simulation and Computing (ASC) program to develop and implement a model-based approach to qualify a refurbished warhead.

The team successfully executed the first full-system nuclear safety drop test of the new design. PRESTO, a dynamic large-deformation mechanics code developed through the ASC program, was used to define the drop test configuration and to help select instrumentation type and location. The test was performed at Sandia's Drop Tower Test Facility.

Manufacturing—not only filling the gaps but creating new models

At the height of the Cold War, the Nuclear Weapons Complex had 55 major facilities



High-speed computer-generated simulation of W76 for weapon surety research.

A Quality Assurance Specialist applies a certification stamp to a Sandia neutron generator as a part of product verification and acceptance process.

The World's Smallest Particle Accelerators

Neutron generators, about the size of a soda can, are the world's smallest particle accelerators, supplying a vast quantity of neutrons at precisely the right time to help initiate fission. Their enormous complexity leads to production and testing challenges at the forefront of technology, as their quality can often be determined only with sophisticated tools such as scanning nationwide, with thousands of suppliers; since 1992, these numbers have been reduced to eight facilities and only a score of suppliers.

In 1993, Sandia assumed production responsibility for a dozen technologies in what became the Concurrent Design and Manufacturing (CDM) Program. CDM began delivering explosive, electronic, and power source components such as gas generators. Since 1993, CDM has delivered more than 70,000 complex components that must function with highest integrity. For the past three years, CDM has achieved a 100 percent first-time acceptance by the NNSA.

Sandia built a neutron generator production facility and produced its first War Reserve neutron generator in 1999. Neutron generator production has delivered re-certified and newly manufactured generators on schedule with 100 percent acceptance by DOE since 1996.

Microtechnology, MESA, and meso-scale fabrication

At any time Sandia's Microelectronics Development Laboratory (MDL) has about ten integrated circuits in process. These circuits, which have critical impacts on multiple weapons systems, are often the last to be specified by systems designers and the first to be needed in assembly. And they must function flawlessly in what systems designers understate as "harsh" environments—rocket launches, release and impact shocks, and temperature and radiation extremes beyond those normally encountered on Earth.

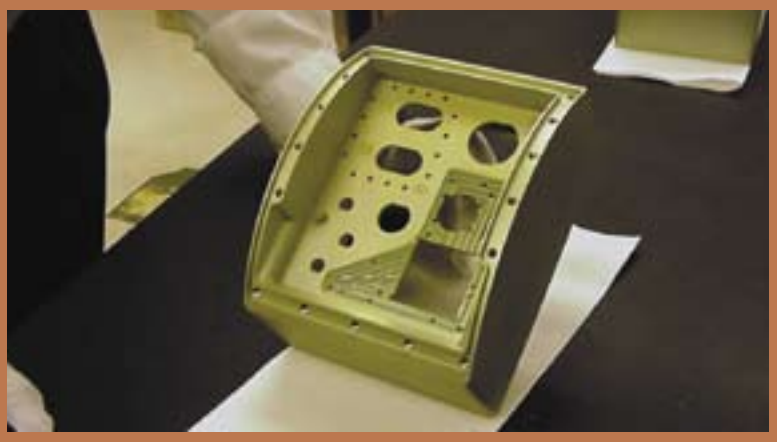
The MDL set a record fabrication time of six weeks, down from 14-18 weeks, to complete the digital controller chip needed for the stockpile life extension of the W76 nuclear weapon system. The chip functioned properly on the first fabrication effort. This integrated circuit is intended to operate in extreme environments (including harsh radiation) at ultra-low power consumption.

A second, very large design, the Crypto Coded Switch (CCS) application-specific integrated circuit (ASIC), was also 100 percent functional at first delivery. The CCS was the largest design manufactured by the MDL and demonstrates Sandia's capability to build high-transistor-count integrated circuits. A third ASIC was fabricated using field programmable arrays and radiation hardened technology.

Sandia is working on new technologies that will radically change weapon design and manufacture. For some time we have explored microsystems technologies to enhance existing systems and enable new system architectures. Sandia's Microsystems and Engineering Sciences Applications (MESA) project, our largest construction project ever, will create a computationally intensive environment for the design, integration, prototype fabrication, and qualification of integrated microsystems into weapon components, subsystems, and systems.

These small, highly integrated and low-power mechanisms are created using integrated circuit fabrication technology that allows for the combination of diverse functions on a single computer chip. We electron microscopes. This year, Sandia's Primary Standards Laboratory and the Neutron Generator groups teamed to improve the quality of tester data. Sources of measurement variations and uncertainties are now more fully understood. The Primary Standards Laboratory has compared neutron measurements between tubes and generators and between tube testers and generator testers, performed voltage waveform analyses, and performed a complete uncertainty analysis of a tester and gas measurements supporting tube production. Control measurements have been implemented, which are ensuring continued product quality.

We also made a significant improvement in the correlation of neutron generator performance data taken at the Sandia Weapons Evaluation Test Laboratory with that measured in the shelf life program at Sandia.



Sandia produced the first-ever model-based mark-quality weapon products accepted by NNSA. Model-Based Product Acceptance is defined as "a method of manufacturing, measuring and accepting mark-quality products using only the solid model and qualified processes." This significant milestone has broken the barrier of creating a 3-D electronic design definition that contains all the information necessary to fabricate, measure, submit, and accept mark-quality weapon products.

DOE Secretary Spencer Abraham joined members of the Sandia Corp. Board of Directors, senior Labs management, and other Sandians on April 28 to officially mark the opening of the new Joint Computational Engineering Lab building (JCEL). The building houses some 175 researchers and support staff in its 60,000-plus square feet of space. The $30.8-million JCEL facility was funded by DOE/NNSA's Advanced Simulation and Computing program and represents an integral part of the MESA project.

have opened the Joint Computational Engineering Lab (JCEL) and are now constructing the Microfab, Microlab, and Weapons Integration Facility—the buildings that constitute MESA proper.

A successful new enterprise has been established—the MESA Technology and Operations Prototype (MESA-TOP). The focus of MESA-TOP is to accelerate the development of advanced microsystems for use in real-world weapons applications. The MESA-TOP team includes experts in microsystems design, development, packaging, testing, analysis, reliability science, and systems engineering. The MESA-TOP facility includes offices for about 70 personnel and contains 5,000 square feet of world-class cleanrooms. The facility is located in the SS&TP.

Microtechnologies also include meso-scale components—components that, in size, fall between microsystems and those that can be made by traditional machining. The meso-scale components are made by a process called LIGA. Sandia has developed a LIGA spring that enabled an Environmental Sensing Device, designed to play a key role in nuclear weapon safety architectures that use environmental sensing as part of their nuclear safety theme. The LIGA Technologies Facility at our California site will enable research on at our California site. LTF is a cleanroom laboratory building that will enable research and development on technologies to provide integrated metal, ceramic, and polymer microsystem assemblies for national security applications.

Computing, data and process management

Sandia recently brought strong new computing and infrastructure support capabilities online, many of which are enabled by the ASC program. Sandia's Red Storm machine was under construction in 2004, and with its completion in mid-2005, Sandia will boast one of the world's fastest computers. To assure the integration and alignment for the supporting information architecture, the Nuclear Weapons Information Environment (NWie) initiative has been created. In its third year, this pro-

gram has already made notable advances in organizing weapons-critical data and in providing a strategic roadmap for advancing design-through-analysis processes critical to the weapons complex.

Since 1988, we have increased our weapons modeling fidelity by several orders of magnitude. With its unique balance between scalar and vector computing, Red Storm will increase this fidelity another order of magnitude. Our JCEL is designed to accommodate the machine's cost-efficient scalability. Modeling and simulation, in combination with above-ground, non-nuclear testing in our refurbished test facilities, are emerging as the keystones to qualifying and assessing the stockpile without nuclear testing.

Sandia's computational tools have received recognition in the international community. One milestone of the Accelerated Strategic Computing is a simulation of electrical performance under extremely hostile x-ray radiation. We demonstrated revolutionary new capabilities to model the response of nuclear weapon electrical components during this past year.

Worldwide nuclear security

Sandia-developed nuclear weapon surety capabilities, which address threat scenarios in a systematic way, have been extended to other threats. We are applying technologies, principles, and systems developed at Sandia for nuclear surety into much broader national security applications.

To protect U.S. military assets from terrorist threats, we examined alternative designs of radiological dispersal devices (RDDs) using explosives, mechanical spray, and other novel approaches. A risk-based systems analysis laid out the RDD threat from end to end—from terrorist motivation to target selection and final weapon delivery and dispersal. The analysis identified immediate security requirements as well as several areas where better understanding is needed.

The DOE Accident Response Group provides worldwide, professional, accurate, and timely technical support in resolving accidents and significant incidents involving U.S. nuclear weapons. Sandia helped deploy a new system, the Digital-Portable Integrated Video System, which provides accident site personnel with real-time secure video and audio channels.

The Security Matrix Project, jointly sponsored by DOE and DoD, completed its fourth year. Project findings for the Navy, Air Force, and DOE operations inside the U.S. are being used to focus attention on improvements to the stockpile during refurbishments and on improved security policies and postures where appropriate.

Site stewardship

Sandia takes its site stewardship responsibility as seriously as its role in stockpile stewardship, executing substantial site planning and capital investment efforts to keep the site viable and responsive to mission needs now and in the future. These site investments are accomplished through line items, general plant projects, renovations, and facilities and infrastructure recapitalization programs, and are carefully incorporated into Sandia's budgeting process to fulfill its site stewardship role.

Mitigating the Proliferation of Weapons of Mass Destruction

"Sandia's Nonproliferation and Assessments (NP&A) Programs support the

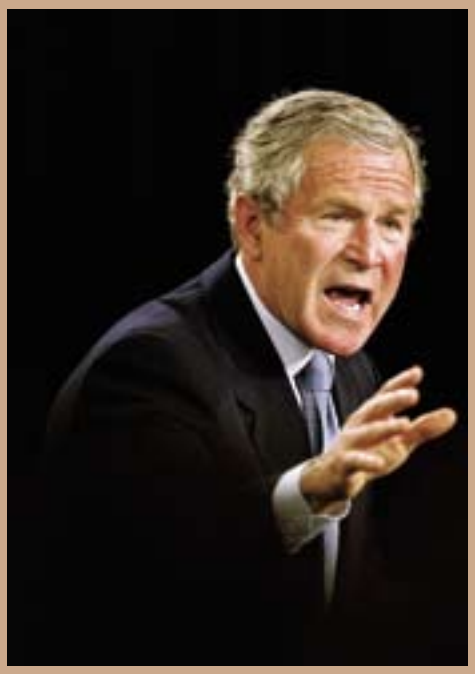
National Nuclear Security Administration's strategic goal to "detect, prevent, and reverse the proliferation of weapons of mass destruction, while promoting nuclear safety worldwide." Our staff travels to remote locations around the globe and reaches into space to provide enabling systems, science, technology, and expertise that will reduce these threats to the United States. The NP&A program works to provide performance and vulnerability assessments of both U.S. and foreign technical capabilities and facilities and associated assessment tools and technologies. The physical-protection systems that we are developing and evaluating include technologies deployable at home and abroad."

Al Romig
Vice President
Nonproliferation and Assessments

Accelerating Our Drive to Make the World a Safer Place

"The greatest threat before humanity today is the possibility of secret and sudden attack with chemical or biological or radiological or nuclear weapons... America, and the entire civilized world, will face this threat for decades to come."

