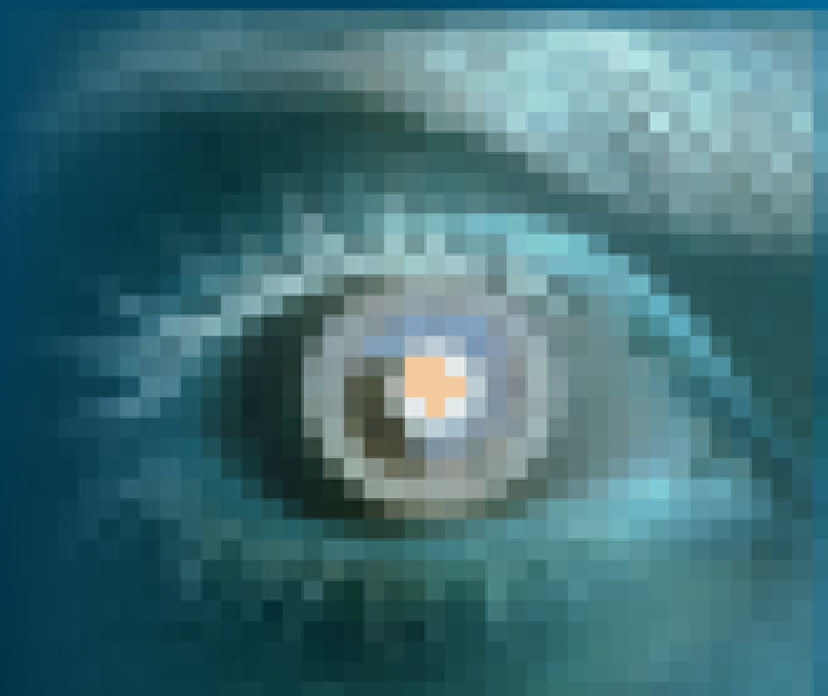
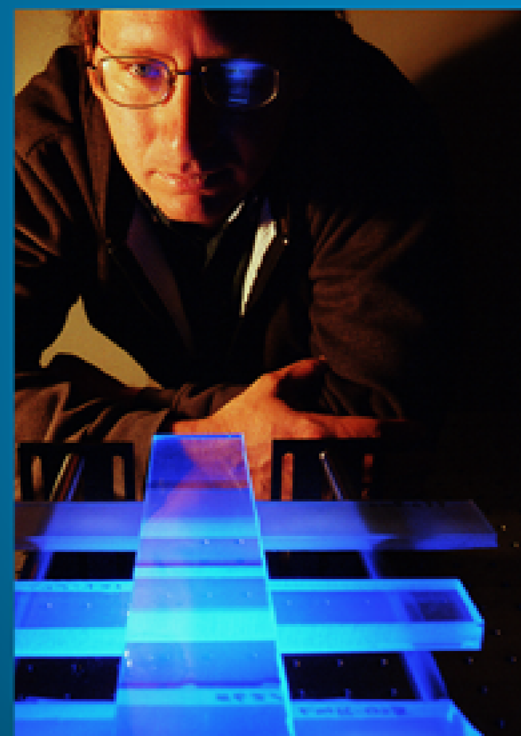
SANDIA Annual Report 2000



PERSPECTIVES ON SCIENCE AND TECHNOLOGY



Sandia National Laboratories

A Department of Energy National Laboratory

SANDIA Perspectives

WITH AN EYE TO THE FUTURE

Sandia National Laboratories' enduring mission is to provide science and engineering support for the nuclear weapons stockpile. That mission has expanded over the years to include other aspects of national security, such as mitigating the spread of nuclear, chemical, and biological weapons, and preventing the disruption of critical infrastructures, such as energy supply, communications, and financial networks. With an eye to the future, Sandia will continue to apply the power of technology and scientific discovery to ensure America remains strong and secure.

Contents

A Year of Extraordinary Challenges, Remarkable Achievements

The past year presented the nation's nuclear weapons program with extraordinary challenges—budget uncertainties, technical difficulties, a disastrous wildfire surrounding Los Alamos, and continuing security challenges. For Sandia National Laboratories it also was a year of remarkable achievements. Our people persevered and rendered another year of "exceptional service in the national interest," a maxim rooted in our origins and a principle that remains very much alive today.

Sandia's nuclear weapons mission requires extraordinarily strong science and technology, and dedication and focus from every Sandian. We continuously seek great improvements in all of our programs. This year, we achieved significant science and engineering advancements in our traditional nuclear weapons work, control of nuclear materials worldwide, and nonproliferation efforts, and we advanced efforts in countering emerging threats to the nation, protecting of our energy resources and critical infrastructures, and strengthening our nation's technological competitiveness.

Sandia produced many fundamental advancements, from world records in computing to the laboratory production of concentrated X-rays that mimic the nuclear weapons environment. Sandia scientists and engineers achieved major improvements in materials sciences, as well as at the component level in electronics and photonics, and in the development of new robots and satellites that are serving as extraordinary platforms for microsystems-based sensors. These developments increase the safety, security, and reliability of the U.S. nuclear arsenal, and more broadly, improve our nation's security in areas as diverse as warfighting, nonproliferation, homeland security, and industrial technology excellence.

Sandia's work force is remarkably talented and dedicated to serving the nation. Many of our thousands of scientists and engineers continue to receive professional awards and honors each year. Our support staff—our too often unsung heroes and heroines—are producing world-class results, from bringing on-line a commercial financial management system to tearing down and decontaminating outdated buildings and spaces. We have built a first-class facility to conduct the best science and engineering in the world and to attract the best science and engineering talent for the future.

Sandia's exceptional service to national security has helped bolster the nation's prosperity and technological excellence. Our research and development has fueled many of today's industries through partnerships that also strengthen Sandia's ability to fulfill its mission for the U.S. Department of Energy.

We invite you to learn more in the following pages about the many ways Sandia's people are contributing to our national security and well-being.

C. Paul Robinson

C. Paul Robinson,
President and Laboratories Director

Joan B Woodard

Joan Woodard,
Executive Vice President and Deputy Director

Guardians of Our Nuclear Arsenal

Sandia is first and foremost a steward of our nation's nuclear stockpile. Today, as in the past, a fail-safe nuclear deterrent is a vital part of U.S. policy for minimizing the nation's vulnerability to attack. Assuring the safety, reliability, and capability of the nuclear deterrent remains our primary mission.

We focus our missions on national security and future-related challenges that face this nation.

SANDIA APPLIES ADVANCED SCIENCE AND ENGINEERING to detect, repel, and defeat national security threats. Our national security mission has grown from responding to the threat of the Cold War to countering a host of less well-defined threats—some nuclear, some not. We develop technologies to prevent the spread of weapons of mass destruction, protect our national infrastructures, and defend our nation against emerging threats such as terrorism. The U.S. nuclear weapons stockpile requires fail-safe engineering and the integration of nuclear weapons with their delivery systems. Sandia researches, designs, and develops 95 percent of the approximately 6,500 components of a modern nuclear weapon.

Sandia's mission will continue to evolve during the 21st century. Sandia's strategic plan has been developed in consultation with our industrial and academic partners and national experts to reflect the challenges of the next half-century. We focus our missions on national security and future-related challenges that face this nation. Sometimes we forget how national security affects our everyday lives. But as we've seen during the second half

Weapon test drop from the B2 bomber.

of the 20th century, a nation relatively safe from catastrophic attack can concentrate on economic strength and quality of life.

In late 1999, Sandia completed start-up of its neutron generator production facility. The first 24 W76 neutron generators were fabricated and accepted by the Department of Energy 60 days ahead of schedule. They were the first neutron generators produced since the Pinellas Plant closed in 1994. Sandia plans to double its capacity to produce neutron generators by FY 2004, providing the nation with the capability to produce enough neutron generators to maintain the current stockpile indefinitely.

Meeting the Challenge

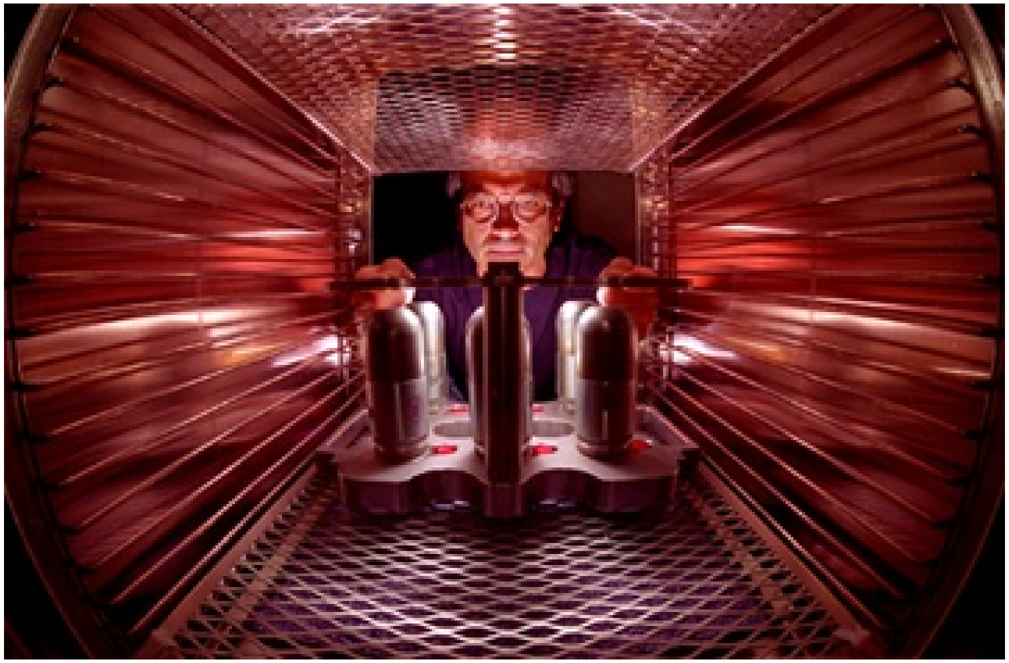
Some of the challenges we faced this year came from the transfer of responsibilities from the production complex to Sandia. We also achieved many successes in our work within the stockpile stewardship program.

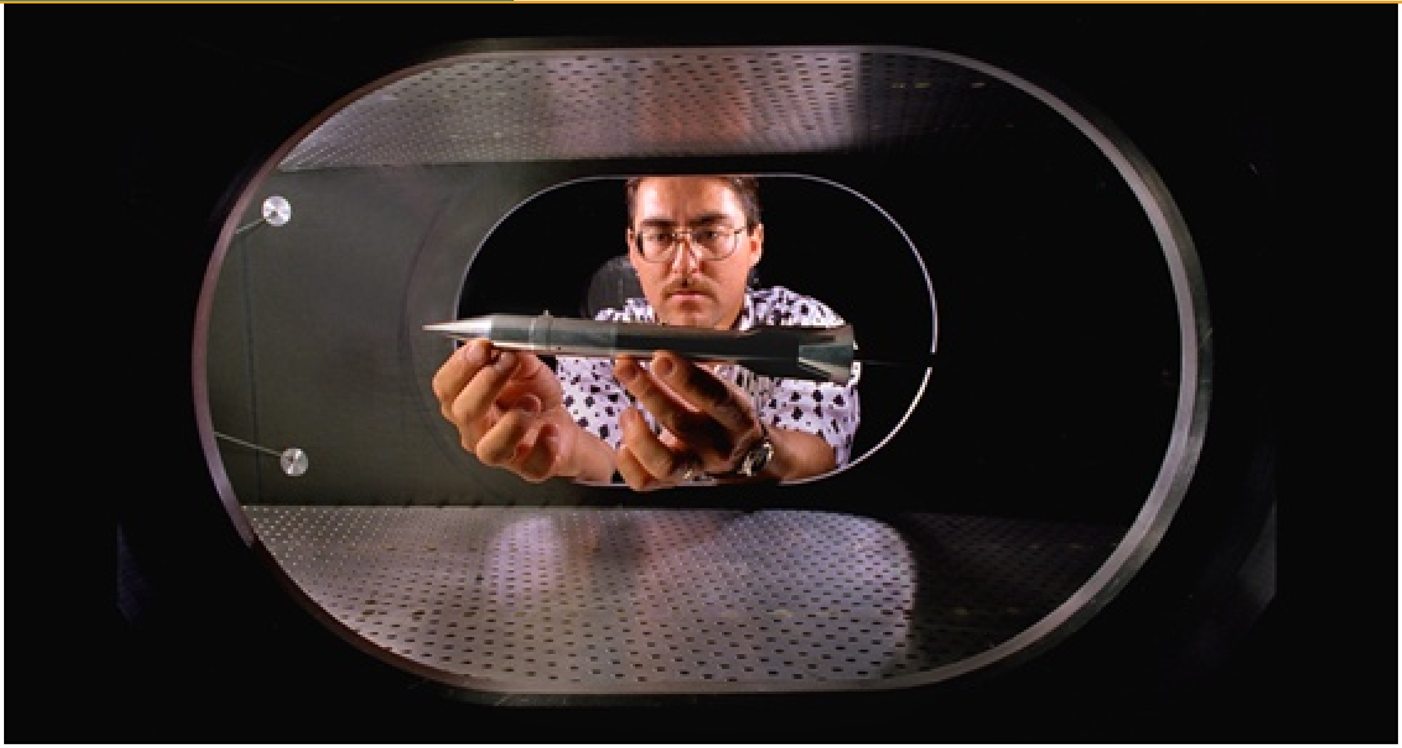
A few examples of our accomplishments:

- We rapidly redesigned, validated, built, and shipped special thermal batteries after a vendor's production lot failed—and we still met the product deadline.
- We are cutting procurement times for specialized forgings from two years to as little as six months.
- Nearly a year's worth of production of special components—and $10 million—was saved by a new Sandia manufacturing process.
- Engineers conducted missile flight tests with warheads that had their nuclear material removed. These joint test assemblies carried a full suite of instrumentation so that data measuring warhead performance could be transmitted instantaneously to engineers on the ground without interfering with vehicle dynamics. The flight of the W76 warhead test vehicle was a major development in enhanced-fidelity instrumented units.
- We supported retrofits and improvements of the enduring stockpile systems to extend the life of the W87 warhead on the Peacekeeper; an improved radar for the B83 bomb; safety and use control upgrades for the B61 tactical bombs; and a strengthened center case for the B61 earth penetrator.

We continued to improve the accuracy of tests that verify, in the absence of nuclear testing, the safety and reliability of weapons in the stockpile. Many of these tests relied on modeling and simulation provided by high-performance computing.

Neutron generator tubes.





Sandian Ken Chavez holds a wind-tunnel model of the B61-11 weapon.

Improved computer modeling, laboratory testing, materials characterization of the aging process, and enhanced fidelity instrumentation for flight tests are all portions of this (stockpile surveillance) program.

- Sandia developed a new Code Management System, which will provide modern, encrypted use-control technology for EUCOM (European Command), and follow-on usage at the Pantex facility and Department of Defense bases in the United States.

- We supported the engineering and cost studies for the life-extension refurbishment of the W76 Trident and the W80 cruise missile warheads.

- Sandia supported the dismantlement of retired weapons at the Pantex Plant, and the characterization of the components and materials for final disposition. In conjunction, we supported the hazard analysis of safety issues at Pantex, including lightning protection.

- We continued development of advanced weapon system and component options, including advanced firing systems, advanced navigation, guidance, and control systems.

- We supported the DOE stockpile surveillance program to perform laboratory and flight tests to ensure the reliability of the stockpile, and led efforts to define the enhanced surveillance program of the future. Improved computer modeling, laboratory testing, material characterization of the aging process, and enhanced-fidelity instrumentation for flight tests are all portions of this program.

- During January 2000, tests that are key to certification of the W76 Acorn gas transfer system were successfully conducted at Sandia's Annular Core Research Reactor. Initial evaluation of the required data from the tests favorably supported certification of the W76 Acorn to the stockpile.

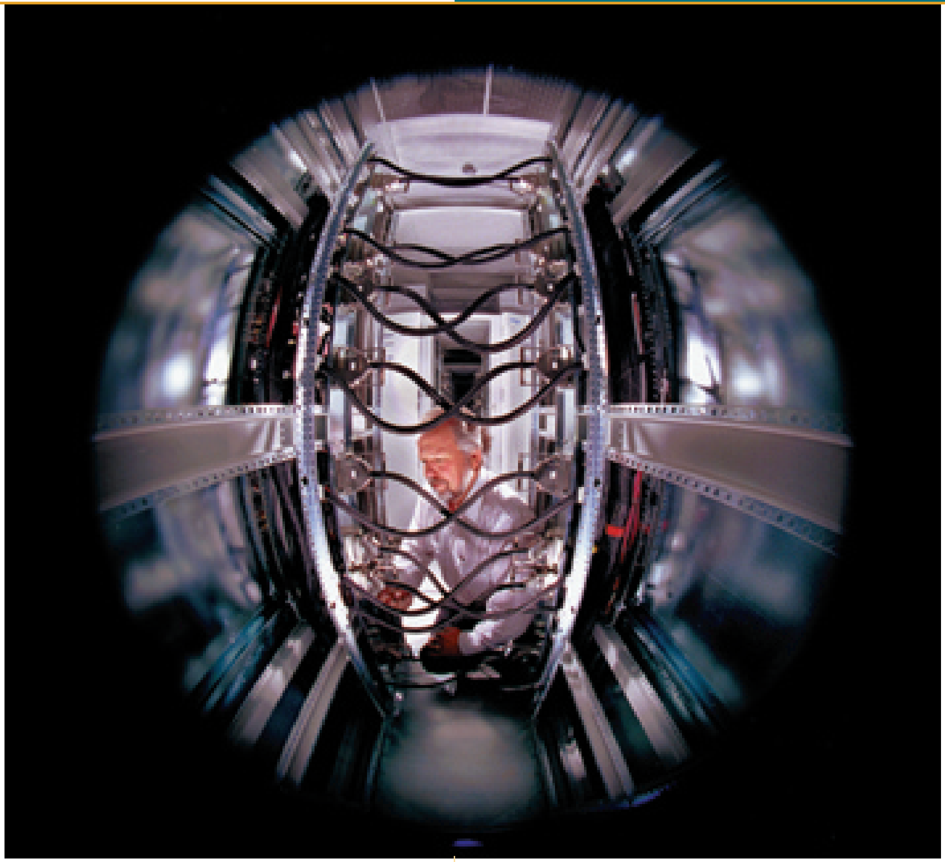
- We completed fabrication of a second-generation data-acquisition chip. This integrated circuit contains a 16-bit analog converter and data compression, which allows us to build smaller instrumentation modules. The chip is a key component in developing distributed telemetry systems, allowing for higher fidelity flight tests.

• Sandia completed major capability upgrades at the Weapons Evaluation Test Facility at Pantex. The upgrades included test program verification of a small electrical centrifuge, now used on the B61; and redesign and test program verification of a new W87 laboratory test bed, allowing higher fidelity of data, more accurate construction, and a reduction in build time by more than 50 percent.

Our stewardship program spans virtually every scientific and engineering capability within our laboratory. To meet our stewardship responsibilities, we must monitor and upgrade aging nuclear weapon systems to ensure they are safe, secure, and reliable. We certify the nuclear stockpile annually and will continue to do so. As one of the nation's premiere scientific institutions, we will keep developing new capabilities, tools, and knowledge to carry out that vital function.

Pushing Computing to New Limits

Weapons development has spurred a 50-year partnership with the computer industry. This partnership has produced today's explosion of computing power, now progressing with rapid leaps under the DOE's Accelerated Strategic Computing Initiative (ASCI). The goal of ASCI is to develop computing power that can provide the numerical simulation capability needed to model the safety, reliability, and performance of a complete nuclear weapon from start to finish. Joining Sandia in this effort are Los Alamos and Lawrence Livermore national laboratories. Such high-fidelity computing power enables design and certification of the nuclear stockpile without expensive and sometimes unavailable or undesirable testing. The initiative will help establish computer modeling and simulation as a new foundation of science and engineering, helping scientists do such widely diverse things as developing new drugs, forecasting the weather more accurately, and configuring more flexible and efficient manufacturing methods.

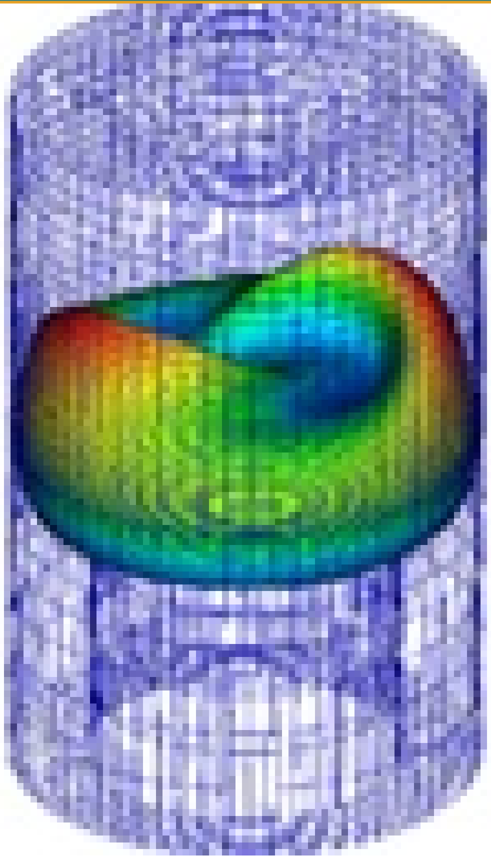


The ASCI Red supercomputer.

Among our other recent achievements in this area:

• The most persistent problem of the computer age has been oceans of data, but only a few drops of understanding. This year, we opened state-of-the-art visualization centers in California and New Mexico. The centers provide Sandia scientists and engineers with an unprecedented ability to visualize complex data sets and to

We upgraded our teraflops computer—which held the record for most of the year as the world's fastest computer at 2.4 trillion operations per second.



Computer simulation of chemical vapor deposition (CVD), a widely used method for depositing thin films of a variety of materials. CVD applications range from the fabrication of microelectronic devices to the deposition of protective coatings.

collaborate on weapons designs and other advanced engineering projects with remotely located team members.

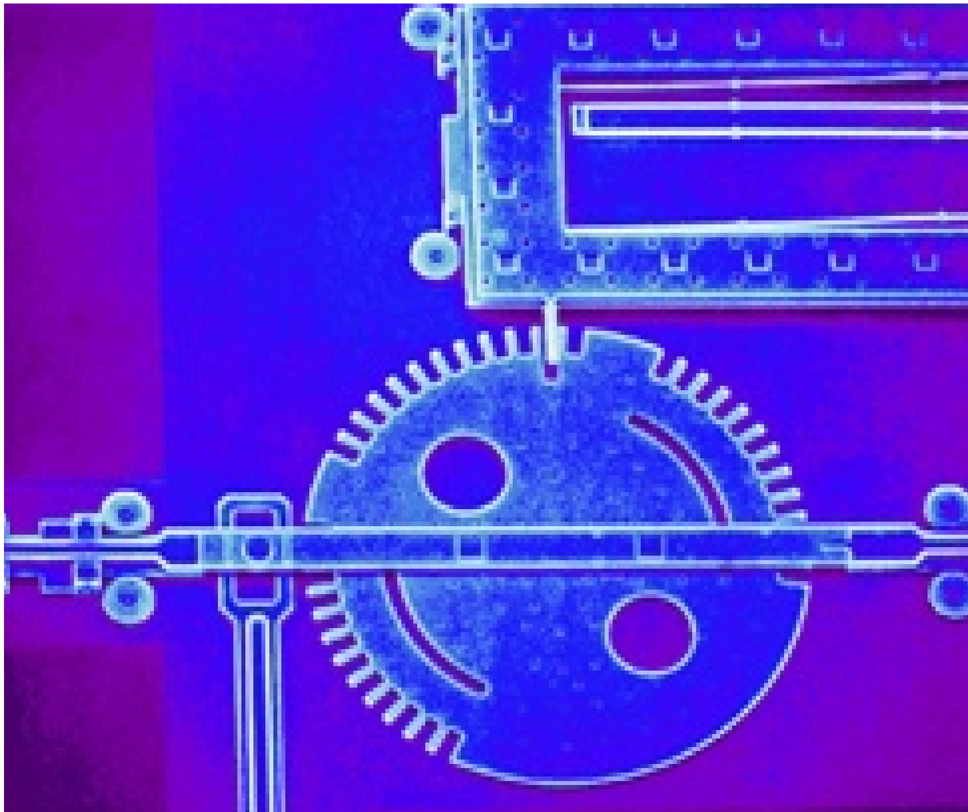
- We upgraded our teraflops computer—which held the record for most of the year as the world's fastest computer at 2.4 trillion operations per second— with commodity parts for a nearly 40 percent performance improvement at approximately 15 percent of the original cost. This represented a nearly 10-fold cost-to-performance improvement.

- We continued to improve the accuracy of tests that verify, in the absence of nuclear testing, the safety and reliability of weapons in the stockpile. Many of these tests rely on modeling and simulation provided by high-performance computing.