—President George W. Bush,
at the National Defense University,
February 2004



Sandia has supported the DOE's global nuclear material security efforts since 1974. Under a variety of programs, we have assisted in efforts to identify and implement security improvements in the U.S. and in more than 50 countries around the world, many of them member states of the former Soviet Union. Recently we have provided assistance to strengthen the physical protection at facilities in 15 nations as a part of the DOE NNSA's Global Nuclear Security Program. These nations are Belarus, Bulgaria, the Czech Republic, Georgia, Hungary, Indonesia, Kazakhstan, Latvia, Lithuania, Poland, Portugal, Romania, Serbia, the Ukraine, and Uzbekistan.

Other work involves deployment of Sandia teams to Russia, Greece, Haiti, and Iraq in support of NNSA's Radiological Threat Reduction (RTR) Program working in cooperation with the NNSA, Department of State, a number of foreign governments. Sandia is also extending its security activities to border crossings for maritime transportation shipments bound for the U.S.

Working with the Former Soviet Union

In the early 1990s, Sandia began helping to protect Russian weapons through the Cooperative Threat Reduction program. This involvement drew upon Sandia's knowledge of nuclear security, having held for many decades, the primary responsibilities for developing and implementing physical security for the entire U.S. weapons complex. We have expanded this mission to improve

the security of nuclear weapons, weapons-grade nuclear material, and transportation in Russia.

The NNSA's Materials Protection, Control and Accounting (MPC&A) Program reduces the threat to U.S. national security posed by unsecured Russian Federation fissile material and nuclear warheads. The MPC&A program has two primary emphases: 1) security of fissile materials and 2) security of nuclear weapons.

This year NNSA accelerated its schedule for work with the Russian Navy to secure warhead storage sites and rail transfer points. By the close of 2006, Sandia will have increased security at all of the tasked Russian Navy fuel and nuclear weapon storage sites. Sandia also concluded an agreement to secure two Strategic Rocket Forces sites by year-end, with the goal of securing multiple facilities on the six remaining sites by 2008. Sandia has now spent or committed more than $200 million toward these important security projects.

The countries indicated in blue on this map have received assistance from Sandia with cooperative programs designed to improve nuclear security.

Advanced stockpile monitoring technologies

A concrete example of the shared commitment to nonproliferation between the U.S. and Russia is the TOBOS program. Sandia has been working with the All Russian Institute of Automatics (VNIIA), under sponsorship of the Defense Threat Reduction Agency (DTRA) since 2001 to develop advanced monitoring technologies for the Russian Ministry of Defense. The TOBOS program (from the Russian acronym for

U.S. and Russian officials marked a milestone in the TOBOS program, for securing Russian warheads, with the opening of a new test bed facility in St. Petersburg.

Safety and Security Technologies for Russian Warheads) tests technologies for enhanced warhead security and safety. Late in 2003, construction of a unique test bed at the ministry's TOBOS Research Center in St. Petersburg was completed and initial field trials were initiated. Sandia, in conjunction with VNIIA, is helping to develop the test program, with the Russian defense ministry approving all plans and operations. The Russian military and safety experts will evaluate monitoring technologies in normal operational and storage environments, extreme environmental conditions, accident environments, and under theft scenarios. After completing these evaluations, the Russian military testing agency will make recommendations to the defense ministry regarding operational deployment of the technologies.

Second line of defense

While we describe the work of securing nuclear weapons and materials capabilities as a "first line of defense," Sandia is also moving ahead with a program described as the second line of defense (SLD), aimed at reducing the risks of nuclear smuggling. This program now extends to some 15+ countries in an effort to deter, detect, and interdict illicit transport of nuclear materials and weapons across borders.

Work in the SLD program to survey sites and install security and radiation detection systems is ongoing. SLD participants are also surveying and equipping foreign seaports to prescreen U.S.-bound container cargo.

Facial recognition project

The automatic visual recognition of objects is a common problem across many security application activities. An intensive international effort is now being made to develop technology to recognize the faces of known terrorists from photographs. However, 2-D image recognition technologies suffer from variations in poses, expressions, disguises, and other variables.

Sandia's Richard Smith (left) and Anatoly Abakumov, part of a Russian delegation, examine a weapon shipping container as part of a conference of weapon security.

3-D recognition offers superior accuracy in this effort.

Sandia's Micro Optical Radar Facial Recognition Project is developing critical pieces of the technology needed to demonstrate the feasibility of facial recognition at a distance. An optical sensor under development depends on the development of a challenging multi-pixel, high-speed, low-noise, application-specific, integrated circuit that is both analog and digital in mode. If successful, the technology has wide application to many national security missions where remote recognition of 3-D features is of importance.

Potential used include crime scene mapping for law enforcement, target detection and recognition for military applications, and collision avoidance systems for vehicles.

Securing high consequence pathogens and toxins

More than 60 scientists from government-operated bioscience research labs around the world gathered in Albuquerque in early February 2004 to discuss how to keep dangerous pathogens and toxins out of the hands of terrorists. Hosted by Sandia's International Security Center, the goal of the first-of-its-kind program was to further cooperation among other governments to secure materials that could be used as biological weapons. Although most bioscience laboratories have systems to prevent workers from being accidentally exposed, no international guidelines exist to specify how labs should prevent theft or sabotage of these dangerous materials.

"A flood of radioactive sources, from discarded cancer treatment machines advertised on the Internet to misplaced industrial gadgets that turn up in junkyards, have yet to be corralled by U.S. authorities three years after the Sept. 11 terrorist attacks, experts say — and could easily be exploited by terrorists seeking to make a dirty bomb. The material is so abundant and easy to obtain, the experts say, that it is almost inevitable that a U.S. city will be the target of a bomb salted with radioactive waste."

—The San Francisco Chronicle, September 5, 2004

Identifying and securing radiological sources

The recurring loss or theft of radioactive materials such as cobalt-60 and cesium-137, widely used in medicine and industry, has long been an issue for the world's public health and law enforcement officials. These materials can contain deadly amounts of penetrating radiation in a lipstick-sized package, and have caused deaths among children who have found them.

With the potential for their use in radioactive dispersal devices, or so-called "dirty bombs," they are even more of a threat. Such a weapon, made with conventional explosives and radioactive materials that would be scattered during a blast, may cause as much or more damage from fear and a panicked response as from the dangers of the explosives or the radioactive materials themselves. But they also have the potential to contaminate an entire city neighborhood to a level where demolition would be the only clean-up alternative.

Security for medical and industrial radioactive materials has become an increasingly important issue, post-9/11 as the potential for their use in radioactive dispersal devices, or so-called "dirty bombs" makes them more of a threat.

As part of Sandia's RTR efforts, a Sandia team has worked with other DOE laboratories and governments of numerous foreign countries to help locate, repackage, secure in place or move to secure locations large quantities of medical and commercial radioactive materials. Often these materials are stored in facilities that offer little protection. The goal of this work is to lock up radiation sources that could become ingredients of a terrorist dirty bomb, while insuring that they remain available for legitimate medical or commercial applications. We have completed work in Lithuania, Greece, Russia, and Tanzania. Work is under way in Latvia, Estonia, Poland, and Egypt.

Sandia is working to locate and control the sources of radiological materials, which may number up to two million in the U.S. alone. The Radioactive Source Registry Tracking System will first track all DOE-sealed radioactive sources and provide decision makers with some estimation of their potential risk. Currently, DOE is the primary user of the system, but DOE has also offered it to the DHS, the Federal Bureau of Investigation, and the EPA for use as a tool to support tracking, assessment, and recovery of these sources.

Sandia also assisted DOE/NNSA in developing a strategic plan to secure and control foreign-origin radiological materials. Such material could potentially be acquired and used against U.S. interests. We are leading a project to search for and secure these materials worldwide.

New approaches and technologies for detecting proliferation activities

Sandia maintains technical capabilities to watch for terrorist or other activities that threaten national security. From concept stages, to demonstration, to operational systems, we develop the technologies needed to advance sensors and processing systems. Our technologies range from microscopic in situ instruments to large remote sensing systems that monitor the globe.

Integrated worldwide systems

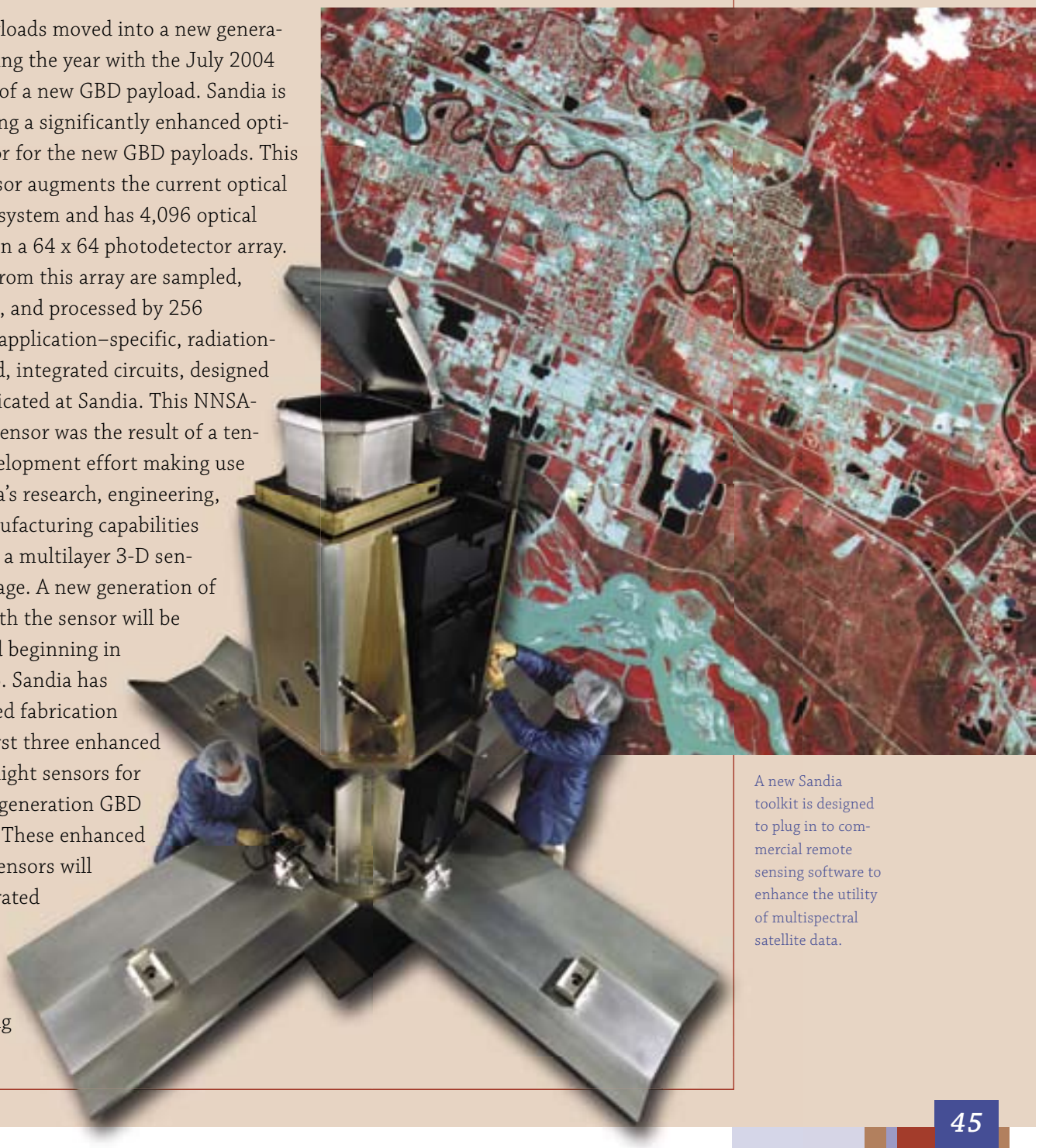
In late December 2003, the U.S. Air Force launched NAVSTAR Global Positioning System (GPS) Space Vehicle Number 47, with a Sandia-supplied Global Burst Detector (GBD) payload onboard. Early in 2004, the GBD payload was powered on and tested using Sandia and Los Alamos national laboratories facilities. The launch was the first of four scheduled NAVSTAR launches for Fiscal Year 2004. It was the tenth of 21 satellites of the Block IIR generation of NAVSTAR to be launched by the Air Force.