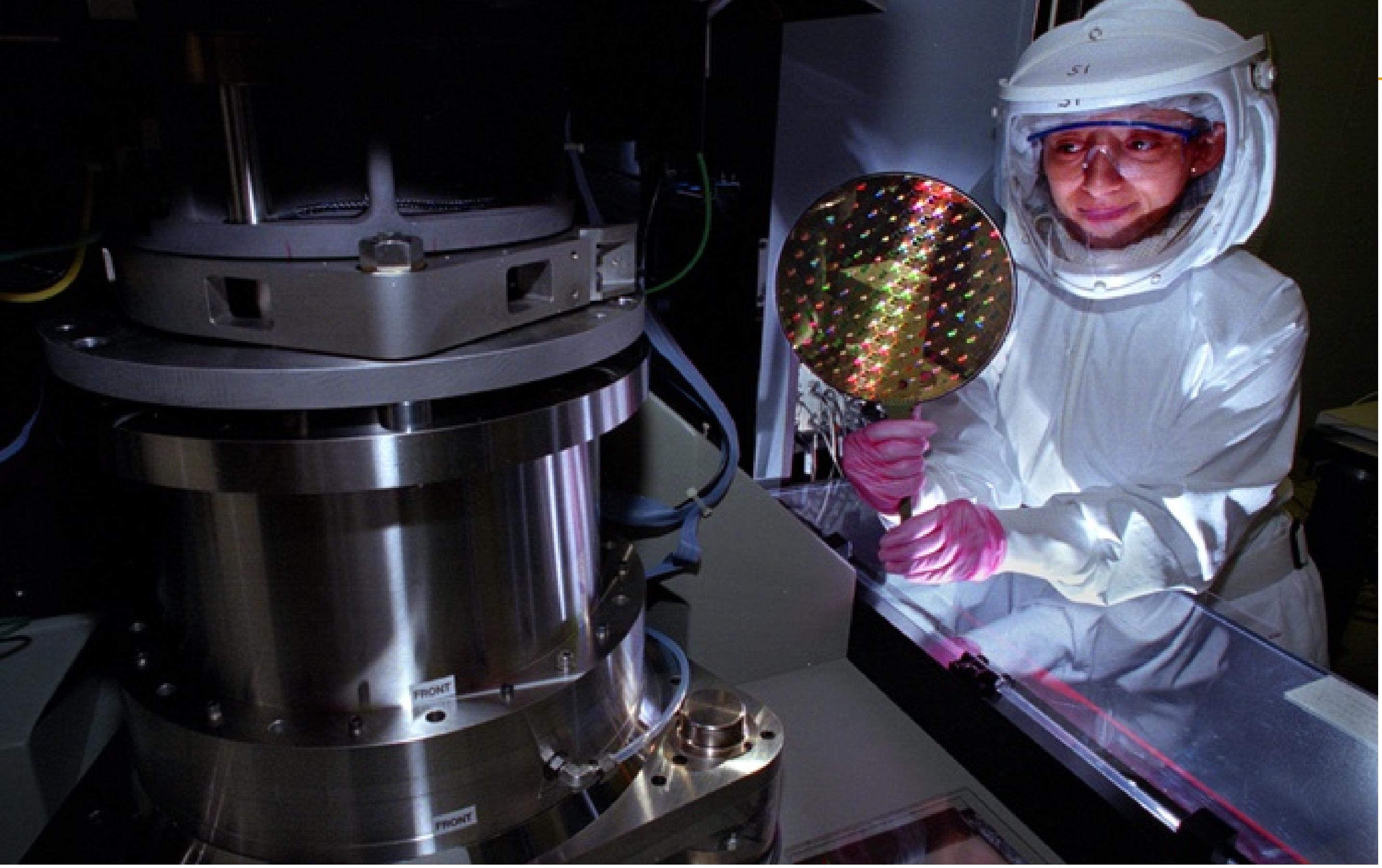
- One of our prize-winning technologies this past year was a data-encryption system on a single,integrated circuit chip. Encryption scrambles information so that it is incomprehensible to anyone without the cryptographic key. Sandia's approach encrypts data at 6.7 billion bits per second, more than 10 times faster than any other encryptor. This development will be crucial in addressing the growing problem of cybersecurity and may well be a key to preventing unauthorized movement of classified information within our laboratories. It can also help make Internet commerce and electronic banking more secure.

- Sandia began radiation-hardening the Intel Pentium® microprocessor to survive weapons and deep-space environments. Intel granted Sandia a fee-free license, saving taxpayers millions of dollars. The hardening of ever-smaller and more sensitive chips is one of Sandia's long-standing contributions to national defense and aerospace industries.

- Sandia continued to refine the microlock, which makes it virtually impossible for hackers or unauthorized users to break into a computer—or into other devices. With gears nearly invisible to the naked eye, the world's smallest lock stores combination codes. The microlock prevents repeated break-in attempts once an inaccurate combination is used.



Sandia's microlock.



The hardening of ever-smaller and more sensitive chips is one of Sandia's longstanding contributions to national defense and aerospace industries.

SANDIA ACHIEVES *Important ASCI milepost*

Sandia has completed the first-ever, fully detailed, three-dimensional simulation of the structural response of an entire nuclear weapon in a hostile environment. The simulation marked the completion of a major milepost of the Accelerated Strategic Computing Initiative (ASCI).

The Department of Energy's ASCI program is developing the computing and simulation capabilities needed to evaluate and certify the aging nuclear stockpile without nuclear testing. Sandia used the ASCI Red supercomputer for major milepost simulations, taking 45 days running on 2000 processors.

The modeling-and-simulation milepost calculations successfully calculated:

- The effects of an intense radiation field on weapon components caused by an enemy nuclear warhead deployed as a countermeasure
- The effects of the mechanical shock on the entire weapon system resulting from the enemy warhead
- And, the effects of the electromagnetic pulse on a weapon's electrical components resulting from the detonation of the enemy warhead

Sandia's achievements demonstrated that validated computer models can be developed to simulate responses to a nuclear weapon's nonnuclear components.

Ultimately, our nuclear deterrent lies in the intellectual, scientific, and technological capabilities of Sandia's people and their ability to develop science and engineering solutions to national security problems.

New Tools for New Challenges

Stewardship of the nuclear arsenal requires new tools for new challenges. The DOE's three nuclear weapon labs—Sandia, Los Alamos, and Lawrence Livermore—are developing the means to "see" inside weapons to understand changes as they age and to be certain how they will perform if ever used. The Sandia team is using pulsed power, a method to contain and release bursts of energy that flash a picture of what is inside a bomb—an X-ray of sorts. The Z machine has produced remarkable achievements over the past two years in the areas of exponential increases in plasma temperature, power, and X-ray output. Intense radiation from the Z accelerator creates conditions on earth that advance our understanding of black holes and neutron stars. This work is aiding the pursuit of achieving fusion in the laboratory, which is one of the grand challenges of science.

Partnerships

Microengineering technique ventures out of the lab

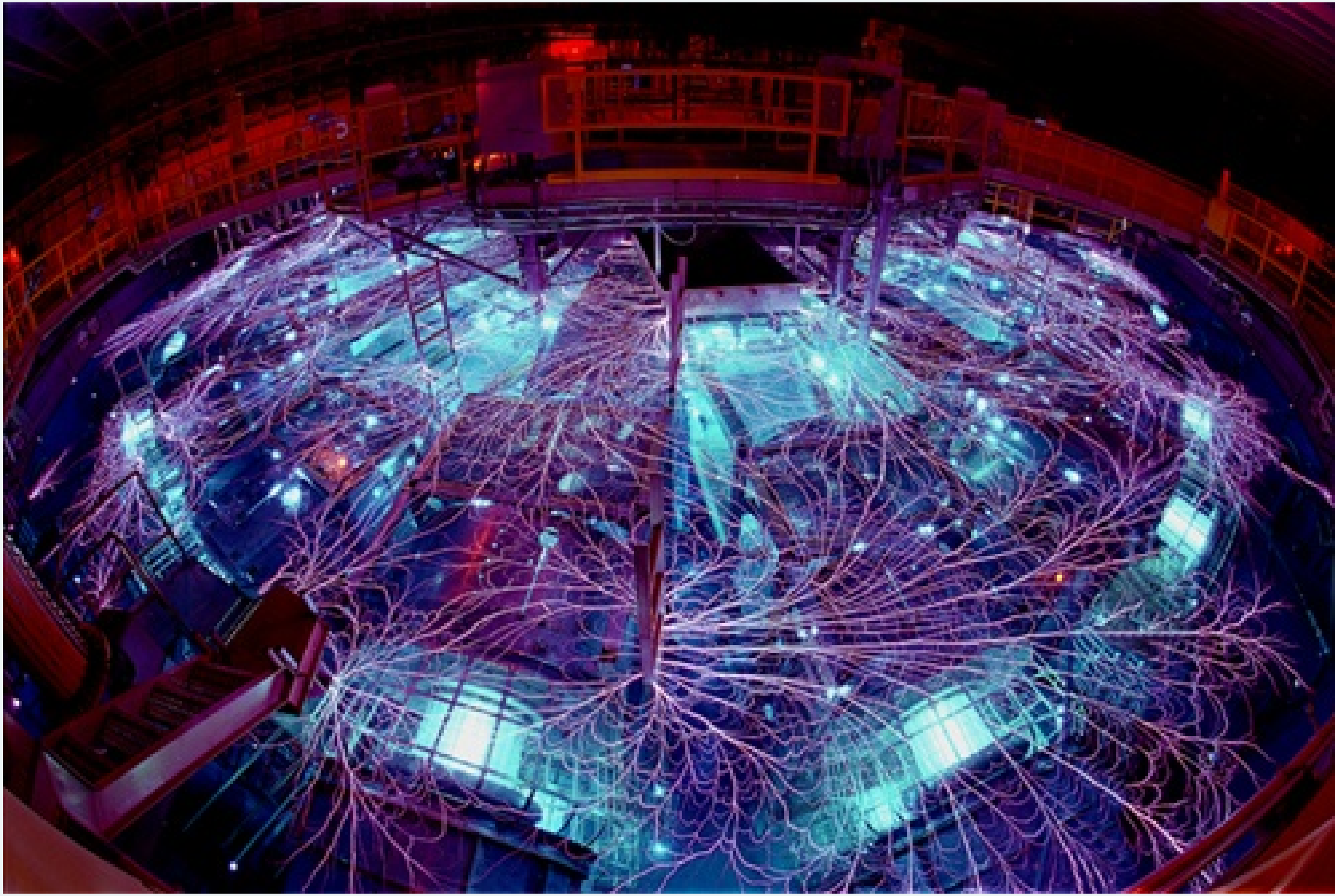
Precision microcomponents.

Precision microcomponents are needed to develop new products in almost every industry. Until now, fabricating microscopic parts has largely been based on semiconductor techniques. But an alternative method called LIGA is emerging and Sandia is playing a lead role in getting the technology into the marketplace. The name derives from the German acronym for a three-stage production process.

Sandia has licensed proprietary LIGA expertise to AXSUN Technologies, a telecommunications firm based in the Boston area. The company is establishing a LIGA foundry in Livermore, Calif., providing the first LIGA commercial production in the United States. The foundry will supply components for AXSUN's telecommunications products and for outside customers.

"Expertise in LIGA design and fabrication is not widely available. Sandia was a clear leader in this field and an exceptional development partner for this key enabling technology," said AXSUN Vice President James Lewis.

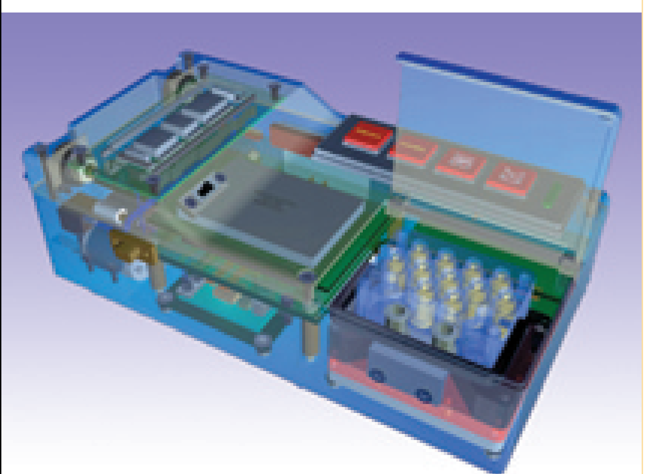
Sandia's cutting-edge LIGA program grew out of a need to create small parts for defense applications. LIGA is a technique to create a mold on a micron scale. It uses the mold to mass-produce tiny, three-dimensional structures in a variety of materials including metals, polymers, and ceramics.



Sandia's Z accelerator is the most powerful producer of X-rays in the world.

Starting with Sandy Mobot in the early 1960s, Sandia has been at the technology forefront in developing robots.

Sandia's Accident Response Mobile Manipulation System (ARMMS) has manipulator arms with a lifting capacity of 250 pounds.



A low-cost, hand-held chemical analysis system will provide rapid, accurate chemical analysis to meet both national security and commercial needs.

New Ways of Seeing

Sandia has been a world leader in developing sensors that can "see, hear, and feel" minute traces of substances that are undetectable by humans. We continue to work on miniaturized sensors that monitor the health of nuclear weapons. This work has far-ranging applications in other missions. Recent Sandia achievements include the Polychromator, which rapidly detects many dangerous substances from a safe distance across a battlefield, and µChemLab™, which puts the equivalent of a fully staffed analytical laboratory in the palm of a soldier or first responder.

Starting with Sandy Mobot in the early 1960s, Sandia has been at the technology forefront in developing robots. We developed robots at first to reduce the exposure of humans to hazardous and radioactive materials in manufacturing, and then to perform hazardous tasks in cleaning up the environment. In addition to those tasks, robots now work in weapons programs, munitions disassembly, and in precision manufacturing. Our mobile robots also are proving to be ideal for conducting reconnaissance and surveillance for military operations. In the years ahead we'll have swarms of small, nearly indestructible robots that talk to each other and figure out the best way to perform tasks.

Ultimately, our nuclear deterrent lies in the intellectual, scientific, and technological capabilities of Sandia's people and their ability to develop science and engineering solutions to national security problems.

As long as the possibility of conflict or attack remains, Sandia will maintain the safety and readiness of the U.S. nuclear weapons stockpile. It is a cost of freedom and, as it has been for our nation for over 200 years, a journey of scientific discovery and exceptional service in the national interest.

NNSA's Gen. Gordon Visits Sandia

Lenny Martinez, vice president of Sandia's Manufacturing Systems, Science and Technology Division, left, and General John A. Gordon, chief of the National Nuclear Security Administration (NNSA), examine a hydrogen furnace at Sandia's neutron generator production facility. Gordon is the Department of Energy's first Under Secretary for Nuclear Security, and Administrator of the NNSA, which officially began operations on March 1, 2000. Its mission is to carry out the national security responsibilities of the DOE, including maintenance of a safe, secure, and reliable stockpile of nuclear weapons and associated materials capabilities and technologies. Gordon visited Sandia, Los Alamos, and Lawrence Livermore national laboratories during the summer of 2000 to conduct a top-to-bottom review of the nation's nuclear weapons complex.

Science and Engineering:

Creative Minds, Extraordinary Innovations

A great many advances touch the everyday lives of American citizens

Sandia's Kevin Linker looks through the air-intake valve assembly of a Sandia chemical preconcentrator. Researchers are miniaturizing the basic preconcentrator technology to create hand-held "sniffers" that can detect minute traces of explosives and drugs.

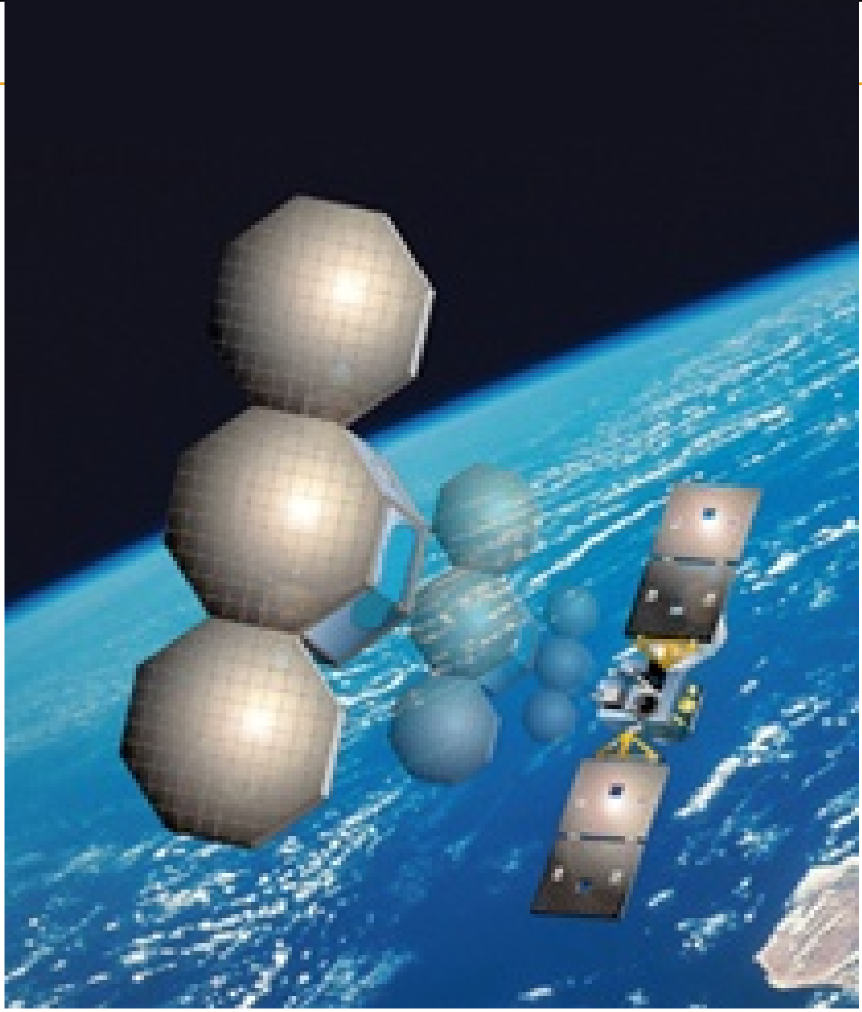
Much of our nation's strong economy derives from technologies spurred by the demands of national security and our strategic deterrence. The nation benefits from Sandia's ability to conduct science with an end in mind—to discover and engineer pure but raw science into overwhelmingly competitive products.

Making Giant Leaps

In science and technology, Sandia strives for advances that greatly improve performance—often by factors of ten, a hundred, or even more—above current technology. This year, for example, we made machines 1,000 times smaller and other machines 20,000 times more powerful. A great many Sandia advances touch the everyday lives of American citizens: school-security systems, airport explosive "sniffers" and walk-through portals, sensitive detectors of harmful chemicals and biological warfare agents, and a fast-dispersing foam that can quickly decontaminate areas subject to a chemical- or biological-warfare attack.

Miniaturization and fail-safing of parts and systems were critical to meet the demands of the Cold War and the aerospace industry. Sandia played a pivotal role in producing materials, arming and firing systems, guidance systems, sensors, instrumentation, and the principles of integration. First called weaponization, Sandia's role extended to the first surveillance satellites in the early 1960s, and then onward to reentry vehicles for many missions. Today, the work continues, not only with the most advanced materials and satellite technologies, but also with ever-increasing abilities to turn endless streams of raw data into useful information.

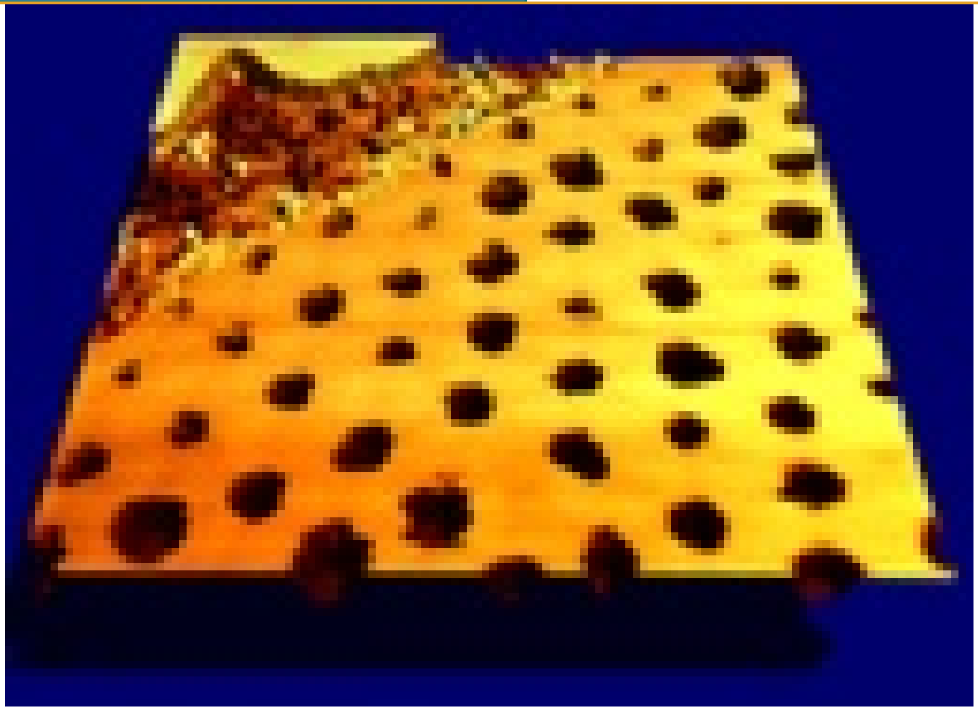
Today, spaceships launch heavy satellites. The satellites themselves and the effort to loft such heavy payloads into space are expensive. If we could build inexpensive, smaller nanosatellites that could perform the same tasks, we could launch scores of these tiny satellites simultaneously and have hundreds or thousands of them in orbit, communicating with



One type of nanosatellite (shown in the foreground and measuring 18 inches by 6 inches) would eject from a larger satellite (shown in the background) after the craft was in space.

We could launch scores of these tiny satellites simultaneously and have hundreds or thousands of them in orbit, communicating with one another and coordinating tasks.

Sandian Colin Smithpeter is developing a Criminalistic Light-Imaging Unit for the National Institute of Justice to help crime-scene investigators quickly find biological evidence.



No assembly required—This Swiss cheese-like micrograph shows the precision of a lacework pattern that emerges on a film of silver one atom thick and sprinkled with sulfur. The phenomenon is one of many that scientists witness as they study nanotechnology—the creation and manipulation of materials and devices built on a scale of nanometers. Scientists are studying what drives this process, which could enable new generations of revolutionary nanostructures.

The Industrial Revolution produced giant machines. Today, machines are much smaller—in some cases the size of a single red-blood cell—but they perform the same work as their larger counterparts.

one another and coordinating tasks. Instead of waiting 24 hours for a single satellite to pass over one spot, we could have constant, real-time surveillance. We are getting closer to developing nanosatellites as we progress in such related areas as collective and distributed intelligence, microsystems, and in constructing the photovoltaic solar cells into the materials of the satellite itself.

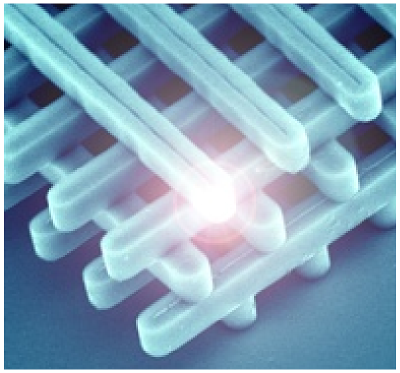
Smaller is Better

Integrated microsystems—microscopic, smart devices that can think, sense, act, and communicate—will be the building blocks of new devices that become part of our everyday lives.

The Industrial Revolution produced giant machines. Today, machines are much smaller—the size of a single red-blood cell—but they perform the same work. Microsystems will be used everywhere, including national security, robotics, and medicine, and revolutionize our concept of what machines can do. Sandia is at the forefront of this revolution. This past year's budget included preliminary design funds for the MESA (Microsystems and Engineering Sciences Applications) facility, which combines computer-integrated designs from many sites to fabricate new generations of micromachines. We envision this facility to be the focal point for a burgeoning new industry centered in New Mexico and the Southwest.

The Sandia-invented photonic lattice brings computers that will work with photons, rather than electrons, closer to reality. This device was recently named one of *Science* magazine's top 10 inventions.

Nanotechnology refers to working with individual atoms, molecules, or molecular clusters to create materials and devices with new or vastly different properties. Scientists believe the ability to move and combine individual atoms and molecules could revolutionize the production of virtually every human-made object and usher in a technology revolution at least as significant as the silicon revolution of the late 20th century. The White House has launched a national initiative in nanotechnology, and Sandia is at the forefront.



The photonic lattice acts as a crystal in guiding light because of its tiny, regularly placed silicon "logs," which are 1.2 microns wide.

Sandia researcher Jeff Brinker observes the structures of a variety of submicroscopic spheres created by his team on the nanometer scale.

The White House has launched a national initiative in nanotechnology, and Sandia is at the forefront.


Sandia researcher Bill Hensley adjusts the Lynx synthetic aperture radar installed on a General Atomics I-GNAT unmanned aerial vehicle.

Sandia's SAR work is unmatched for all-weather and long-range imaging ability.

Collaborating with Industry

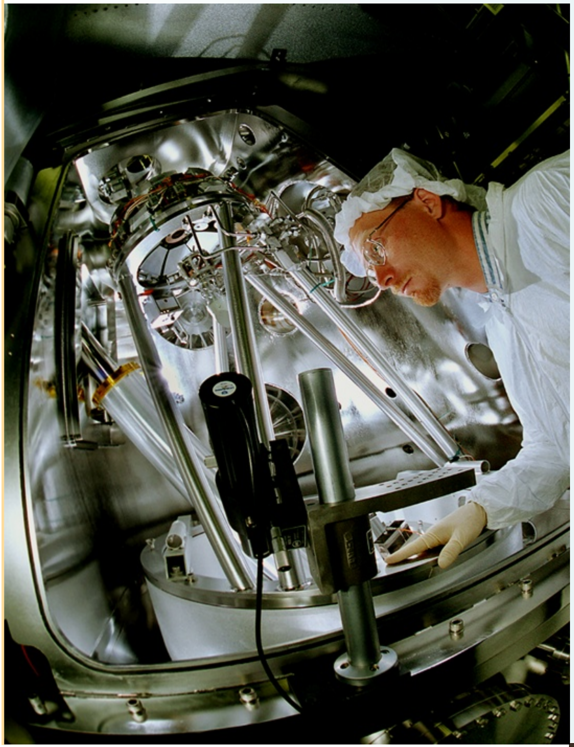
Our science and engineering programs support all our missions and depend upon industrial partnerships to extend our reach. A few examples:

- We have developed a revolutionary robotic manufacturing system. Today's products are built with many machines, each handling a limited range of tasks. The larger the machine, the less precise its results. Now imagine a single machine—our Hexapod—that can handle tasks from nanometers in size (billionths of an meter) while making something like a compact car. The Hexapod has six variable length struts and makes feasible the construction of machines that compete with human adaptability and dexterity.