The GBD is a key component of the U.S. Nuclear Detonation Detection (NUDET)

System that provides a worldwide capability to detect, locate, and report nuclear detonations in the Earth's atmosphere or in near space. Today there are NUDET sensors on all of the 24 satellites in operation in the NAVSTAR GPS constellation. Every year Sandia supports new launches.

GBD payloads moved into a new generation during the year with the July 2004 delivery of a new GBD payload. Sandia is developing a significantly enhanced optical sensor for the new GBD payloads. This new sensor augments the current optical NUDET system and has 4,096 optical sensors in a 64 x 64 photodetector array. Signals from this array are sampled, digitized, and processed by 256 custom, application–specific, radiation-hardened, integrated circuits, designed and fabricated at Sandia. This NNSA-funded sensor was the result of a ten-year development effort making use of Sandia's research, engineering, and manufacturing capabilities to create a multilayer 3-D sensor package. A new generation of GBDs with the sensor will be launched beginning in fall 2006. Sandia has completed fabrication of the first three enhanced optical flight sensors for the new generation GBD payload. These enhanced optical sensors will be integrated into the GBD payloads beginning in 2005.

In another innovation, Sandia continues to make progress on the first of a new generation of integrated microsystems for satellite applications. Integrated microsystems in the new ENRAD sensor process data 10,000 times faster with sharply reduced power consumption. Size and



A new Sandia toolkit is designed to plug in to commercial remote sensing software to enhance the utility of multispectral satellite data.

weight are reduced by a factor of 2,000. The ENRAD sensor was launched into orbit in June 2004, and Sandia engineers are evaluating its operation and performance.

Sandia developed a number of new analysis techniques and tools for multispectral and thermal data based on more than 8,500 images from the Multispectral Thermal Imager satellite. The satellite, which exceeded its operational mission goal of three years and has completed more than 20,000 orbits, became a powerful space-based research and development project for nonproliferation research and engineering.

The Sandia Multispectral Analyst Remote Sensing Toolkit, or SMART, was developed as a result of the development of these new analysis techniques and released under government license to 22 organizations.

Iran's Nuclear Challenge

"Iran announced on [July 30] that it had resumed the construction of centrifuges that are capable of producing material for a nuclear bomb.... There would be little reason for Iran to take the provocative step of restarting centrifuge construction now unless it also intended to resume operations at some later date."

—NY Times, August 4, 2004

Cooperative international security leadership

The importance of international cooperation to enforce nonproliferation has become starkly clear. Our government has been long concerned about the risk of conflict, terrorism, and the proliferation of weapons of mass destruction in the Middle East and other unstable areas of the globe. Sandia has expanded its efforts to support a range of cooperative international security programs, in turn supporting the U.S. nonproliferation policy globally.

The success of Sandia's Cooperative Monitoring Center (CMC) in Albuquerque, established in 1994 to support the DOE, DoD, and State Departments cooperative programs, led to CMC in Amman, Jordan, which marked its official grand opening in late 2003. CMC-Amman provides a forum for regional training on nonproliferation technologies, new monitoring capabilities, monitoring demonstrations, and interactions among scientists, engineers, and policymakers.

More recently, the Center facilitated an agreement among the NNSA, the Arab Science and Technology Foundation, and CMC-Amman. The agreement outlines a multi phase effort to help rebuild key elements of Iraq's scientific infrastructure. Early in 2004, foundation members traveled to Baghdad to recruit an Iraqi team and complete work on a survey of the nation's battered scientific infrastructure. Scientists in Iraq have been isolated from mainstream science for nearly 15 years. Survey results showed major areas of interest, including water resources, public health (including medical infrastructure), and environmental restoration. Agriculture, biotechnology, and communication system restoration were also rated high in the survey. Next steps involve increasing international funding for high-priority projects.

Maj. General Mohammad Shiyyab (center), Director of the Cooperative Monitoring Center -Amman leads a tour of the facility during opening ceremonies late in 2003.

Non-weapon enterprises provide jobs

The Russian Transition Initiative's first commercial joint venture was established with Numotech, a U.S. medical devices firm, and Spektr-Conversion, a Russian entrepreneurial start-up company. The joint venture designs and manufactures several medical equipment devices and may eventually employ up to 500 people. Sandia has been a key technical player, improving Numotech's products. A recent development has seen an authorization by Overseas Private Investment Corporation for $10 million in loans to move the venture forward once Russian approval is obtained.

A Department of State-sponsored nonproliferation program provides technical support of two international science centers in Moscow and the Ukraine. Through this program, Sandia researchers work with scientists in the former Soviet bloc to fund research projects, ensuring that no dual use, i.e. weapons-related research, is funded.

A second program, the Russian Transition Initiative, sponsored by NNSA, dates back to the early 1990s. Goals of this initiative include reducing the size of three nuclear weapon enterprises in Russia and finding non-weapon employment with commercial potential for highly skilled former weapons scientists and engineers.

"The U.S. military is transforming from a focus on major theater warfare to a force that is responsive, deployable, agile, and versatile, with increased lethality, survivability and sustainability. This change demands swift, state-of-the-art technology development, the ability to rapidly deploy high-impact systems and transfer advanced technology to industrial production, and a system-of-systems approach. The reality of asymmetrical warfare as well as chemical, biological, nuclear, and information warfare

poses greater threats than ever to America and nations around the world. Our mission supports many agencies worldwide in an effort to combat proliferation, attempts at regional supremacy, terrorism, and threats against our armed forces and homeland."

Jim Tegnelia
Vice President
Department of Defense Programs

Helping Maintain Superiority for the Future Fighting Force

"Army officials are accelerating the delivery of selected future combat systems to the current force. Under the program, the Army will speed up deployment of some segments of the system. They will begin reaching the field in fiscal 2008, rather than in fiscal 2014.

The five technologies that will be accelerated are the non-line-of sight cannon, the non-line-of-site launch system, the unattended ground sensors, two classes of unmanned aerial vehicles and armed robotic vehicles."

—DOD News Release, July 22, 2004

The 2002 Nuclear Posture Review, requested by President George W. Bush, replaced the Cold War's nuclear triad of missiles, bombers, and submarines with a broader new triad for strategic defense that includes conventional weapons and missile defense. Together with the Quadrennial Defense Review and the Defense Planning Guidance, these documents define a dynamic new environment in which Sandia is playing a strategic role.

Because Sandia designed many elements of the nation's nuclear stockpile, we now possess a vast storehouse of knowledge about warhead flight characteristics, various signatures, and behaviors. Sandia has supported more than 80 full-scale flight tests, principally demonstrations of advanced and exploratory designs. Today, Sandia uses this knowledge to design and build targets for National Missile Defense tests. This year we produced payload suites for five tests, and also suites for five penetrator tests.

Other missile defense projects include:

- Sandia successfully fielded a next-generation inertial navigation system for spinning vehicles in a National Missile Defense test. To meet program requirements, weight and volume were reduced by 50 percent below previous navigation systems.

- Sandia delivered a space-qualified Radiation-Hardened Key Data Processor (RH-KDP) system design to the Air Force NAVSTAR GPS Joint Program Office. General Dynamics Decision Systems has integrated Sandia's design into a Selective Availability Anti-

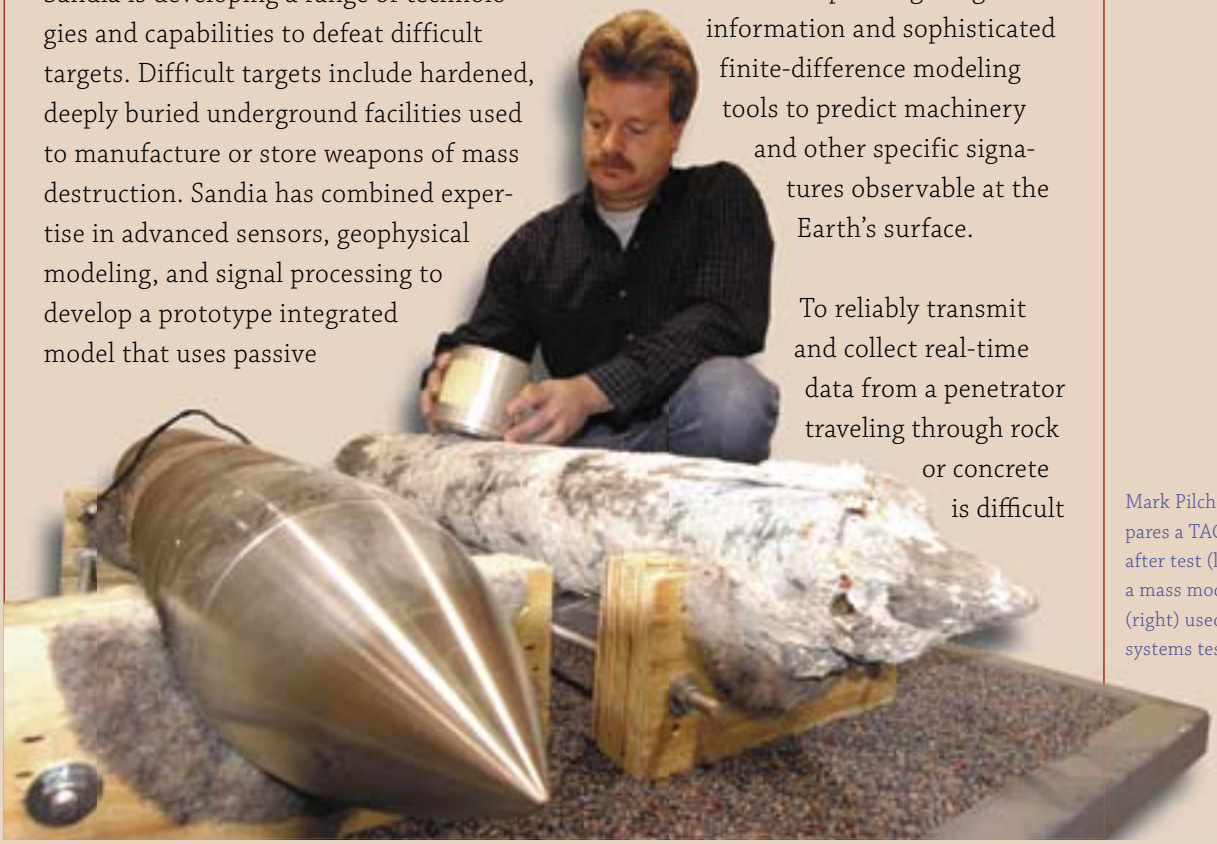
Spoofing Module (SAASM) for space vehicle applications. Sandia is the sole supplier of National Security Agency-endorsed terrestrial and space RH-KDP designs, which implement the SAASM features mandated by the Joint Chiefs of Staff to enhance the security of all future military GPS receivers.