- Sandia-developed micromirrors may one day be part of the Next Generation Space Telescope, the successor to the Hubble. In 1999, Sandia demonstrated to NASA an array of working mirrors, each 100 microns square. There would be about 65,000 of these mirrors in a square inch. The goal is to have four million independently moving mirrors in the new telescope.

- Sandia extended its successful track record of industry collaboration with the delivery of the Lynx synthetic aperture radar (SAR) to General Atomics. This is a lightweight, high-performance SAR for unmanned aerial vehicles. Sandia's SAR work is unmatched for all-weather and long-range imaging ability.

Getting every last bit out of silicon



A consortium of national laboratories and chip manufacturers is developing a lithography technique that likely will be used to build the next-generation computer chip. Called extreme ultraviolet lithography (EUVL), the advanced-patterning technique allows computer manufacturers to pack more circuits into much more powerful processors. The effort could produce computer processors that operate 100 times faster and memory devices that can store 100 times more information than current processors.

The effort has drawn talent and resources from government labs and private industry. Sandia, Lawrence Livermore National Laboratory, and Lawrence Berkeley Laboratory have joined with Intel, Advanced Micro Devices, Motorola, Micron Technology, and Infineon Technologies in a government-industry partnership called Extreme Ultra Violet LLC.

Semiconductor experts have judged EUVL as the leading successor to the current optical lithography technique. EUV light allows chipmakers to project extremely small circuit features onto silicon wafers. That in turn allows manufacturers to put more transistors onto each wafer, which increases power.

The three labs—called the Virtual National Laboratory—have produced a prototype alpha EUVL machine to be located at Sandia. The goal is to print a prototype circuit by the end of 2001 and to start producing computer chips with EUVL technology by 2005.

The effort could produce computer processors that operate 100 times faster and memory devices that can store 100 times more information than current processors.

Top: Kevin Krenz at the chamber of the extreme ultraviolet lithography device where workers align light used to pattern circuits in this potential next-generation approach to microchip manufacturing.

Left: Duane Sunnarborg aligns measuring equipment on a metrology tray that provides stability to the apparatus which patterns circuits on wafers using extreme ultraviolet lithography.

Keeping America Running:

Protecting Our Energy Resources and Critical Infrastructures

Stable energy supplies and environmentally sound solutions for energy production are critical to our nation's well-being. So is protecting the critical infrastructures that move all this energy around the country and support many aspects of a dynamic economy.

The loss of any of these systems would disrupt our lives on a broad scale.

TO KEEP EVERYTHING RUNNING SAFELY AND SMOOTHLY, Sandia has developed a consequence-based methodology to assess risk and reliability. The methodology identifies potential causes of failure and develops protection strategies.

Critical infrastructures refer to a complex set of subsystems that include:

- *Transportation*
- *Telecommunication*
- *Electric power*
- *Banking and finance*
- *Water*
- *Emergency services*
- *Oil and gas*
- *Government*

The loss of any of these systems would disrupt our lives on a broad scale. These subsystems have become increasingly interdependent, making our unified infrastructure increasingly vulnerable to error, attack, malfunction, and natural disaster.

New Methods to Combat New Threats

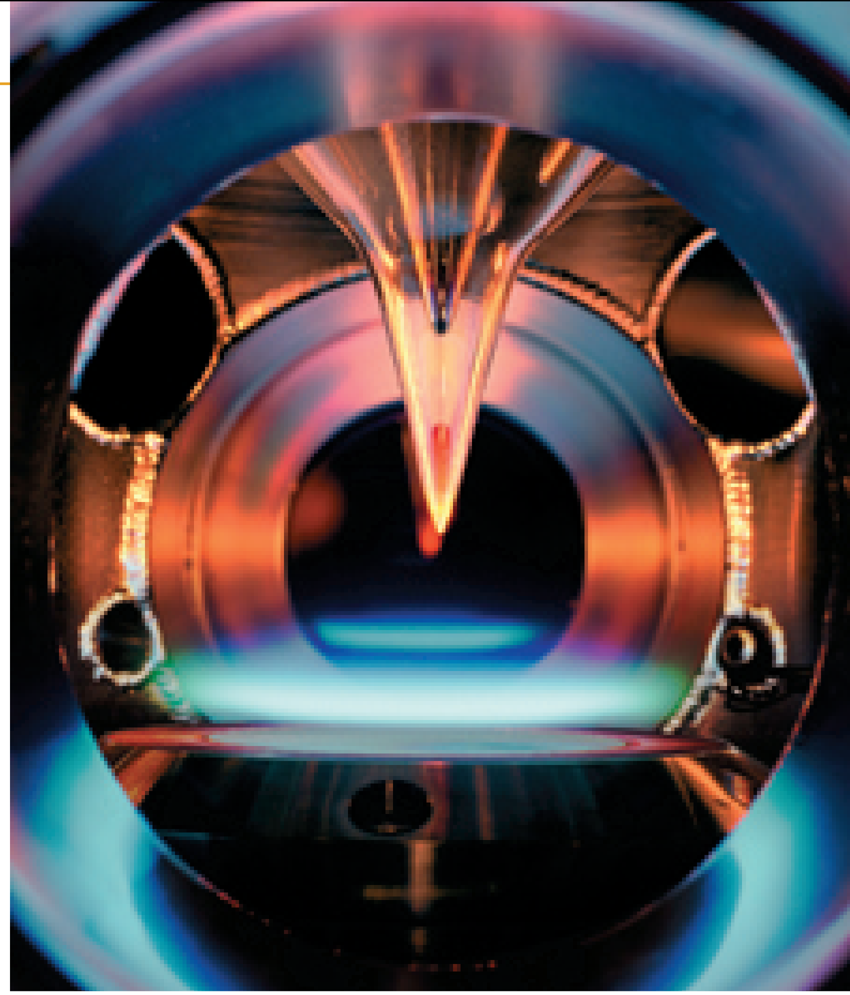
Threats to our nation require a coordinated, systematic response from many organizations. Sandia is taking a lead role in protecting our critical infrastructures from all forms of disruption. A few examples from the past year:

- Sandia and the Federal Aviation Administration (FAA) are working together to design a systematic approach to aircraft safety. The alliance strives to help 3,500 FAA inspectors track safety trends and spot potential problems in the aging U.S. fleet. Applying Sandia's principles, the FAA can anticipate meeting the national Safer Skies program goal of reducing accidents by 80 percent during the next decade.

This year we acquired a 1970s vintage Boeing *747* aircraft to serve as a program test bed for investigating aging electrical and mechanical systems.

- At the request of the Partnership for a New Generation of Vehicles, we developed a diagnostic that will measure the amount of exhaust gas which is recirculated into an operating engine during acceleration or deceleration. Called EGR (exhaust-gas recirculation), this process is used extensively in gasoline engines and will be implemented on diesel engines in the near future to control nitrogen oxides (NOx). Our diagnostic, developed and demonstrated on a small-bore diesel engine, will be applied next to heavy-duty diesel engines in test cells located at engine manufacturing sites in the United States.

- Sandia patented a polymer material that ensnares hydrogen atoms. The material is helping industry remove hydrogen buildup from chambers designed to capture heat in industrial processes. Hydrogen must be removed because its buildup impairs the ability of the chamber to capture heat. Hydrogen also can corrode metal.



The combustion chemistry of a blue methane flame is studied using a molecular-beam mass spectrometer. The toothlike quartz probe provides input to the spectrometer.

- We completed testing of the Solar Two 10-megawatt power plant near Barstow, Calif., in April. The project's success has led members of the Solar Two consortium to pursue commercial power-tower opportunities abroad.

- Conventional three-dimensional seismic imaging for oil exploration fails near vertical structures, such as salt dome flanks. Sandia has developed modeling methods for single-well seismic imaging data, in which both the seismic source and receiver are placed downhole adjacent to the salt dome.

Understanding how fuel properties affect emissions is a key step toward producing cleaner, more efficient engines.

Solar Two power plant near Barstow, Calif.

Larry Yellowhorse examines an instrument that measures the intensity of sunlight. The instrument is typical of the sensing equipment used in a Sandia-integrated atmospheric monitoring station on the tiny Pacific island of Nauru.

Energizing Our Future

By looking deeper, with more precision, we can help find the energy reserves geologists think are buried deep in the ground. We can extend our conventional energy reserves with technology.

For years, our Energy Storage Systems program has helped utilities and large private users smooth out peaks and valleys in our nation's power supplies. The estimated costs savings are in the billions of dollars. With new technology coming online, we can help America meet the power demands of the next half-century by more efficiently using existing power.

Sandia has helped develop efficient and reliable energy sources for Arctic environments. Typically, residents of far northern villages rely on noxious, noisy diesel generators. A small network of fuel cells in a village of several dozen homes will meet the need for heating and lighting throughout the winter. A microgrid of fuel cells could avoid the risk of losing power during extreme cold snaps.

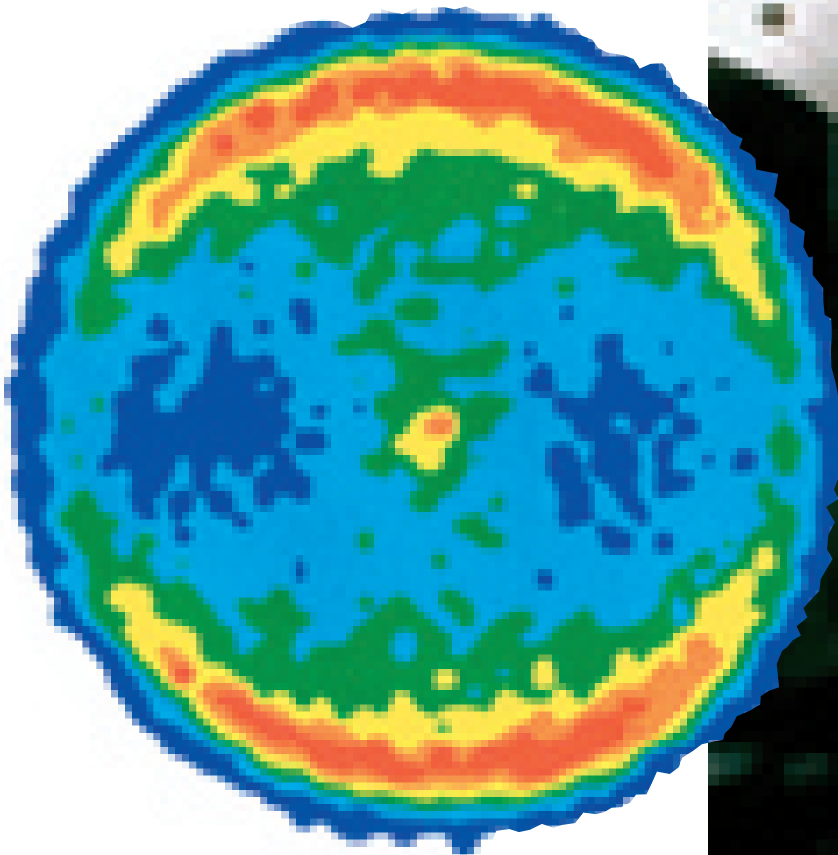
A version of Sandia's RATLER (Robotic All Terrain Lunar Exploration Rover) robotic vehicle was fitted with a fuel cell power source designed and fabricated by a Sandia team working with the Fuel Cell Propulsion Institute. Small robotic vehicles powered by fuel cells are needed for search and rescue, reconnaissance, security, perimeter control, and battlefield operations. Robotic vehicles are ideally suited for the tasks, but the vehicles typically carry large, heavy batteries with limited capacity. Fuel cells can extend the robot's life and operating range and reduce telltale evidence of the robot's presence.

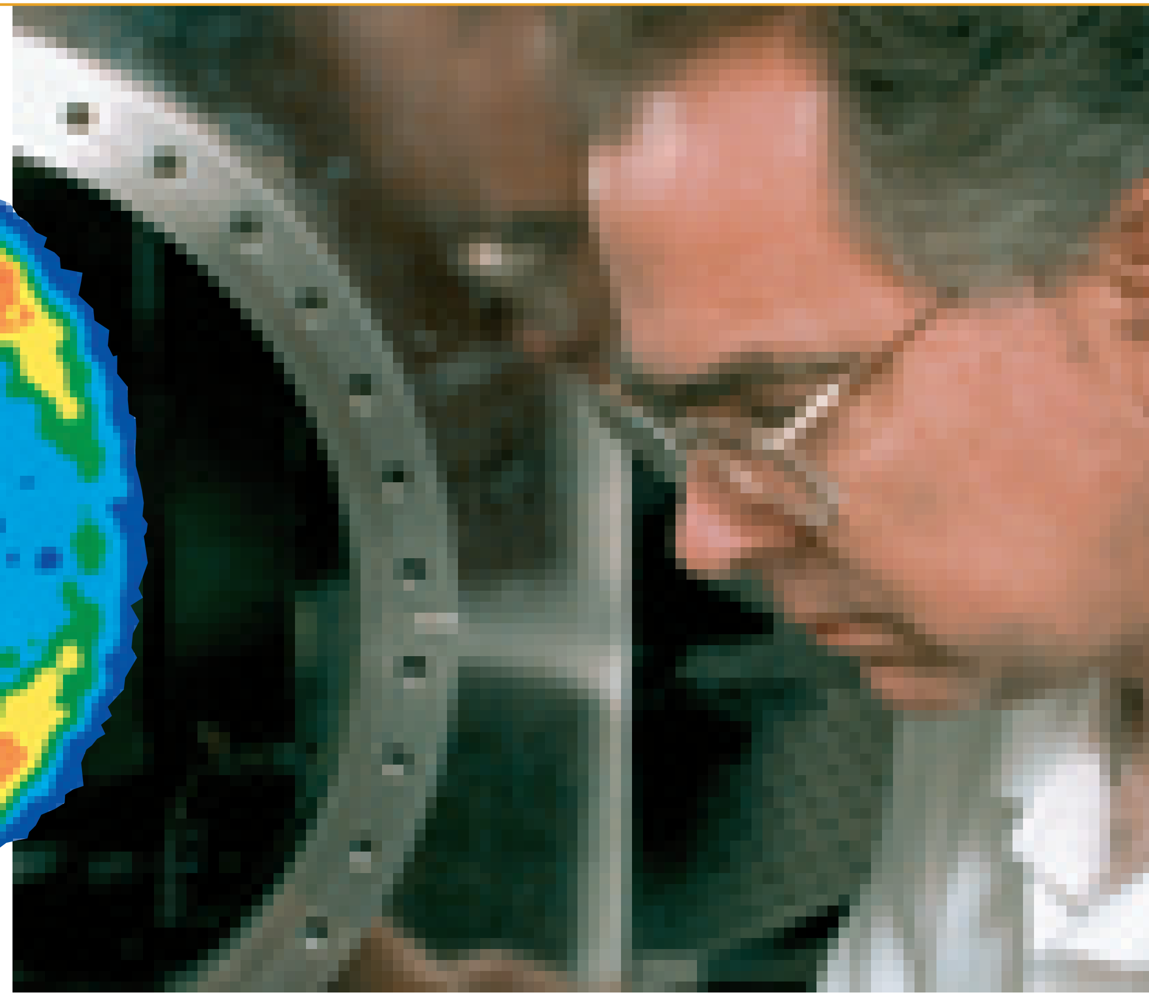
Sandia is working to perfect the rechargeable, lithium battery. The battery does not produce poisonous heavy metals and it generates more power than other batteries of equal size but higher cost and greater weight. The lithium battery would eliminate the need to dispose of depleted lead-acid batteries.

For years, our Energy Storage Systems program has helped utilities and large private users smooth out peaks and valleys in our nation's power supplies.

Left: Sandia researcher Tim Boyle checks a flask that contains dried cathode precursor powder. The powder will be put into a furnace and baked into the desired cathode material for a lithium ion battery.

Below: A team of robots demonstrates how their computer program would help rescuers locate a skier buried under an avalanche.





Physical chemist David Chandler of the Combustion Research Facility.

During combustion, the atoms in a molecule split apart, rearrange, or combine with others in a variety of ways that are difficult to observe.

Sandia successfully built and tested the world's first microminiature thermionic converter. This generates electricity directly from heat at high efficiencies and modest temperatures. The device was developed for both micro- and macroscale applications, including electrical power for spacecraft and chip devices.

During combustion, the atoms in a molecule split apart, rearrange, or combine with others in a variety of ways that are difficult to observe. Laser-based diagnostics at the Combustion Research Facility (CRF) enable researchers to analyze this phenomenon. The CRF's powerful new experimental technique allows researchers to study events that typically occur in femtoseconds (one millionth of a billionth of a second). Scientists use this information to model combustion reactions. The more accurate models help to develop more efficient and cleaner burning devices and processes.

A Cleaner Environment

We also reached some milestones in remediating the environment.

- In March 1999, the Waste Isolation Pilot Plant (WIPP) near Carlsbad, N.M., received and stored the first transuranic waste. WIPP is the world's first certified repository for disposing of radioactive waste deep underground in stable salt beds. The event ended 25 years of delay and uncertainties. Sandia served as WIPP's official scientific advisor throughout the project. Our geologists, engineers, and scientists studied and helped select the site, designed the prototype facility, generated the first environmental impact statement, tested the transportation casks, and provided the scientific understanding and documentation that regulatory agencies used to certify the repository.

- Sandia is using the technical expertise and experience from the WIPP and Yucca Mountain programs for the Korea Atomic Energy Research Institute to develop a conceptual design for a spent nuclear fuel repository.

Synthetic sludge could reduce the cost of decommissioning some radioactive waste storage sites.

- The decommissioning of the Strategic Petroleum Reserve Weeks Island, a 72-million barrel underground oil storage site and former salt mine, was completed in November 1999. This ended the high-consequence effort of removing oil and controlling water leakage without an environmental incident.

- At Sandia, the Environmental Restoration Program completed all performance measures on or ahead of schedule, achieving general programmatic excellence for Sandia and the DOE. This is the fifth year of outstanding performance.

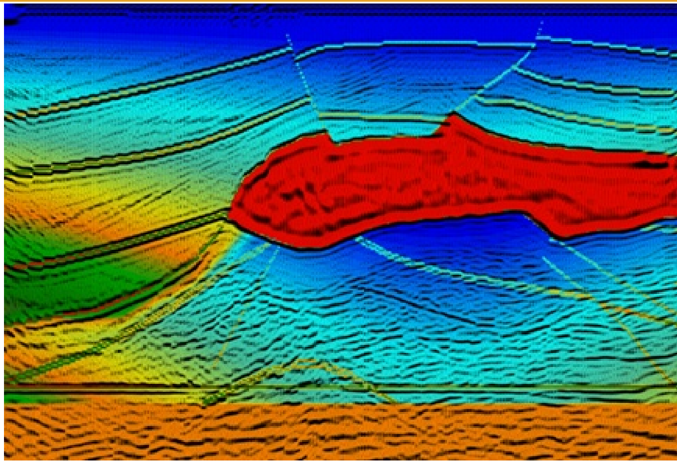
At Sandia, the Environmental Restoration Program completed all performance measures on or ahead of schedule.

Sandia is researching natural attenuation, a "natural" alternative to cleaning up uranium-contaminated sites.

• Sandia's California site became the first national lab to finish environmental cleanup when it cleared the last hurdle in its cleanup of 23 solid waste management units. The last hurdle was overcome when the San Francisco Bay Regional Water Quality Board ruled that bioremediation of a subterranean fuel-oil spill was working as planned. We will continue to monitor the site.

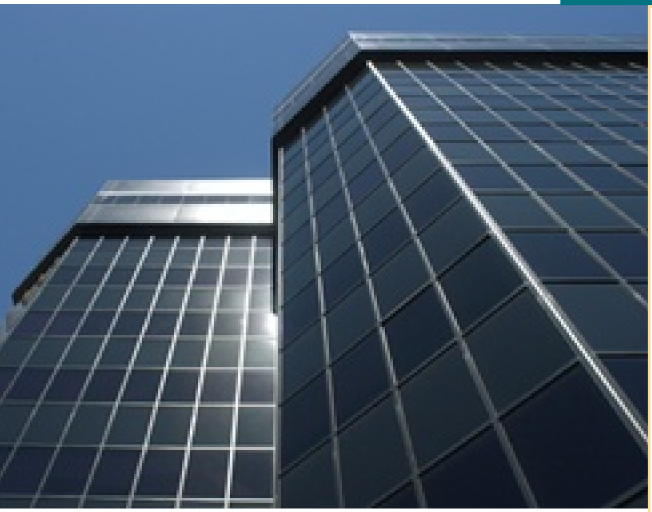
• A typical, large U.S. refinery spends about $1 million a year looking for leaks in a vast array of high-pressure process pipelines. The EPA-mandated process is meant primarily to curtail pollution. The process is time-consuming because every potential leak point—valves, flanges, junctures—must be surveyed using a hand-held, wand-like gas "sniffer." Sandia researchers in California have developed a new infrared laser leak detection system that significantly speeds up the process. Inspectors can use a portable videocamera system to scan a wide area for leaking hydrocarbon emissions, which appear as dark clouds in the video picture.

• In the spring of 1999, Sandia led the multilab Atmospheric Radiation Measurement unmanned aerial vehicle team in a successful series of remotely piloted aircraft flights at more than 55,000 feet above the ocean near Kauai. The flights—the highest so far for the program—provided data on water vapor in clear skies and in clouds. The data are of great interest to climate modelers.


Sandia's seismic imaging computer code models a region of salt that may trap oil.

Partnerships

Glassmaking made better



Although glassmaking goes back thousands of years, the complex process is still not fully understood. Determining how to optimize the melting process, remove gas bubbles, and reduce furnace degradation from corrosive gases are a few of the issues still challenging the industry.

Part of the problem is that it is not economically feasible to stop production in a multimillion-dollar glass furnace in order to run tests and conduct research. It's also difficult to take measurements inside a 3,000 degree F furnace. However, a pilot-scale furnace in the works at Sandia's Combustion Research Facility (CRF) will provide the industry with a test bed for studying the glassmaking process, without disrupting output.

The Glass Melting Research Facility will be able to produce several tons of glass a day. The furnace will be part of a larger Glass Research Facility designed to help industry address challenges such as techniques for applying coatings. The CRF has collaborated with the glass industry for years because of the facility's expertise in combustion processes and optical-diagnostic techniques.

A storage area at the Waste Isolation Pilot Plant near Carlsbad, N.M.

Nonproliferation: *Waging Peace in a Perilous World*

Nonproliferation efforts must address 50 years of weapons development. Stockpiles exist worldwide. The United States and Russia maintain arsenals with thousands of nuclear weapons, while Britain, France, and China have smaller arsenals. India and Pakistan have developed and tested nuclear weapons, and other nations—Israel, North Korea, Libya, Iran, and Iraq—are suspected of having weapons of mass destruction or of having attempted to acquire them.

Sandia National Laboratories is developing technologies that help reinforce U.S. nonproliferation policy, with a focus on materials control and monitoring activities.

THE UNITED STATES ENCOURAGES A POLICY OF NONPROLIFERATION for all types of weapons of mass destruction, whether nuclear, biological, or chemical. Sandia National Laboratories is developing technologies that help reinforce that policy, with a focus on materials control and monitoring activities.

Sandia's Multispectral Thermal Imager satellite was launched in March 2000.

Nonproliferation Technologies

Sandia's support for the Department of Energy's Office of Nonproliferation and National Security includes research and development for a variety of systems, technologies, and processes to detect proliferation of weapons of mass destruction.

The following are highlights of our work in developing nonproliferation technologies during the past year.

Remote Surveillance

Since the early days of the VELA (Spanish for "watchful") satellite program for detecting nuclear bursts, Sandia has designed sensors to support verification of international arms control agreements. Sandia's latest effort in remote surveillance was the March 2000 launch of the Multispectral Thermal Imager (MTI) satellite, which represented a major success in the nation's nonproliferation program. Funded by DOE's Office of Nonproliferation and National Security, the MTI has a broad range of national defense and civilian applications. The satellite is used to monitor treaty provisions, map chemical spills, detect heat pollution from waste streams in lakes and rivers, observe vegetation health, and detect volcanic activity. A government and industry team led by Sandia designed and built the satellite's camera, which was then calibrated at Los Alamos National Laboratory. The camera enables the satellite to photograph light and heat patterns that are invisible to the human eye.

Sensor-fusion technology combines independent information collected from multiple sensors to provide a clear understanding of one object.

Sensing Technologies

• Sandia has developed advanced sensors for weapon systems, safeguards and security, and for nonproliferation. Advanced sensors produced in our fabrication facilities offer unprecedented sensing abilities. Because of their small size, the sensors are inexpensive to fabricate and use low power.

• Sandia's sensor-fusion technology combines independent information collected from more than one sensor to provide a clear understanding of an object. Sensor-fusion technology can identify obscured objects and track, for example, military vehicles to show a history of activity at a site.

• Sandia has developed an award-winning radiation sensor that can be used for long-term applications. The radiation sensor uses a cadmium-zinc-telluride (CZT) crystal that enables the sensor to operate at room temperature. The CZT technology is less expensive because the sensor does not have to be cooled or attended and is less complex than existing technologies. The sensor can identify nuclear materials used for weapons. CZT crystals are used to ensure safety and accountability of nuclear and fuel-cycle materials in storage and for treaty verification.

Sandia has developed advanced sensors for weapon systems, safeguards and security, and for nonproliferation.

Antineutrino detection would allow nonintrusive, direct measurement of a nuclear reactor core.

Other Nonproliferation Technologies

The Cobra Brass ground system collects and processes real-time, high-volume data from sensors aboard a satellite. Sandia developed this complex payload and the associated command, control, and data-processing systems for the U.S. Air Force. This system upgraded an Air Force satellite system to detect sensor data that records events in real time. Sandia will continue to provide technical support and processing enhancements throughout the lifetime of the Cobra program.

Sandia is researching a detector that nonintrusively monitors plutonium produced inside nuclear reactor cores. A nuclear weapons fissile material, plutonium could be diverted from civilian nuclear facilities to illicit weapons programs. The nonintrusive detector measures antineutrinos emitted from the nuclear fuel during normal reactor operations. Measurements can ensure that plutonium has not been removed or produced at an abnormally high rate. Other monitoring methods require counting fuel bundles or checking random samples of fuel rods while the reactor is not in operation. The new method can provide continuous, direct, remote measurement of events inside the nuclear reactor core.