This year the first Sandia-designed-and-built satellite laser threat-warning sensor was launched. Successful laser illumination testing verified its detection and reporting capabilities. Validation testing over the next year will determine the optimum satellite configuration to perform its mission. An updated warning sensor is being developed under a $15.6 million technology transfer agreement with Northrop Grumman Space.

Sandia provides launch support for the Missile Defense Agency's flight test program. We perform lethality calculations and study national missile defense countermeasures.

Sandia is developing a range of technologies and capabilities to defeat difficult targets. Difficult targets include hardened, deeply buried underground facilities used to manufacture or store weapons of mass destruction. Sandia has combined expertise in advanced sensors, geophysical modeling, and signal processing to develop a prototype integrated model that uses passive seismic, acoustic, and electromagnetic signals for target characterization. The model combines site-specific geological information and sophisticated finite-difference modeling tools to predict machinery and other specific signatures observable at the Earth's surface.

To reliably transmit and collect real-time data from a penetrator traveling through rock or concrete is difficult



Mark Pilcher compares a TACMS-P after test (left) with a mass mockup (right) used for systems testing.

challenge. In a test a penetrator instrument package of only 6.2-cubic-inch volume measured, recorded, and transmitted 3-axes of acceleration data in real time. Our laboratory and test facilities are critical in these developments. We can measure extremely high strain-rates in materials, which is essential to designing a penetrator and selecting materials. Our sled track assessed the survivability of the MicroFuze and high-explosive package during the impact. The predicted depth of penetration was achieved, the fuze was functional after the test, and data were downloaded from the internal memory. The high explosives showed no signs of cracks or failure and the bond with the case wall was still intact. The penetrator was extracted from the concrete target using a remotely operated demolition tractor fitted with a jack-hammer.

Transformation of the Armed Forces

Future Combat Systems (FCS), the Army's cornerstone transformational programs, is a networked "system of systems" that uses advanced communications and technologies to link the soldier with distributed manned and unmanned air and ground platforms and sensors. This highly agile and lethal system of systems will equip the tactical formations that will fulfill the Army's vision of the Future Force.

The DoD and industry recognize Sandia as a unique provider of systems analyses, engineering prototypes, and validated/verified developmental products.

Sandia formed an unmatched multi-laboratory DOE/DoD team to provide innovative systems-of-systems (SoS) solutions. FIST (Future Combat Systems Integrated Support Team) members—Sandia (lead), Oak Ridge National Lab, and specialized expertise from others such as Idaho

National Engineering & Environmental Lab, MITRE, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, the Institute for Defense Analysis—are providing integrated solutions. This work is in partnership with the Army's FCS Program Office, DARPA, the Lead System Integrator, Boeing, and Science Applications International Corporation and the contractor base.

Redefinition of ground combat for the 21st century requires complex SoS integration of disruptive technologies and accelerated development. The FIST is providing

Demonstrating Hard Target Defeat

Sandia engineers have designed and successfully tested a new conventional weapon concept that gives U.S. forces a way to attack hardened targets promptly, precisely, and from many miles away which reduces the danger to the attacking forces.

Under the DoD-funded Advanced Concept Technology Demonstration (ACTD) Tactical Missile System – Penetrator (TACMS-P) program, Sandia designed, developed and tested a new strike missile concept and will, by the end of FY05, provide six special-purpose weapon payloads for inclusion in the Army's arsenal. The March 2004 test was the first demonstration of a high-speed, precision-guided earth penetrating weapon delivered by the Army Tactical Missile System. It met all requirements for range, impact accuracy, and warhead penetration depth.

The Sandia portion of the program required the mating of an existing tactical weapon design – the Army Tactical Missile System (ATACMS) – with the design of a new warhead developed under Navy guidance. New systems include actuated fins to provide enhanced flight maneuverability advanced fuzing systems to detect target features, and improved navigation, guidance, and control systems. The redesign also features a Sandia-patented cast steel warhead called the Monolithic Ballasted Penetrator (MBP) – designed for improved depth of penetration and stability in the target, even when impacting at several thousand feet per second. The MBP contains insensitive high explosive and a Sandia-developed fuze that triggers the warhead and explodes inside the target. Sandia applied its expertise in high-speed flight systems; precision navigation, guidance, and control; all electronic fuzes; modeling and simulation; and earth penetration technology to rapidly move from design concept to flight test.

Like the ATACMS, a standard ground-to-ground missile in the Army inventory, the TACMS-P will be transported and launched from the Army's Multiple Launch Rocket System. Following further development, it could be used in Navy submarine launch systems. The ability to launch penetrating weapons from mobile launchers hundreds of miles away removes aircraft and crews from harms way, provides for greater weapon effect through improved strike accuracy and greater depth of penetration, and reduces the time between target selection and weapon engagement to minutes instead of hours – a desirable capability when targeting scenarios change quickly and frequently. The TACMS-P provides a new capability the Army and Navy need in today's combat environment.

Sequence illustrates flight test of TACMS-P in March 2004 at White Sands Missile Range, including launch from Complex 33 (top), approach to target near northern end of the range (middle), and successful impact (bottom). The test met specific range, accuracy, and penetration objectives.

Lars Wells with radar tag prototype. The tagging device is recognizable to an attack aircraft as a "friend," rather than an enemy.

technology solutions using novel analytical processes and a strong team effort to:

- assure mobility in mined areas
- assure combat identification in a distributed joint battlefield environment
- assess network vulnerabilities
- assess communications/network architectures and protocols
- assess SoS operational availability
- assist developing SoS specifications and requirements
- develop prototype advanced decision support systems
- initiate innovative projects, including remote emplacement of unattended ground sensors and electromagnetic coilgun technologies
- provide a framework to insert spiral technologies, including Military Operations in Urban Terrain

FIST has significantly advanced the development and application of unique SoS analysis tools that have, in just two years, accelerated the movement of many key components of FCS from the Concept and Technology Development phase to the System Development and Demonstration phase, a striking example of how DOE science, technology, and engineering can meet pressing DoD and national security needs. Sandia's analysis tools have been adopted by the FCS program manager and the Army Logistics and Support Planning and Analysis organizations, including the Army Evaluation Command and the Army Test and Evaluation Center.

The sweep of transformation

Transformation is a sweeping concept that embraces disruptive technologies, new

weapons platforms, new battle concepts, and new logistics and procurement practices. Sandia is contributing across the spectrum:

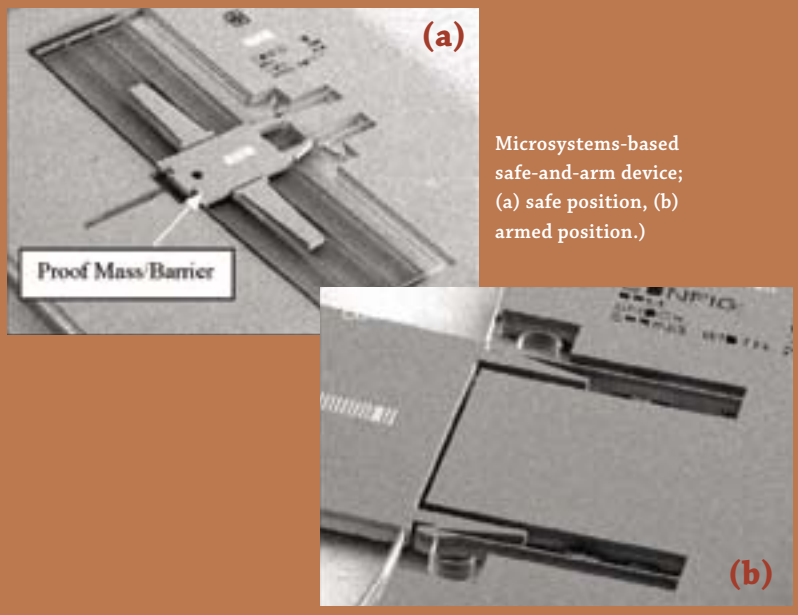
- Sandia's directed-energy group has successfully developed a highly compact high-voltage pulser capable of powering various directed-energy loads. The design uses Sandia's pulsed power experience and combines a battery-driven power supply and Marx generator in producing its output pulse. This development effort has resulted in a battery-driven pulser capable of delivering a 30-gigawatt drive to a load. This extremely compact, lightweight, and rugged approach will enable many future directed-energy systems that require portable high-power drivers.

- Sandia's electromagnetic coil- or rail-gun technologies are being investigated as long-range launchers for hypersonic weapons. These weapons could hold far-inland targets at risk of fast, decisive attack.

- To reduce the fog of war, Sandia has pursued a longstanding effort for better combat identification. Lightning-fast ground force movements on the battlefield make it difficult for U.S. and allied airborne strike fighters to distinguish friendly forces. Sandia's radar tags offer a combat ID solution because these tags operate with most airborne radars and provide direct and short-time latency information to the shooter. This work is based on prior development of radar tag technology and most recently on radar tags tested with the Sandia/General

Microfuze—Microsystems withstand the shock

The ability to penetrate hard targets requires a fuze that can withstand the extreme contact shocks and detonate the weapon at the correct instant. Under the Microfuze project, Sandia invested research funds to develop miniature fuzes for non-nuclear weapons applications, including penetrators. A microsystems-based safe-and-arm device was fabricated using a novel multi-mask silicon process. The device reacts to, and operates during, the harsh acceleration and spin common to a gun-launched projectile.



Microsystems-based safe-and-arm device; (a) safe position, (b) armed position.)

Innovative materials and techniques were used to fabricate low-energy initiators compatible with the microsystems architecture and structure. Tackling the challenging issue of identifying explosives compatible with microsystems, sensitive and insensitive explosive materials were modeled, and a "train" of explosives was chosen. This train successfully started an explosives detonation, with performance equal to larger traditional detonators. This detonation marks the first of its kind on the MEMS-size scale.

Atomics Lynx radar mounted on a Blackhawk helicopter for the U.S. Army.

- Future aircraft operations on the next-generation carrier seek to improve mission capabilities substantially by optimizing the workload among the crew. Sandia is undertaking an independent review and analysis of flight operations.

- Sandia is helping ensure the integrity and exclusivity of DoD systems that provide military superiority for the U.S. war fighter while enabling foreign military sales worldwide to our allies. Sandia develops critical security subsystems for the DoD such as the Key Data Processor, the secure crypto-engine for the current version of military GPS receivers. In addition, Sandia is providing the DoD with security guidance and direction covering methods and techniques for the DoD industrial base to deal with hostile or friendly exploitation of military capabilities.

- Sandia played a key role in the successful completion of the Joint Air-to-Surface Missile Initial Operational Test and Evaluation Flight Test Program. The Test Program consisted of six separate missile launches from a B-52H over the Nevada Test Range. The missiles flew preplanned routes and impacted specially prepared targets at the Tonopah Test Range. The Tonopah test team collected high-speed system performance data as the missiles impacted the targets.