Sandia also is developing a remote-monitoring device to detect gamma radiation and thereby monitor a warhead inside a shipping container. This can be done without revealing sensitive warhead information. The device also would detect tampering with the container. The resulting information could be transmitted to a base station, helping the arms control community with treaty compliance.

Security Technology Development

Sandia is the DOE's lead laboratory for research, development, and application of physical-security systems that protect nuclear weapons and materials. We do not manufacture or sell security technology products; instead, we serve as an independent, third-party evaluator. Drawing on the expertise of more than 150 staff, our physical-security center provides unbiased information on the capabilities, performance, and features of commercially available products so users can select the appropriate technology for a specific purpose.

For example, Sandia has helped more than 100 schools evaluate their security systems. With violence, theft, vandalism, and drugs on school campuses at

Researchers are studying thin-film, ultralight piezoelectric material for future use in space telescopes and surveillance satellites.

Sandia has helped more than 100 schools evaluate their security systems.

Sandia is working with the National Nuclear Security Institute on a remotely operated, armored firearm of extreme accuracy.

Sandia is evaluating a highly precise remote-operations weapons platform for Department of Energy security applications.

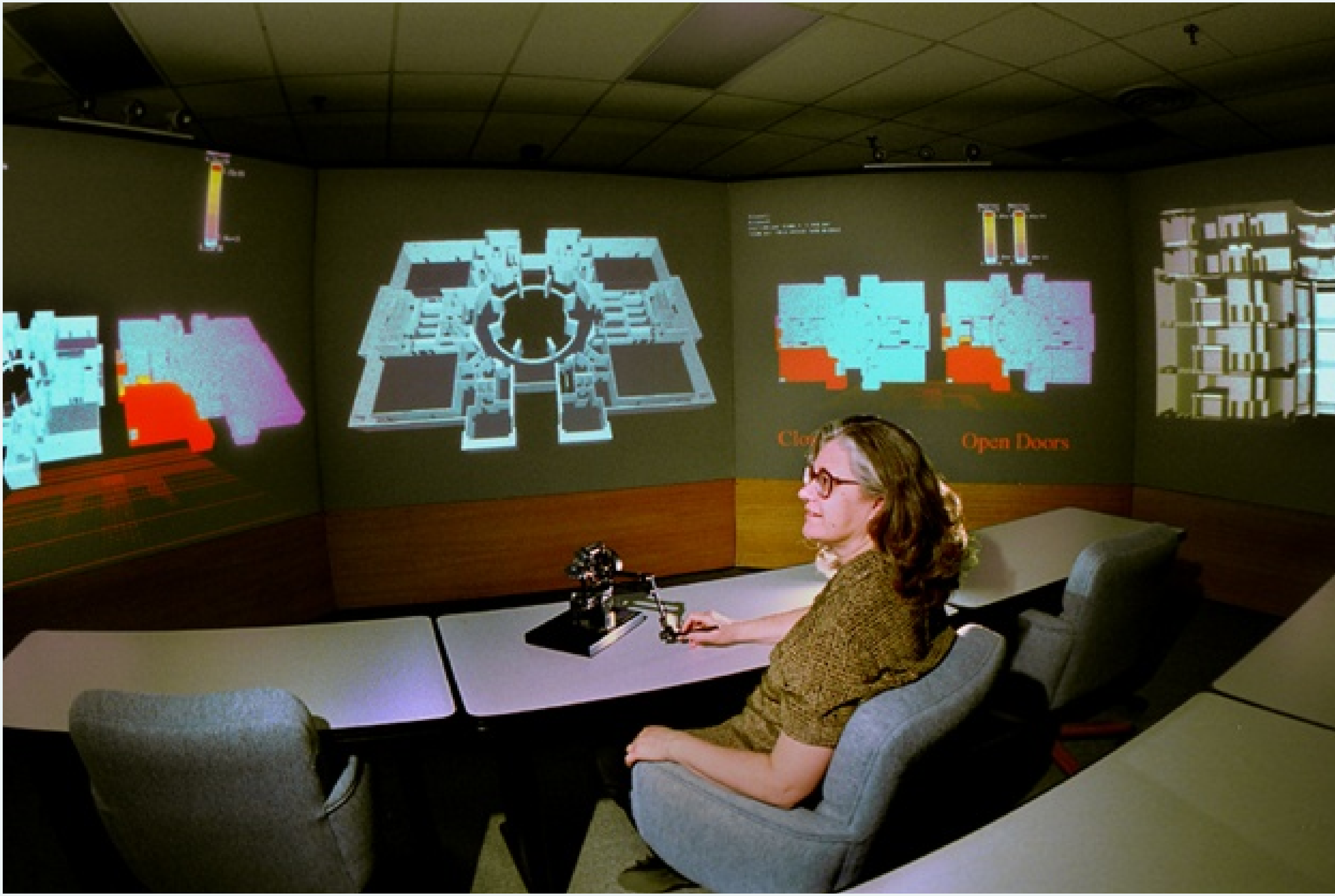
an all-time high, Sandia cohosted a three-day course on school security in Dallas in July 2000. About 200 principals and school security professionals attended the workshop to learn the latest in security technologies and strategies from experts, courtesy of the Department of Justice's National Institute of Justice, the Department of Education's Safe and Drug-Free Schools program, the DOE, and Sandia.

Based on our work with schools, Sandia also authored a Web handbook titled "The Appropriate and Effective Use of Security Technologies in U.S. Schools." It serves as a practical guide for school officials and offers guidance on several aspects of security, including security concepts and operational issues, video surveillance, weapons detection devices, entry codes, and duress alarms. The document is available on DOE's Web site at www.doe.gov/schoolsecurity/pdf.htm.

Another Sandia project for physical security at DOE sites could increase the protection of nuclear assets and reduce risk to our security officers. Sandia is working on a remotely operated, armored firearm of extreme accuracy. The system would allow a security officer to remain out of harm's way in many dangerous situations. We are using commercially available hardware and incorporating enhanced safety, video, and armoring options.

During the past year, Sandia licensed technology for an explosives-detection portal to Barringer Instruments, Inc., a leader in explosives-detection equipment. The portal, which blows a puff of air over an airline passenger and checks for minute levels of explosives, might soon be used at U.S. airports as a security-screening tool.

Modeling and simulation techniques developed in our weapons program are being applied to design structures that can survive catastrophe. Sandia is using technology to create buildings that protect, rather than harm, people. Our architectural surety program is a team effort with government agencies, professional associations, and universities. The program spots structural weaknesses, identifies corrective designs, and improves building codes and construction standards. Other initiatives include designing glass that, instead of splintering, converts to sand granules, and determining how materials and floor plans affect the speed of fire traveling throughout a building.



Sandia has three new data visualization facilities.

The collaborations help reduce nuclear weapon proliferation, and help prevent theft, diversion, and unauthorized possession of nuclear materials.

Two Sandia Programs are Based on Partnership

The Materials Protection, Control, and Accounting program and the Cooperative Monitoring Center at Sandia National Laboratories promote global safety, reduce production of weapons of mass destruction, and wage world peace through international outreach.

Sandia Works to Ensure Nuclear Materials Are Safe Worldwide

Since the breakup of the Soviet Union in 1991, the United States has been working with scientists and engineers at various Former Soviet Union institutes, laboratories, and organizations. The collaborations help reduce nuclear weapon proliferation, and help prevent theft, diversion, and unauthorized possession of nuclear materials. Sandia's International Security Program helps achieve worldwide protection and control of nuclear materials and weapons by working with Russia and other newly independent Soviet states on material protection, control, and accounting. The program's systems provide cost-effective, reliable management of special nuclear materials.

During the past year, the Materials Protection, Control, and Accounting program has improved protection of and accounting for nuclear materials at 12 Russian facilities. We provided new fuel-storage containers, placed vibration sensors on doors and walls, and installed motion detectors and cameras. We developed an advanced exterior sensor prototype for wide-area surveillance and early intrusion detection system. The prototype provides 360-degree panoramic imagery in infrared and visible spectral bands. A third sensor operates in poor weather conditions. A data-fusion technology combines results from the three target trackers to reduce false alarms.

Sandian Tim Crawford adjusts an infrared break beam on a system used to profile vehicles for the Intermediate Nuclear Forces (INF) Treaty.

Sandia met a major milestone regarding collaboration with Russia's lead nuclear weapons design institute, Arzamas-16. Remote-monitoring equipment was installed to oversee storage of nuclear material at both U.S. and Russian facilities.

CMC Studies Seek Cooperation Among Nations

The Cooperative Monitoring Center (CMC) at Sandia hosts international training workshops to explore how technology can be used to resolve conflicts and assist ongoing international negotiations and discussions for peace. CMC initiatives support international experiments that use technology to enhance nuclear transparency and confidence-building measures to reduce tension between nations.

Last year, the CMC expanded its regional security, nonproliferation, and arms-control efforts by conducting workshops and demonstrations at six foreign locations. The workshops brought together regional experts and policymakers to assess security options in Southeast and Northeast Asia and in the Middle East. The technologies discussed at the workshops focused on physical security, remote sensing, on-site inspection, and environmental data acquisition.

The Mini Intrusion Detection System (MIDS) uses a passive infrared sensor that detects an intruder without his or her knowledge.

Protecting America *from Emerging Threats*

The United States faced a well-understood threat during the Cold War. Now we must face the reality of emerging threats, primarily those arising from terrorism and rogue states. Sandia is applying its engineering expertise to developing tools to combat threats to our national security.

But these new and still unanticipated threats demand advances not only in technology, but also in military science and human understanding.

New Technologies to Combat New Threats

Sandia has developed the following technologies to protect Americans:

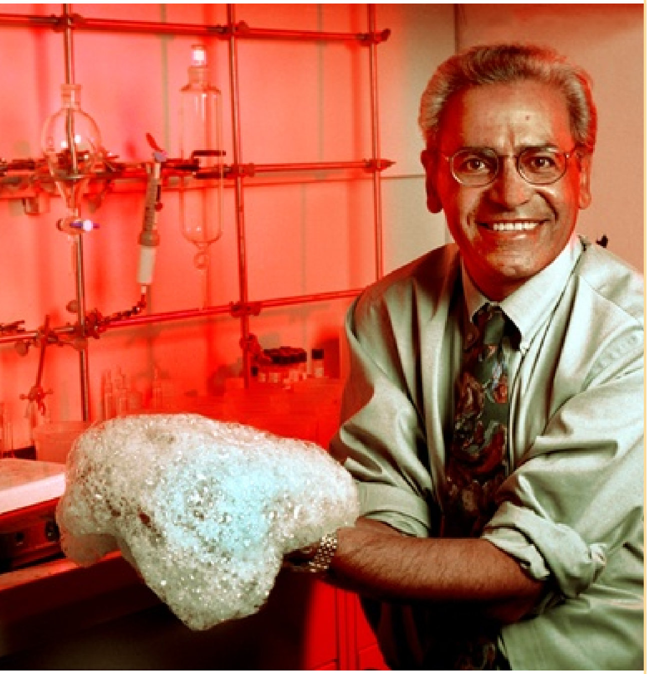
- We developed a prototype virtual-reality system called BioSimMER for the Department of Defense to train responders for biological terrorism. This system permits two responders to train together. Training tasks include decontamination, sensor placement, and triage. Sandia agent-transport codes were integrated to simulate concentrations and disposition of agents over time, provide exposure dosages, and permit dynamic simulation of sensor readings. The national Emergency Response and Rescue Training Center at Texas A&M University will evaluate the technology.

BioSimMER, a virtual-reality training system.

- A Sandia software designed to fend off hacker attacks successfully protected five network-linked computers during two days of concentrated attack by Sandia's Red Team, a four-person hacker force that tests computer security. The project leader noted that the software would have been able to stop the

Sandia's Information Design Assurance Red Team seeks out weaknesses in computer systems.

Foam decontaminants are effective against a variety of chemical agents and anthrax spores.



Sandian Maher Tadros received a Discover Award this year for his work on decontamination foam.

I-Love-You virus had the Sandia software been in wide use during the spring 2000. A multiagent collective, the cyberagent software detects any suspicious or unusual port scan, and then cuts off services, closes ports, and tightens the firewall. In contrast, existing virus-protection software recognizes only specific virus patterns.

- Sandia California's College Cyber Defenders program is training students from local and national colleges and universities to protect and defend computer systems and networks. The program was expanded this year to include 25 students working on more than a dozen information security research and development projects. Through these projects, students actively helped secure computers worldwide. Participants tested thousands of attacks published on the Internet, reported the results, and helped establish means to detect and defend against the attacks. Students are beginning to graduate from the program and pursue careers in information technology and computer security. The first graduate is a new Sandia employee.

Sandia is developing µChemLab™, a powerful, portable chemical-analysis device that fits in the palm of a hand.

- Sandia developed liquid foam decontaminants for rapid response to terrorist threats. Foam decontaminants are effective against both chemical and biological agents. Sprinkler systems, fire extinguishers, or fire trucks can rapidly deploy the decontaminants. They are nontoxic and noncorrosive, generate minimal fluid runoff, and have no lasting negative effects.

- We demonstrated the concept and viability of a system to destroy recovered chemical munitions that are unsafe for transport and storage. The project supports a U.S. Army initiative. The Army is preparing the prototype for emergency use.