- Leveraging technologies developed for nuclear weapons programs, Sandia's Technologies for Systems Analysis and Simulation group is developing an integrated, knowledge-based Support Enterprise Modeling capability for the Joint Strike Fighter (JSF) program. The modeling capability will enable Lockheed Martin Aeronautics to determine the best-value JSF business approach and to assess and optimize performance/cost as the JSF program moves forward.

The DoD has set an ambitious goal of reducing logistics costs by about $20 billion over the next few years. Achieving this goal will require revolutionary new technologies and systems for how we build, supply, maintain, repair, and eventually retire our defense assets.

- Sandia's success in using robotics to refurbish the stealth coatings on the F-117A Nighthawk, saving time and money and improving the final finish quality, has led to additional contracts to develop robotic systems to apply coatings to future U.S. fighter planes, the F-22 Raptor and the Joint Strike Fighter.

- The Army's Apache attack helicopter recapitalization program is intended to reduce operating and support costs and improve readiness for the 700-plus units in use. Sandia has applied our reliability models and optimization tools to guide recapitalization investment decisions for a program that had a potential cost of $600 million. Sandia's analyses resulted in a recommendation that the program invest only $150 million in specific subsystems, resulting in a $183 million per year savings for the fleet, while increasing availability. This approach can be applied to many of 26 Army weapon systems undergoing or due for recapitalization, as well as for other complex aircraft such as the new Comanche attack helicopter and the Osprey tilt rotor, vertical take-off aircraft.

- We fabricated, tested, and delivered to the Army a second large Explosive Destruction System (EDS) trailer. Sandia agreed to build this system, when its proven technology was selected over a fixed-facility technology under development. The EDS will be used to destroy 1,200 recovered chemical munitions in storage at Pine Bluff Arsenal, Arkansas. In support of the Pine Bluff operations, we also developed the ability to process three munitions at one time in a single EDS and the capability to destroy munitions containing Lewisite and Arsenical agents.

- Much as it has with the Homeland Security Department, Sandia is providing objective advice and assistance to the military's Northern Command, headquartered in Colorado Springs, in areas as diverse as specific technologies and systems organization. The Northern Command's mission is homeland defense.

Surveillance and Reconnaissance

For more than 15 years, Sandia has been providing solutions to DoD and industry customers for military surveillance and reconnaissance applications. Typical applications include radars, remote sensing, communications, weapons fuzing and firing, microelectromechanical systems, high-integrity software, and data processing and exploitation.

Sandia has developed advanced LIght Detection And Ranging (LIDAR) systems that can be employed to scan battlefields for detection of chemical or biological airborne agents. Sandia has also developed a scannerless technology that leads the world in high-resolution 3-D imaging. We are providing a Scannerless Range Imaging (SRI) system to NASA, a key to NASA's early return to flight. SRI will allow the NASA/Sandia team to detect and quantify damage in orbit.

Minimally manned warfare

Once futuristic, the success of Sandia's small robotic vehicles on surveillance missions in Afghanistan and Iraq has led to an accelerated program for robotic vehicles for military and other applications. Cooperating squads of robotic vehicles have conducted a variety of military missions. Sandia robots range from insect-like (one cubic inch) vehicles equipped with microsensors to large systems for coating aircraft or transferring 20-ton containers between ships at sea.

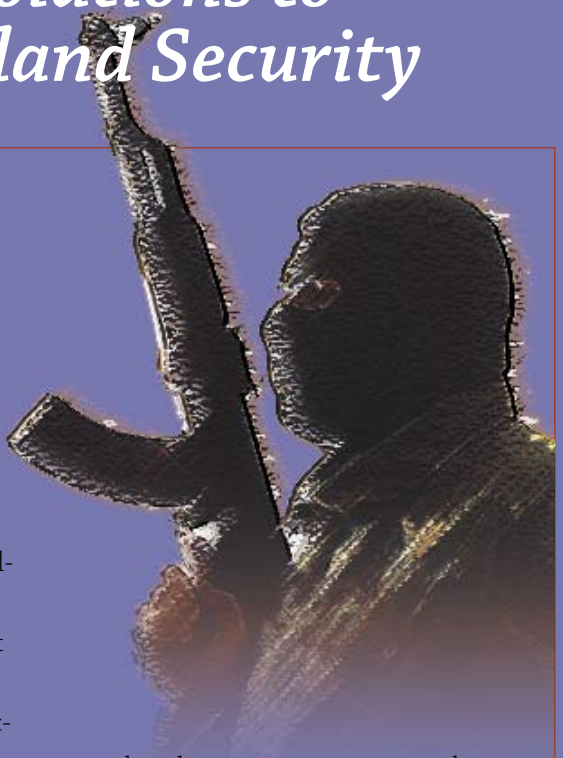
Alex Maish checks out SandDragon, developed for use in rugged outdoor terrain with two bodies, which push and pull each other over obstacles. SandDragon robots offer surveillance, reconnaissance, target acquisition, and response options in support of the military.

The Defense Ammunition Center has funded Sandia for two robotic disassembly systems based on technologies developed under the DOE/DoD Memorandum of Understanding program. The first system, which disassembles a projectile containing 36 mines, will be part of a new Munitions Demilitarization Cryofracture Facility under construction at the McAlester Army Ammunition Plant, in McAlester, Oklahoma. The second system will disassemble 8-inch rocket-assisted projectiles at the Blue Grass Army Depot.

As with bomb-disabling systems, Sandia human-centered control systems allow first responders to perform remote inspection and render-safe operations. Tests at the Army's Maneuver Support Center demonstrated that combat engineers and chemical technicians could successfully perform remote operations such as fuse removal, trip-wire cutting, and sample collection using commercially available equipment retrofitted with Sandia software. These tests were done without rehearsal, in the field, and with one hour of training with the equipment. Such operations typically require intensive training for a week or more.

The SnifferStar chemical sensor, a lightweight, low-power, rapid-responding chemical warfare agent sensing module for unmanned aerial vehicles, was selected by *R&D Magazine* as one of the 100 most significant technologies introduced in 2003. The technology is a joint development between Sandia and Lockheed Martin, funded through Lockheed Martin's Shared Vision program.

Crafting new solutions to enhance Homeland Security



Through a half-century of national security work, Sandia has built up unparalleled capabilities in the science, technologies, systems analysis, and engineering needed to safeguard lives and assets against terrorist acts. We're now applying that expertise to support the Department of Homeland Security (DHS), creating technology-based systems to decrease the nation's vulnerability to terrorism. These systems benefit from a multi-disciplinary approach that fosters innovation. Our legacy of approaching work from a systems perspective ensures that our solutions provide end-to-end responses to real-world problems.

We are also committed to helping DHS put our solutions to work quickly. To this end, we test and deploy systems to protect public facilities, provide extensive training to first responders, and are active in international efforts to improve port security. One of our most notable achievements in 2004 was joining with industry partners to sign the first CRADA that will result in a product with homeland security applications.

Chemical and biological security

Events such as the release of poison gas in the Tokyo subway and the delivery of letters in Washington, D.C. containing lethal doses of anthrax underscore the threat posed by chemical and biological weapons. Sandia is developing technology-based solutions to detect, deter, defeat, and mitigate the impact of chemical or biological attacks.

One such solution is MicroChemLab™, hand-portable, highly sensitive devices that can detect and identify a broad range of chem/bio agents rapidly with low false alarm rates. The result of a decade of work, this technology demonstrates Sandia's ability to innovate

"Today the technological challenges of protecting our nation against terrorism are as great as any we have faced in the past. In its role as a national security laboratory, Sandia began developing new technologies for the war against terrorism in the mid-1990s. These technologies are now playing an important role in guarding against biological, chemical, and radiological threats, as well as providing new capabilities for maintaining the health of infrastructures such as transportation, telecommunications, electrical transmission, water systems, national parks and monuments, and more.

Sandia and other national laboratories are serving as the wellspring for the integrated solutions that will maintain peace and freedom throughout the world."

Mim John
Vice President
California Laboratory

by integrating capabilities in an array of areas, including microsystems, chemistry, biology, and systems engineering. To place this tool into the hands of first responders, Sandia is moving quickly with commercialization plans.

Already, MicroChemLab™ Chemical Detectors have been at work under demanding real-world conditions at San Francisco International Airport and at a major subway in the northeast. In addition, Sandia-developed decontamination foam that renders all typical chem/bio agents harmless—now licensed to several commercial firms—was used in government and commercial buildings after the anthrax attacks in 2001.

The MicroChemLab™ Bio Detector is the core technology for Sandia's first major Homeland Security CRADA. Under this agreement, partners Tenix Investments and CH2M HILL will work with Sandia to produce the Unattended Water Safety System, which promises to enhance the safety of drinking water by automatically monitoring the water supply for previously undetected biological agents.

Other critical projects span the range of activities needed to prevent, prepare for, and respond to chem/bio threats. For example, Sandia is working with Lawrence Livermore National Laboratory to design and produce BioBriefcase, an automated, compact device that will continuously monitor for aerosol biological pathogens, working quickly and inexpensively, while providing excellent sensitivity and specificity.

To help the nation better protect heavily populated urban areas, we are contributing to a multi-lab study to define and explore planning scenarios for chem/bio attacks. By identifying capability gaps and vulnerabilities and metrics for evaluating countermeasures, the study will help the United States implement more effective defensive strategies.

And to provide immediate tools for protecting large facilities, we've developed operational strategies—based on tests at the San Francisco International Airport and elsewhere—to minimize human exposure to releases of chem/bio agents. These strategies are outlined in a report developed by Sandia and Lawrence Berkeley National Laboratory, being distributed to airport officials and security personnel.

Securing seaport and borders

Sandia is developing tools and expertise to help the nation respond to the new threat of potential terrorist activities at seaports and border crossings. We've been particularly active in helping secure the nation's seaports—points of entry for more than 95 percent of all freight from overseas. Aware that the nine million shipping containers enter these ports annually, officials are looking for solutions to ensure safe and profitable operation in these troubled times.

Work at the San Fransisco International Airport takes a comprehensive approach to airport facility defense, including vulnerability assessment, tracer testing and modeling, facility hardening concepts, biological and chemical detection system testing, response planning, and simulation-based tabletop exercises.

One solution is Operation Safe Commerce-Pacific, an international partnership aimed at monitoring freight security from overseas points of origin to final U.S. destinations. Partners in this effort include U.S. Customs; U.S. Coast Guard; the nation's two largest ports, Los Angeles and Long Beach; and numerous private-sector technology providers.

In another effort, Sandia is refining its Sensor for Measurement and Analysis of Radiation Transients (SMART) to help screen containers. SMART not only detects radiation, but identifies specific isotopes, a critical advantage in efficiently identifying threats from among other sources of radiation. Field tests at ports in the northeast are helping researchers tune the system and develop procedures to enable accurate threat detection, while minimizing the impacts on port operations.

Synthetic aperture radar (SAR) systems engineered and manufactured by Sandia show promise for Homeland Security applications. Able to image broad areas at high resolution and to collect data at night and in inclement weather, SARs are already having an extraordinary impact on the conduct of battle. Advances are increasing their value and applicability. In one example, Sandia has engineered SARs into event recorders that allow viewers to detect sub-millimeter changes in landscapes over a period of time, such as the appearance of footprints over grass or leaves rustling in the breeze. The ability to perceive these subtle changes has homeland security implications, particularly in border monitoring.

Protecting against radiological and nuclear threats

Our long-standing mission to secure the nation's stored nuclear weapons has positioned Sandia to provide exceptional countermeasures against radiological and nuclear threats. Our assets include expert staff with a deep understanding of security issues,

Sandia's Operation America events to train bomb technicians continue to draw accolades from law enforcement officials.

as well as a research and development program that spans the range of activities needed to address homeland security.

Our work is already having an impact. Sandia's radiation detection capabilities are opening new possibilities for ensuring a higher degree of protection at vulnerable points. Our threat characterization expertise has helped partners around the world. And our sampling and signature proficiency is adding to our forensic competence.

Sandia is also contributing to a larger DHS program to develop short- and mid-range radioactive/nuclear countermeasures. Efforts include establishing scenarios and defining performance metrics to evaluate alternative countermeasures; designing, simulating, and evaluating sensor networks and response strategies; and completing a source signature database for radiological dispersal devices, or so-called dirty bombs.

Bolstering cyber security

In fulfilling its primary mission, Sandia develops intricate computer systems that operate in complex environments—and that are subject to thousands of attacks daily from adversaries of all types.

To protect the integrity of its data, Sandia has actively secured its online network and transmission systems and built up a comprehensive array of tools and deep expertise in cyber security. Our Information Operations Red Team and Assessments program has performed cyber system assessments, evaluations, and vulnerability experiments for a broad range of systems. Customers include civilian government agencies, DoD, industry, and operators of critical infrastructure assets.

Sandia researchers are also developing information security practices to meet the next generation of Internet threats. Tools in our portfolio include Standard Agent Architecture II/Agent-in-a-box. These intelligent agents not only contribute significantly to national security, but also represent substantial commercial value for the multibillion-dollar cyber security industry.

High explosives countermeasures

Sandia stands among the world leaders in developing solutions to the most difficult challenges of developing countermeasures to explosives. Our work includes conducting research and development in counter-explosives technology, characterizing explosives and their blast effects, performing vulnerability assessments that highlight areas for improved defense, and identifying ways to harden buildings.

Our work to understand explosives properties led to the development of Sandia's patented advanced sample collection and preconcentration technology, now used in many applications. The hand-portable

explosives detector MicroHound™, for example, employs Sandia's sample collection and preconcentration techniques and microsensors to improve detection capabilities and lower unit costs. Sandia also integrated the technology into the design of a portal to detect trace explosives on people and in a vehicle detection portal. The personnel portal has been commercialized by Smiths Detection, and the vehicle portal is now under field test.

Other Sandia work is improving the nation's response and forensic capabilities. Sandia's Percussion-actuated Nonelectric (PAN®) Disrupter, for example, allows remote disabling of improvised explosive devices without initiating the explosives or destroying evidence. A Sandia-developed aqueous foam suppresses explosive blasts, reducing potential damage. In addition, through Operation America, Sandia has hosted workshops in advanced bomb-disablement technology for bomb squad personnel.

Safeguarding critical infrastructure

The nation's well-being depends on the smooth operation of vital infrastructure, including energy, communications, transportation, finance, water supply, agriculture, and emergency services. With growing automation, once-separate infrastructures are increasingly interdependent, and disruption in one sector—through a physical or cyber attack —can quickly cascade into multi-sector failures, imperil lives, and affect national security.

The National Infrastructure Simulation and Analysis Center (NISAC)—operated jointly by Sandia and Los Alamos National Laboratory—was established to provide an understanding of interdependencies among the critical infrastructures. Through modeling and simulation, NISAC is building expertise in infrastructure interdependency analysis and identifying potential vulnerabilities and consequences of disruption. This knowledge will enable better prevention and response planning, investment decisions, and first responder training.

Sandia has conducted wide-ranging risk assessments on behalf of many national agencies. Further, Sandia security experts have traveled the country to develop and apply security assessment methods and other risk-management tools for dams, power systems, government buildings, chemical plants, water supplies, and other infrastructure elements.

Notable studies include assessing the management systems and security practices of the U.S. Bureau of Reclamation, the nation's second largest producer of hydroelectric power. This project, which led to the integration of the latest supervisory control and data acquisition technologies at six hydroelectric projects, is now providing similar input for five additional dams.

Sandia also participated on a multi-lab team engaged by the NRC to analyze the consequences of specific terrorist threats on nuclear plants. Two ongoing plant-specific assessments are refining the insights gained in the initial study. Sandia has performed similar studies for NNSA and DoD facilities.

"Energy underpins our national security, economic prosperity, and global stability. Any interruption in the steady supply of electrical power, oil, or gas in the U.S. could have a crippling effect on our national security.

Water is also a key factor in global stability. Tied closely, too, are the supporting critical infrastructures that assure water and energy supply. The goal of Sandia's Energy and Infrastructure Assurance program is to enhance the safety, security, and reliability of energy and water through the application of science and technology. Sandia is providing solutions to the complex problems of supplying the nation with clean, abundant, and affordable energy and water."

Les Shephard
Vice President
Energy and Infrastructure Assurance

Enhancing the Safety, Security, Reliability of our Energy and Water

Energy, water, and security enabled by technology

It's no secret. While world resources are sufficient to satisfy demands for energy and water in the foreseeable future, challenges abound. They include environmental problems, political concerns, distribution of resources, and a myriad of other issues. Internationally, the relative scarcity of energy and water is a barrier to raising prosperity and a destabilizing influence. At home, the generation and delivery of these key resources require a vast inter-related network of circuits, wires and cables, pipelines, information, and services—all part of the nation's critical infrastructures. Sandia is at work to develop technologies and expertise to ensure those infrastructures remain secure and reliable.

Energy efficiency and renewable/fossil energy

Sandia has a long track record of providing assistance to the U.S. energy sector. Since the oil embargo of 1973, Sandia has recognized the link between secure and abundant energy and our national security. Sandia continues to develop technologies to boost production in petroleum, hydroelectric, geothermal and solar power, nuclear fission, and fusion. We continue to work with the oil industry to develop more efficient means of producing and extracting fossil fuels, using our knowledge of exploration

Sandia is joining forces with Stirling Energy Systems of Phoenix to build and test six new solar dish-engine systems like this one. Each system will provide enough solar electricity to power more than 40 homes.

technologies and reservoir-management practices. Sandia is taking a new approach as drilling reaches deeper and deeper to tap new gas and oil reserves, extending our high-temperature drilling technology developed in the geothermal industry. This effort involves bit design improvements, down-hole electronics, diagnostics-while-drilling technologies and broadband borehole telemetry systems.

Sandia and petroleum explorationists in Southeast New Mexico and West Texas have teamed on a three-year project to develop geophysical mapping and computer simulation tools to identify new reserves on the Central Basin Platform. A Texas study estimates potential reserves in the area as high as five billion barrels, straddling the two states. The relatively small and deeply buried reserves aren't detectable by conventional seismic techniques. Sandia researchers are applying mathematical approaches to the seismic data to better identify rocks with reservoir potential.

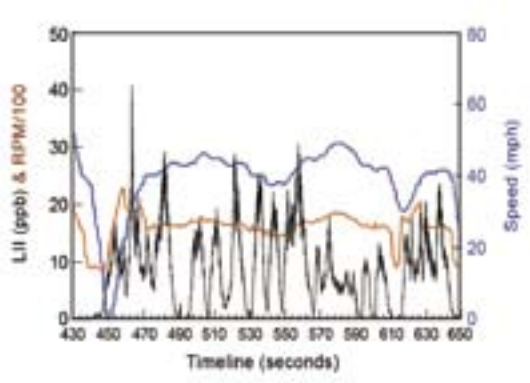
Sandia continues in the role of science and engineering advisor to the DOE's Strategic Petroleum Reservoir. This reserve, in 60 salt caverns along the Gulf Coast, helps ensure oil supplies during the nation's war on terrorism and in response to other threats. Sandia supplies the geotechnology and engineering needed to fill and update the existing facilities and to lay the foundation for potential future expansion. Further offshore we are working with a consortium of deepwater producers to model and manage issues relating to stability of deep wells, a new frontier for domestic production.

Sandia's Richard Steeper and Amelia Fayoux, of Peugeot-Citroen, at work in Sandia's Combustion Research Facility at the optically accessible single-cylinder HCCI engine.

Given that 85 percent of our nation's energy is produced by combustion, the design of more efficient, less-polluting combustion devices continues to be a national priority. At the Combustion Research Facility (CRF) in California, Sandia has studied ways to increase the efficiency and decrease the emissions of combustion sources, especially with diesel engines. In the years since its inception in 1979, CRF has become recognized as a world leader in state-of-the-art measurement and computational tools for application to combustion. Recent research includes:

- The 2007 EPA regulations for both light- and heavy-duty vehicles call for significant reductions in particulate matter emissions. To meet these requirements, industry has a critical need for new instrumentation capable of real-time measurements with high sensitivity.

Sandia's collaborative effort with the National Research Council Canada and Artium Technologies has led to Artium's development of a commercial instrument using laser-induced incandescence. The technology has been evaluated at test facilities at Ford and Cummins and on-board a diesel passenger car in collaboration with Chevron-Texaco.



Emissions data captured by LII method compared to engine speed (red) and vehicle speed (blue) show that fuel injection cycled on and off during this coasting descent.

- A new laboratory that allows researchers to study a promising new combustion concept for ultra-low emission, high efficiency engines came on line. The laboratory houses a single-cylinder automotive scale engine with extensive optical access. Researchers can use advanced optical diagnostics to study combustion occurring inside the cylinder. Called the Homogeneous Charge Compression Ignition engine, this alternative piston-engine can rival the high efficiency of diesel engines with low levels of nitrous oxides and particulate emissions.

- Sandia joined with four other national laboratories and 10 automotive engine manufacturers in an agreement to better focus research on a next-generation of efficient, clean engines. Research will investigate in-cylinder mixing, combustion, and emission processes relevant to advance engines. Conventional, non-petroleum, and hydrogen fuels will be included in the effort.

Sandia Center of Excellence for Hydrogen

Hydrogen is the dream fuel of the future. The DOE has selected Sandia to lead a virtual Center of Excellence for the development of reversible metal hydrides materials. A key objective will be to develop a class of materials capable of storing

Research team for evaluation of laser induced incandescence (LII) for measurement of real-time air emissions.

hydrogen safely and economically aboard a vehicle that can run for at least 300 miles before refueling. The virtual center consists of eight universities, four other national laboratories, and three industrial companies. Sandia is serving as lead laboratory and coordinator of research and development. It will undertake $30 million of research and development over the next five years. Additionally, we have been assigned the responsibility to provide the science needed to draft domestic and international codes and standards for hydrogen commercialization.

Energy research shows technological promise

Sandia's California site established the Distributed Energy Technologies Laboratory (DETL) to assist in the development and implementation of distributed energy resources. DETL tests microturbine, engine-generator, photovoltaic, fuel cell, and energy-storage technologies both individually and in a collective microgrid. Collaborators include manufacturers, utilities, DOE, DoD, the California Energy Commission, universities, standards organizations, and other national and private laboratories. Energy security is one of several important benefits that distributed energy resources will offer to the nation's electric power infrastructure.

Already, the DOE and the California Energy Commision are supporting integration of distributed resources into the energy infrastructure. Sandia is a member of a partnership to develop this integration. Our information technology and data visualization experts are developing a real-time control system to help electric system operators monitor voltage and frequency across the grid. At the same time secure communications and control technologies are also being developed to reduce vulnerability of the nation's electric system to cyber threat.