- Sandia is developing µChemLab™, a powerful, portable chemical-analysis device that fits in the palm of a hand. The device provides quick, sensitive, and selective chemical analysis on a chip and it is not tethered to large lab equipment. We expect µChemLab™ will become affordable and widely used in the near future. Researchers envision automated, field-portable systems that detect landmines, chemical hazards, and pollutants near their source in real time.

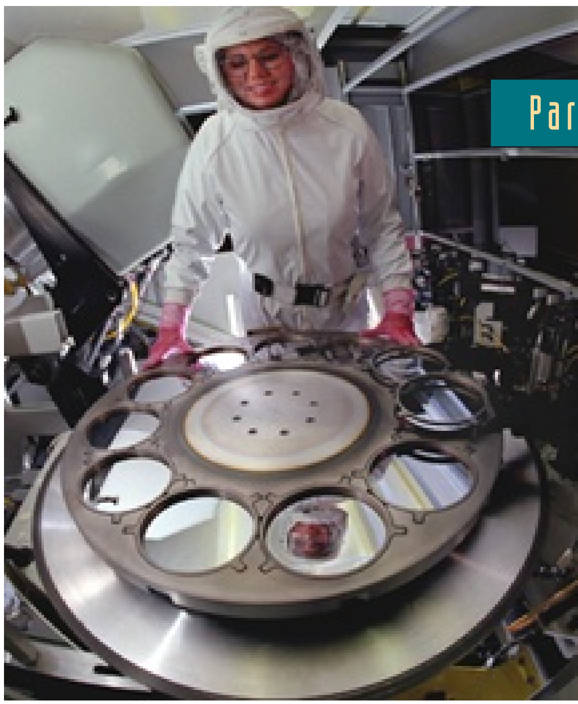
- Terrorist analysis is part of Sandia's work in designing security devices on warheads or storage vaults and in identifying emerging threats. For example, We completed a summary on Osama bin Laden, the Islamic leader associated with the 1998 bombings of U.S. embassies in Kenya and Tanzania.

Sandia provides highly instrumented, well-characterized targets for both element and integrated system tests.

National Missile Defense

Sandia supports the development of National Missile Defense in three areas: threat and countermeasures development; lethality analysis and assessment; and flight test targets. All these programs are conducted for the Ballistic Missile Defense Organization through the U.S. Army Space and Missile Defense Command. The largest and most visible of these programs is flight targets. Sandia provides highly instrumented, well-characterized targets for both element and integrated system tests. During the flight tests, Sandia's target objects are launched from Vandenberg Air Force Base, Calif., toward the Kwajalein Missile Range in the South Pacific. About twenty minutes after the target launch, an interceptor is launched from the Kwajalein Missile range on a collision course with the target. All of the target performance parameters are received on the ground before and during the collision event. These parameters are provided post-test for comparison with the defensive system element data.

Sandia provided targets for three integrated system tests over the past 12 months. All of the instrumented targets performed satisfactorily.



Partnerships

Sandia-Intel Partnership: Hardening the Pentium® Chip

The computing power used in satellites, space vehicles, and defense systems presents an effective weapon against a legion of emerging threats.

But that power can quickly be compromised if a computer microprocessor is not "immunized" against radiation, such as that coming from cosmic rays or even nuclear blasts. A Sandia-Intel partnership is ensuring microprocessors are protected in hostile environments. Sandia is developing a custom, radiation-hardened version of the Pentium processor that saves taxpayers millions of dollars in microprocessor-design costs and provides the federal government with a 10-fold increase in processing power over the highest-performing existing technology.

Energy Secretary Bill Richardson has heralded the agreement as a model of industry and government cooperation that will "significantly advance the state of the art in space and defense electronics."

Sandia Reaches Out:
A Community of Partnerships

Sandians understand we are part of a larger community, that communities are about people, and that people are at their best when helping one another.

In New Mexico, Sandia accounts, directly and indirectly, for $4.4 billion, or almost 4.8 percent of the state economy.

Economic Impact

Each year, Sandia purchases more than one-half billion dollars in goods and services. Close to $300 million of that is placed with New Mexico businesses and another $50 million goes to businesses in California. In New Mexico, Sandia accounts, directly and indirectly, for $4.4 billion, or almost 4.8 percent of the state economy. We create or support nearly 30,000 jobs—about 3.5 percent of the state employment.

Sandia has a long history of partnership with our supplier community to provide innovation, quality, and team success. We depend heavily on the partnerships with suppliers to enhance our ability to provide the best products and services to our customers. Sandia currently does business with more than 6,000 companies around the United States. We actively support small, small-disadvantaged, 8(a), and women-owned enterprises through a variety of outreach and technical assistance programs. Of the approximately $300 million spent annually in New Mexico, about 70 percent goes to small businesses.

Sandians raised more than $12,000 to purchase 450 pairs of shoes for needy children.

We form partnerships with numerous civic organizations. In

Many Sandia employees, retirees, and family members have made volunteerism a part of their daily lives.

New Mexico those organizations include the Greater Albuquerque Chamber of Commerce, Albuquerque Hispano Chamber of Commerce, Albuquerque Economic Development, and the Albuquerque Business Education Compact. Our California partnerships include those with the California Council on Science and Technology, Economic Development Alliance for Business, Bay Area Economic Forum, Bay Area Regional Technology Alliance, and the Livermore and Pleasanton chambers of commerce. The partnerships in both New Mexico and California focus on quality of life planning, regional growth strategies, water quality, education, workforce development, transportation needs, leadership programs, and business and economic development.

Lockheed Martin Corporation, which manages Sandia for the Department of Energy, maintains a philanthropic presence in the Middle Rio Grande community, with 63 percent of its efforts directed toward youth education. Lockheed Martin/Sandia corporate contributions invest in the local communities by providing awards and grants to nonprofit organizations and by encouraging youth development. In addition, the Sandia/Lockheed Martin Foundation donates nearly $300,000 annually to local cultural, educational, and human services groups.

For the 2000 United Way campaign, Sandians donated more than $2 million throughout our work sites, including Albuquerque and Carlsbad, N.M.; Livermore, Calif.; Tonopah, Nev.; and Kauai, Hawaii.

Volunteerism

Many Sandia employees, retirees, and family members have made volunteerism a part of their daily lives. Volunteers implement corporate-sponsored projects and develop relationships and partnerships with local businesses and nonprofit organizations. This past year, Sandians rallied to help the people of Los Alamos after fire destroyed much of the town. Sandians raised nearly $100,000 for town residents, donated food and clothing, and answered phones for the Red Cross. Some Sandians also opened their homes to Los Alamos residents after authorities ordered an evacuation of the town.

In 1999, we volunteered more than 80,000 hours for our communities. Sandians and Sandia retirees have volunteered for nearly 250 New Mexico and

Irv Hall, who retired from Sandia in 1994, volunteers much of his time to building homes with Habitat for Humanity. Hall also donated $30,000 in cash to construct this home.

Retired Sandian Bob Colgan volunteers with many Albuquerque-area organizations, including the New Mexico Zoological Society.

Many organizations provided nonprofit agencies with gifts and food during the holidays such as 1,000 pounds of food for Roadrunner Food Bank.

A postdoctoral student works in a lab at Sandia California.

California agencies. Examples include the YWCA, the Animal Humane Association, the Literacy Center of Albuquerque, Leadership Albuquerque, St. John's Women's Retreat, community fire stations, a Bosnia mission for the United Methodist Volunteers, Women's Housing Coalitions, Boy Scouts of America, Meals on Wheels, library and hospital assistance, Christmas in April, Albuquerque Zoo and Biological Park, and a project to build and repair homes in the Albuquerque area and in Oakland.

Sandia California employees volunteer many hours to community assistance projects. Volunteers work with the East Bay Habitat for Humanity to build new housing and participate annually in United Way Week of Caring projects. Other California outreach projects include the Holiday Spirit gift and grocery campaign for needy families in area communities each December and July; a pen pal exchange between middle school students in Livermore and their Sister City of Snezhinsk, Russia; and a children's book collection/donation project for Marylin Avenue School's learning and literacy program in Livermore.

Sandia California donated a nuclear weapons fissile-materials container to the City of Livermore, Calif., for its Millennium Time Capsule. We collected 85 items to be buried in the capsule near Livermore City Hall in January 2000.

Sandians in New Mexico and California volunteer as science fair judges, tutors, and classroom speakers.

Sandia New Mexico volunteer efforts have included the following:

- In 1999, more than 100 volunteers donated 400-plus hours during the Week of Caring to refurbish a youth crisis shelter in the South Valley of Albuquerque. Additionally, a cash contribution of $5,000 paid for the patio, patio cover, and supplies for the project. Sandia employees donated more than 40 boxes of school supplies for South Valley youth.

- As part of this national effort, 130 Sandia employees donated time on Make a Difference Day to help six United Way agencies. Volunteers repackaged frozen potatoes at the Roadrunner Food Bank, conducted a mass mailing, built sturdy wooden tables for a shrink-wrap operation at Adelante Development Center, and landscaped a home. Volunteers also sewed and assembled small-area dividers for a Campfire Boys and Girls after-school program; spoke to high-school classes for Focus Foundation about staying in school; stapled red ribbons on cards for Mothers Against Drunk Driving; and painted, washed windows, and turned mattresses at Casa Esperanza, a home-away-from-home for cancer patients and their families.

- Many Sandia organizations provided nonprofit agencies with gifts and food during the holidays such as 1,000 pounds of food for Roadrunner Food Bank; gifts for 30 Native American women and children through Morningstar, a community based advocacy program for Indian women and children in Albuquerque; 180 hats and 90 gloves, socks and shirts for Joy Junction, a shelter for homeless and transients; toys for Healing the Children, a program to bring children needing medical care to the United States from other countries; personal hygiene products for Haven of Love mission, a transitional living shelter for teens and young adults; gifts and food for families from Alta Mira Specialized Family Services, which gives respite care and education for children with developmental delays; and gifts and food for Martineztown House of Neighborly Service, which serves a specific low-income Albuquerque neighborhood.

- In 1999, Sandians raised more than $12,000 to purchase 450 pairs of shoes for needy children in our Shoes for Kids program.

Education

Sandia emphasizes education through many outreach and internship programs.

- The Student Internship Program supports youth training while recruiting the Labs' future workforce. Interns, under-graduates, and graduates are from science and engineering university programs. Participants gain real-world training with experts at one of the nation's largest research and engineering labs, have access to cutting-edge facilities, and receive competitive salaries for summer work. Minorities—including African- and Asian-Americans, Native Americans, and Hispanics—and women are encouraged to apply.

- Another recruitment program—the DOE-sponsored Science and Technology Alliance—strives to increase the number of minorities in mathematics, science, engineering, and technology careers with the DOE. The program develops curricula in these fields and offers laboratory resources. The Alliance has four member universities—the Ana G. Mendez University in Puerto Rico, New Mexico Highlands University, North Carolina A&T State University, and the Montana Consortium of American Indians.

Sandia emphasizes education through many outreach and internship programs.

To improve science education in Albuquerque schools, Sandia volunteers partner with teachers through Crosslinks, a program for hands-on science activities.

The Georgia Institute of Technology also is an affiliate. Three DOE laboratories participate: Los Alamos, Oak Ridge, and Sandia national laboratories. Members from private industry include AT&T and Lockheed Martin. Alliance staff, faculty, and students number 70,000.

- Sandia California's Education Partnerships helps the Labs recruit top recent graduates in such key fields as computing, microsystems, and engineering. During the past year, the organization has offered programs that bring students to the lab to conduct research that contributes to Sandia's mission. In addition, Sandia California offers several student programs in specialized areas, including the College Cyber Defenders program, Microsystems Institute, and the Engineering Sciences Summer Institute.

- The Sandia California Women's Committee promotes achievement in math and science for girls by sponsoring an annual awards banquet to honor high-achieving local high school girls. Sandia sponsors the National Physical Sciences Consortium by providing research opportunities for participating students. The consortium offers doctoral graduate fellowships for under-represented minority and female physical science students.

- The Lockheed Martin-sponsored Thunderbird Award recognizes exceptional achievement by at-risk youths. The award was expanded this year to include five more high schools outside the greater Albuquerque area. This past year, 23 high-school seniors in Albuquerque and Carlsbad, N.M., and nine in the area in and around Livermore, Calif., received monetary recognition for refocusing energies from negative or nonproductive activities to those that empowered students to achieve their potential.

- A Sandia partnership with Albuquerque businesses and educational and government entities held the first School-to-World event. Approximately 1,500 middle-school students and their parents attended the career-education activity. Sixty-five Sandia volunteers participated by discussing career options with students and encouraging youths to pursue their goals.

- To improve science education in Albuquerque schools, our volunteers partner with teachers through Crosslinks, a program for hands-on science activities. The project employs children's fascination with objects they can see, touch, and discover.

Sandia
Annual Report 2000
is an annual publication
issued by Sandia National Laboratories.
Sandia is a multiprogram engineering and science laboratory
operated by Sandia Corporation, a Lockheed Martin company, for the U.S. Department of Energy.
With main facilities in Albuquerque, N.M., and
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(A special thanks to the many Sandians who provided suggestions and information for this publication.)