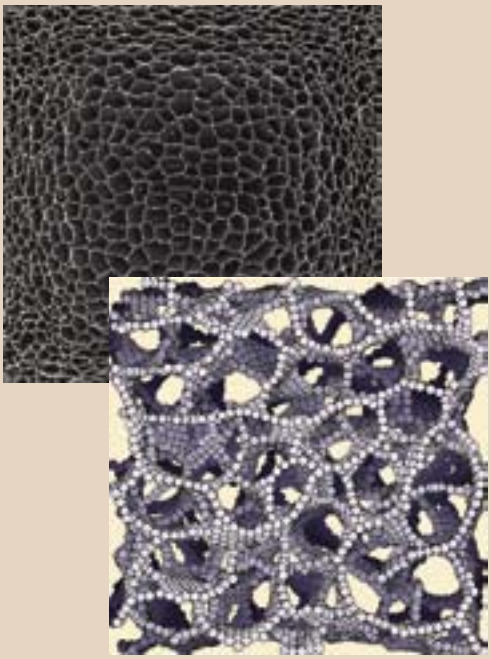
Sandia is working with industry, academia, and government to establish a national research initiative in solid-state lighting—the Next-Generation Lighting Initiative. Solid-state lighting uses light emitting diodes that are potentially as much as 10 times more efficient than incandescent and twice as efficient as fluorescent lamp technologies. Although not yet proven in all wavelengths, these diodes offer greater versatility and a longer lifetime. Sandia has completed editing a DOE Technology Roadmap for this important project.

Nanoscience: for energy and the environment

DOE Office of Science research has shown that nanotechnologies have great promise for innovative materials that will positively impact our energy and environmental problems.

The Office of Science funds many Sandia energy research projects. Nanotechnologies hold great promise, just as in Sandia's other mission areas. Construction began on the Center for Integrated Nanotechnologies, jointly operated by Sandia and Los Alamos national laboratories. The center will provide tools and expertise for integrating the world of nanoscale materials and devices with other technology scales. This expertise will be available "outside the fence" to university, industry, and government laboratory researchers.

A number of advances have already been made. By directing the assembly of nanoparticles in suspensions by the application of magnetic and electric fields, Sandia scientists have created not a single class, but classes of tailorable materials that have no counterparts in nature. These materials have strongly enhanced magnetic, dielectric, mechanical and thermal properties. Once assembled, the suspensions are polymerized to freeze the structures.



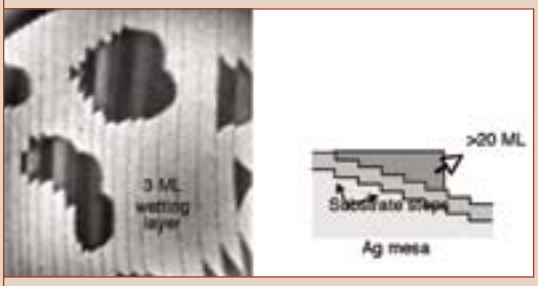
A composite structure formed by a triaxial magnetic field. We have demonstrated the use of these composites in ultra-sensitive chemical, stress, temperature and motion sensors, actuators, and super capacitors.

The work has combined experiments, theory, and simulations in novel ways and is receiving high recognition for its originality and innovativeness. Sandia has demonstrated the use of these composites in ultra-sensitive chemical, stress, temperature and motion sensors, and in actuators and supercapacitors. Other novel applications include tamper-proof, two-level memories, artificial muscles, filtration membranes, super-magnetostrictive or -electrostrictive elements, particle patterning, and microfluid stirring.

Sandia is using engineered defects and newly developed analytical techniques to unravel the mysteries of how localized corrosion begins in aluminum. We are generating mechanistic information by comparing the characteristics of nanometer-length scale degradation processes in synthesized protective oxide structures with those in actual alloy systems. This knowledge is a critical component in our ongoing effort to develop predictive models of materials aging.

Through low-energy electron microscopy (LEEM) observations, we have discovered a fundamentally new mechanism by which thin films can "de-wet" their substrate. A long-standing mystery has been how thin film islands can thicken upon de-wetting since there is a large energy barrier to creating new surface steps. Our experiments have shown that thin film islands can avoid this barrier by moving laterally down a "staircase" of atom-high substrate steps. This entirely unanticipated result suggests strategies by which nanoscale thin film islands may be controlled by manipulating the density of atomic-scale steps in the underlying substrate.

Researchers also used the LEEM real-time imaging technique to analyze how a surface of reactive titanium oxide responds when the ambient oxygen concentration is varied. Increasing the oxygen pressure caused atomic steps on the surface to advance. The crystal grew when the gas-



Low-energy electron microscope images like this one have suggested strategies by which nanoscale thin films may be controlled by manipulating the density of atomic-scale steps in the underlying substrate. Shown are silver film islands on a stepped ruthenium substrate.

phase oxygen reacted with excess titanium stored in the form of interstitials. Quantitative analysis revealed that the local rate of crystal growth was strictly proportional to the local length of steps. That is, crystal growth only occurs when oxygen reacts with titanium near a step.

In cooperation with our Science, Technology and Engineering unit, the Genomes to Life (GTL) project is developing computational methods and capabilities to advance understanding of more complex biological systems and predict their behavior. The Sandia-led GTL project includes participants from four DOE laboratories, three universities, and four institutes with diverse backgrounds ranging from biology to physics to mathematics. The goal of the project is to better understand carbon-fixing microorganisms in the ocean and their response to man-made increases in carbon pollution.

The water initiative

Global scarcity of fresh water and subsequent instability are being described as the next great flashpoint, much like the role oil played in the 20th century. Sandia's water-management initiative seeks solutions to the challenges facing our nation's water infrastructure—challenges of scarcity, systems vulnerability, quality, and the economics of supplying drinkable water.

The dark bands are atomic steps on a TiO2 surface as observed by low-energy electron microscopy. The closed islands are spawned from the two dislocation spirals. Field of view is 5 mm

The initiative focuses on monitoring water quality, assessing infrastructure security, providing treatment technologies, and supporting international cooperative water management. These areas of concern are addressed through a variety of programs. Sandia, in cooperation with the American Water Works Association Research Foundation and the EPA, developed security risk-assessment methodology for assessing the surety of water utilities. This water infrastructure assessment tool has been employed to evaluate security and mitigate risks at more than 90 percent of

The Tularosa Basin National Desalination Research Facility in Alamogordo, now in the early stages of construction, will be a focal point for advanced research projects. Sandia worked with the Bureau of Reclamation to develop a conceptual design for the facility.

the largest U.S. cities, serving an estimated 130 million consumers.

Purification of Earth's saline water (more than 97 percent of this planet's water) could provide relief to a growing demand for fresh water that already outstrips supply in many parts of the world. Sandia, in cooperation with the U.S. Bureau of Reclamation, has taken a two-pronged approach: 1) a research and development roadmap defining a path through the year 2020 that will support solving our water supply-related needs by advancing water desalination technology; and 2) building of a research facility in Alamogordo, New Mexico, in the Tularosa Basin, to test and evaluate novel desalination technologies. Now under construction, the 16,000-square-foot facility will be a national center for research that involves the removal of salts in brackish ground water. The facility will also look at the use of renewable energy, such as solar and wind, for water treatment.

Community-based management of water resources is a key to using every drop wisely. Sandia has developed a dynamic simulation model of the hydrology, demography, and economy in the Middle Rio Grande Basin and applied it to helping stakeholders understand the ramifications of trade-off decisions, from chosing crops to providing water for the endangered silvery minnow. Our cooperative modeling process bridges the technical demands and capabilities of a rigorous, quantitative model and the collaborative social processes required for community-based management. For researchers the next step is extending the use of this valuable tool to help resolve regional and international water disputes around the globe.

The global nuclear future

As the world comes to grips with the energy challenges of the 21st century, it becomes clear that nuclear power will be vital to the global energy future. To regain U.S. leadership in the energy field, an integrated energy, nuclear leadership, and national security policy must be developed, recognizing inter-relationships between all aspects of nuclear energy and our national security.

"Global Nuclear Future" is a Sandia vision, now shared by many others, about how nuclear energy can serve our requirements for domestic energy security, global national security, nonproliferation, and nuclear materials management.

We are highly involved in a joint effort between Russian and American scientists to help policymakers and technical entrepreneurs understand the issues and opportunities posed by nuclear power. In the U.S., Sandia and a group of seven national labs reached out to bring energy and manufacturing companies into the vision, with a meeting and discussion of issues at mid-year. Later, laboratory directors from both Russia and the U.S. met in Vienna, Austria, to chart out a path to gain political and public support.

Nuclear safety

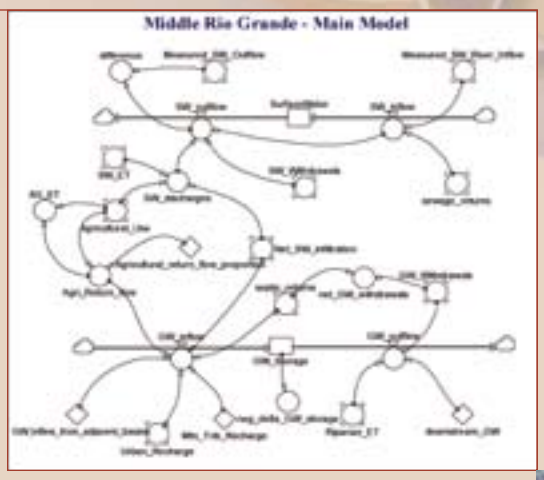
Sandia's blend of modeling, analytical, and experimental capabilities, combined with expertise in risk assessment for nuclear power plants has put us in a lead position in working with the NRC on a variety of projects. Sandia is using its knowledge of reactor safety to help DOE and industry

identify research to help maintain safe nuclear power plant operations throughout the lifecycle. Current focus areas include fire risk, severe accident modeling, human factors analysis, risk assessment applications, analysis of containment and storage casks, spent nuclear fuel transport, and vulnerability assessment for reactors, fuel cycle facilities and spent fuel.

Sandia is assisting NRC with risk-informed regulations to improve power plant safety for current plants and in developing a regulatory framework for the next generation of nuclear power plants. We are an international leader in severe accident sequence modeling. Our MELCOR computer code provides comprehensive modeling capability for nuclear plants and is currently being extended to model advanced reactor designs.

Two international research projects involve: 1) advanced monitoring techniques to detect possible failures and help with maintenance of reactors for South Korea, and 2) development of a sulfur-iodine process to produce hydrogen using high-temperature nuclear plant heat for France.

High-temperature reactors have greater efficiency with vastly reduced amounts of waste and lower risks of producing weapons-usable materials. Beneficial by-products of these reactors are the high-temperature production of hydrogen and the energy to desalinate water. Sandia is involved in programs to develop the capabilities to produce both hydrogen and desalinated water (see "Water initiative" page 67). Sandia is coordinating a multi-lab effort that will guide nuclear hydrogen research, investigating processes that can be coupled with high-temperature reactors.

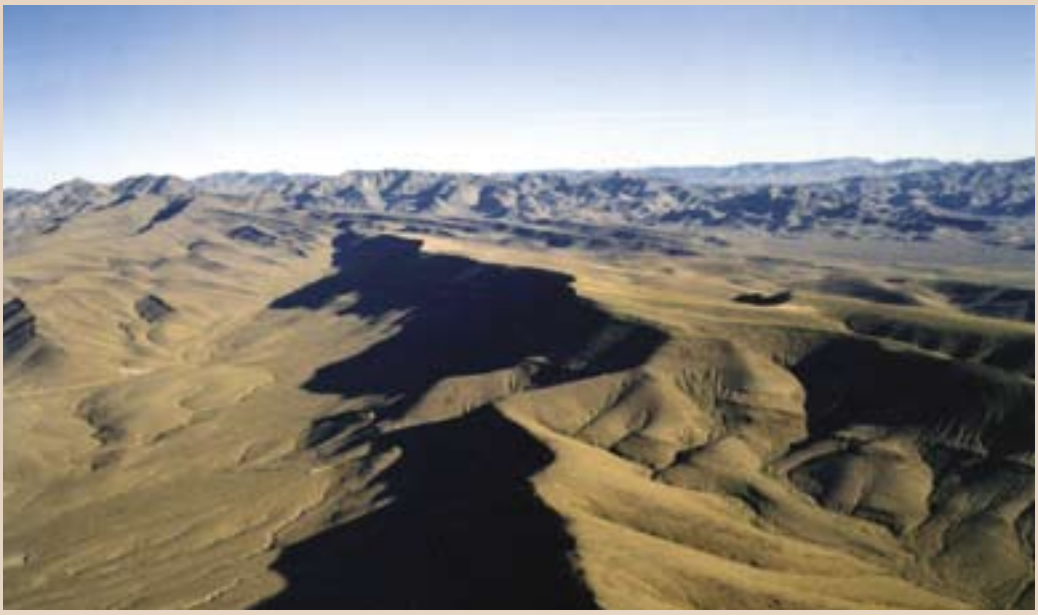


Community-based management, recognizing technical and social issues, is a key to resolving water problems and maximizing the use of water resources. Sandia worked with government agencies and citizen groups in the Middle Rio Grande Valley to create a model to aid in decision-making.

Nuclear materials transportation

Sandia demonstrated a wireless instrumentation system, which couples power and data, allowing instrumentation of sealed containment vessels for nuclear materials. The power and data are coupled through the container walls via magnetic coupling between concentric coils inside and outside the canister. This technology supports the goal of ensuring safe transportation of nuclear materials and eliminating costly individual container inspections. Bench testing has demonstrated the feasibility of transferring energy and data through multiple walls of stainless steel and lead. Future development will require high temperature electronics to measure hydrogen content, pressure, and temperature,

Sandia manager Tom Sanders (right) confers with Sandia President C. Paul Robinson at an international meeting of Russian and U.S. laboratory directors, held in Vienna, Austria, to map out a path forward for promotion of safe and clean nuclear power around the globe.



Yucca Mountain is the proposed permanent repository for high-level radioactive wastes, including spent fuel rods from nuclear reactors. The site, mostly buried beneath this mountain, is 100 miles north and west of Las Vegas, Nevada.

Ron Price examines shards from a large block of Yucca Mountain volcanic rock tested for strength at his laboratory in Albuquerque. His work provides critical information for developing design and performance standards for the repository.

and to add electronic identification to each containment vessel.

Waste legacy

While the 2004 political campaigns brought claims and counterclaims about the feasibility of the nation's first high-level waste and spent nuclear fuel geologic repository, research by Sandia engineers continued. Following a site recommendation from the Energy Secretary, approved by congress and the president in 2002, Sandia and other research institutions sharing scientific responsibilities at the site began the effort to assemble a license application to the NRC. Engineers at Yucca Mountain continue to press to meet a demanding schedule for repository data to satisfy the licensing process. High quality data and analysis are requisite for licensing success and public assurance. Sandia directly contributed to a monumental body of work with defensible analyses of site performance, for a decision of national importance affecting America's national and energy security.

Meanwhile, our participation in the DOE's Advanced Fuel Cycle Initiative is aimed at developing spent fuel treatment and transmutation technologies to enhance the performance of the proposed repository and reducing the costs of geologic disposal. Working with five other labs as integrator, Sandia is providing systems analysis for the program.

Sandia and Lockheed Martin Missile and Fire Control (LMMFC) in Orlando, Florida, forged the first-of-a-kind agreement with the government of the Republic of China (Taiwan) that makes a win-win situation for the three entities. Sandia will provide technology to Taiwan's geologic repository science program, thereby helping Taiwan maintain its nuclear power program and safely dispose of its spent nuclear fuel. LMMFC will fund Sandia's work and simultaneously earn credit toward Lockheed's contractual obligations to the Taiwanese government.

Strengthening Our Communities

Supporting economic growth

Sandia continues to make a concerted effort to support local and regional small businesses and to partner within the communities where we live and work. In cooperation with Lockheed Martin Corporation, our operating contractor since 1993, we work in the development of growth strategies, workforce and transportation issues, and leadership programs.

Sandia's impact on New Mexico's economy is approximately three times the total of the money that Sandia spends for salaries, purchases, and taxes. Each of these dollars funds additional jobs, purchases, and investments that promote economic growth. The total economic impact on New Mexico is approximately $5.7 billion. In addition to the average of more than 8,000 on-roll jobs created by Sandia, other jobs are supported by needs for goods and services and re-spending by individuals and businesses. The result is a total impact of about 32,300 jobs.

In Fiscal Year 2003, Sandia committed to purchasing $866 million of good and services. Of the total, $408 million, or 47 percent, was placed with New Mexico businesses and $292 million, or 71 percent of New Mexico commitments, were with small businesses.

Science education

Sandia's commitment to education focuses in the areas of leadership, student

Sandia supports the Marylin Avenue Elementary School reading program, in Livermore, California, and many Albuquerque, New Mexico, schools by donating children's books from their own libraries and adding bilingual books and classics to the collection.

"We at Sandia take pride in being part of our communities. We benefit tremendously from our partners and friends in our communities, and we proudly give back through our commitment and service. We support small and minority-owned businesses in New Mexico, California, and across the nation with contracts for challenging scientific work that enhance local economies as they help our national missions.

The people of Sandia National Laboratories have a long tradition of service in their communities. With support and encouragement from Lockheed Martin Corporation, our service and partnerships in the community have increased dramatically."

Joan Woodard

Executive Vice President and Deputy Director

engagement and achievement, professional development, continuous improvement, and focused corporate gifts and grants.

Leadership

Our management and staff have provided leadership as chairpersons in organizations supporting education, such as the Albuquerque Business Education Compact (ABEC), Albuquerque Hispano Chamber of Commerce, Greater Albuquerque Chamber of Commerce, the New Mexico Business Roundtable for Educational Excellence, the Livermore Chamber of Commerce, the Tri Valley Technical Consortium and the Tri Valley Business Economic Council. We provide leadership as well in programs such as Join a School, Youth Leadership, and the ABEC "Read to Me" program.

Student engagement and achievement

Our efforts in elementary schools focus on making science fun and engaging children and their families. Sandia hosted more than 50 Family Science Nights during the school year; this program was expanded to two Livermore (California) elementary schools in Spring 2004. Sandia also offers a Fun in the Sun summer science program at local community centers. The National Atomic Museum summer science camps attract more than 400 children each summer, and its Up 'n' Atom Mobile serves more than 20,000 students throughout New Mexico.

At the middle and high school levels we have partnered with schools and local governments and businesses throughout New Mexico to establish a successful career day for 8th and 9th graders called "School to World." Now in its sixth year, it attracts more than 2,200 students and presents more than 150 different careers. More than 30 Sandia speakers encouraged 8th graders to take a more rigorous course of study in high school, in partnership with the New Mexico State Scholars program. We sponsored new Math, Engineering, and Science Achievement chapters at Albuquerque middle schools, and a high school math, science, and engineering essay contest with awards of $2,000 in U.S. savings bonds. Our Photonics Academy has trebled in size to 89 freshmen next school year—Albuquerque is unique in the country, offering a Photonics education and career ladder than spans middle school through Ph.D level.

A Sandia-sponsored Microtechnology Academy was piloted at Bernalillo (New Mexico) High School in Fall 2004. Currently, there are 620 students participating in our year-round Student Internship Program.

In California, the Association of Women Engineers sponsors an essay contest for high school age women. We support this event with volunteers who mentor students and judge the essays. Other programs we sponsor include the Math and Science Awards, aimed at junior-level high school women for their excellence in math and science; Go Figure for elementary, middle, and high-school-age students demonstrating math and comprehension abilities; and Expanding Your Horizons. Our California site also recognizes a Las Positas College (Livermore, California) student who shows extraordinary work in community service.

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.

Professional development

Sandia donated $2000 to all 11 comprehensive high school science departments in Albuquerque and $350 to alternative high schools—to purchase much needed equipment such as microscopes, balances, and computerized analysis equipment.

In support of National Board Certification for science and math teachers at the middle and high school levels, Sandia is providing fees, mentors, and coordination of a statewide network of Board Certified teachers. We have also supported the re-establishment of the Albuquerque Science Teachers Association.

An Albuquerque student learns about static electricity at Space Day activities at the Labs' National Atomic Museum. Sandia's philosophy is that active participation in a variety of educational partnerships and programs will strengthen our future through the success of our students.

Our Excellence in Science Teaching Awards (ESTe) program has recognized 37 outstanding science teachers in New Mexico since its inception in 2001. The program will be expanded to California in 2005. Our California site already partners with Teaching Opportunities for Partnering in Science (TOPS) program through training the elementary and middle school volunteers and sharing science projects to enhance the student learning.

Continuous Improvement

Sandia continued its longstanding support of a New Mexico state initiative, Strengthening Quality in Schools, which provides expertise needed to develop a world-class education system in New Mexico. The program is training more than 700 educators in 116 districts, schools and universities statewide to use the Baldrige Criteria and Quality Concepts in their efforts to improve student achievement.

More than 300 volunteers built Sandia's fifth Habitat for Humanity house. Lockheed Martin Corporation provided the funding.

New Mexico employees donated more than $16,000 to the Shoes For Kids program, a Sandia tradition since 1959.

Focused corporate gifts and grants

Lockheed Martin Corporation on behalf of Sandia donated more than $2 million to non-profit organizations in support of educational initiatives and programs during the year. In addition to the programs described above, we support programs to encourage family literacy in preschool, to purchase school supplies and uniforms, and to assist local museums. Funds directed toward students include Jr. Achievement, Science Bowl, Science Fair, MathCounts, New Mexico Adventures in Supercomputing Challenge, and the Science Olympiad.

Likewise in California comparable programs benefit from the Gifts & Grants program, including an annually selected Las Positas College student, who is recognized for community service work.

Service in the community

Since 1993, Lockheed Martin Corporation has donated more than more than $16 million to local cultural, educational, and human services groups, emphasizing Sandia's engagement with its communities. This has meant a greater participation by Sandia employees serving on community boards, chambers of commerce, service clubs, and museum foundations. We also have expanded the grassroots participation of our staff in volunteer efforts for community charities.

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 nearly $2.5 million, Sandians in Livermore and Albuquerque have now attained four straight years of donating more than $2 million to local United Way and other charitable agencies. New Mexico employees contributed $2.25 million; Sandians in California, through the Livermore Employee Assistance Program, donated $233,000.

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Sandia National Laboratories

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