SANDIA PERSPECTIVES

1998

Sandia National Laboratories

Velocity equals distance divided by time. Momentum equals velocity times mass.

It isn't that hard to measure the variables that govern motion. But how does one measure trillions of variables all at the same time?

The solution is massively parallel computing, which divides enormously complex problems into smaller pieces that can be solved simultaneously on multiple processors. Sandia is a leader in developing algorithms for this process.

A revolution in engineering began this year when Sandia's teraflops computer came on line. The teraflops completes more than 1 trillion mathematical operations per second. This achievement is opening new vistas of understanding in science and engineering, and has become an important tool in Sandia's nuclear surety mission. High-performance computing makes it possible to simulate catastrophic events, from climate change to the impact of the Shoemaker-Levy comet on Jupiter to crashes involving aircraft or land vehicles.

Computer science spans all technical disciplines — mathematics, engineering, physics, chemistry — disciplines that are essential to Sandia's mission.

The comparison of Sandia's high-resolution, three-dimensional simulations to actual events has shown that the scientific approach of the Department of Energy's Accelerated Computing Strategic Initiative is valid. Not only do predictions match actual events, but in some cases they increase scientific understanding.

Michael Hannah checks cabinets in the teraflops supercomputer, used for both classified and unclassified computational work.

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Secretary of Energy Federico Peña talks with reporters during a visit to Sandia in 1997.

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On the cover
Computer science spans all technical disciplines. Examples include (clockwise from top): finer electronic features that improve computer speed and memory, airborne data collection for modeling climate change, precise location of seismic activity anywhere on the globe, the world's fastest computer, and software that enables solar arrays to track the sun's position in any weather any time of year.

For more information about Sandia, please visit our Web site at http://www.sandia.gov

WELCOME

1997 was a year of remarkable progress at Sandia National Laboratories, reflecting dramatic change throughout the world. We expanded multilateral cooperation and arms control efforts with other countries; increased our strategic partnerships with industry, academia, and government; and received numerous awards and accolades.

Recognizing the value of international cooperation in preventing conflict, the governments of Eastern and Western Europe and the United States agreed to cooperate on security issues, from counterterrorism to nonproliferation of nuclear weapons. Russia will also have a voice, though no veto power, in the newly expanded North Atlantic Treaty Organization. These events came 50 years after the Marshall Plan provided a blueprint for rebuilding a war-torn Western Europe. The new NATO represents the most sweeping transformation of the balance of power in Europe since 1945.

At Sandia, the Minister of Defense of the People's Republic of China led a delegation of officials who were given a tour of laboratory facilities in December 1996. The minister's visit was hosted by the departments of State, Defense, and Energy. We believe the visit helped improve future relationships between the United States and China.

Another example of global cooperation is the Comprehensive Test Ban Treaty, under which many nations have agreed to cease all nuclear explosions. It is a priority of the Clinton administration to maintain a safe, dependable arsenal without nuclear test explosions. Today, computer simulations are helping to replace underground nuclear explosions as the basis for understanding and maintaining our nuclear deterrent.

Sandia President Paul Robinson discusses Sandia's achievements during 1997.

High-performance computing provides the Department of Energy weapons labs with a powerful tool for maintaining a safe, secure, reliable nuclear stockpile. The world's fastest supercomputer, built by Intel Corp. and housed at Sandia, recently achieved a processing speed of 1.34 trillion floating point operations per second. Called the teraflops, it has a peak capacity of 1.8 trillion floating point operations per second.

Sandia's mission is centered on stewardship of the U.S. nuclear arsenal. Although the United States and the former Soviet Union are dismantling many nuclear weapons, to a certain extent, nuclear deterrence remains our defense against aggression. It is clear that in addition to countries already having nuclear arsenals, other countries are attempting to acquire weapons of mass destruction.

growth in the past 40 years is the result of the nation's investment in basic scientific research. R&D touches every one of us — how we learn, what we earn, whether we have jobs, medicine, transportation, food, and warmth.

Nearly 50 years ago, President Harry Truman described Sandia's mission as "exceptional service in the national interest." The world-class science and engineering that are Sandia's heritage will be vital to addressing emerging threats — such as proliferation of nuclear, chemical, and biological weapons, terrorism, and sabotage of information systems.

"I COULDN'T HAVE HIRED THIS KIND OF EXPERTISE IN THE OPEN MARKET AT ANY PRICE."

— Dan Castilleja, Academy Precision Materials, semiconductor manufacturer

We invite you to learn more on the following pages about the many ways Sandia's people are providing *"…exceptional service in the national interest."*

Sandia's role in national security, nonproliferation, emerging threats, and energy and critical infrastructures advances interests of national and international importance. Our researchers have achieved breakthroughs in supercomputing, semiconductors, and sensors. They have designed secure computer networks and high-speed communication links; increased energy supplies through imaging of oil reserves and conversion of sunlight to electricity; and revolutionized microelectronics and manufacturing with three-dimensional computer modeling. Each of these advances is the result of a deep reservoir of technical expertise and dedication. By partnering with industry, we have helped transform new technologies into commercially useful products and processes.

Technological leadership is one of the hallmarks of our nation's success. Economists estimate that half of American economic

Sandia continues to expand its partnerships with government, industry, and universities, notes Executive Vice President John Crawford.

Technology for the 21st Century

"Congratulations to the entire Sandia team for your outstanding success with the B61-11 program. ... Thanks to your effort, the job was completed over eight months ahead of schedule — unparalleled!"

— Gen. Eugene Habiger, Commander in Chief, U.S. Strategic Command

Science-based management of the nuclear weapon stockpile has replaced explosive nuclear testing and presents immense challenges and opportunities for our nation. New technologies that meet national security needs give rise to new industries that could revolutionize our well-being as individuals, as a nation, and as a member of the community of nations well into the 21st century.

At Sandia, we continually strive for excellence in natural sciences such as physics, mathematics, and chemistry. We strive for innovative engineering, our heritage, in which a simple intuitive insight or advance can lead to solutions and industries never before possible. We evaluate proposals for new research and development through rigorous peer review by scientists and engineers. Our research and development awards reflect our dedication to science with an end in mind.

Sandia's primary mission is to provide engineering support for the nation's nuclear weapon stockpile. The cornerstone of this mission is the design of components and controls that ensure the safety, security, and reliability of nuclear weapons. In this role, Sandia works with the Department of Energy and the Department of Defense to establish nuclear weapon requirements and address problems of design, logistics, surveillance, and dismantlement.

Sandia also provides technical leadership for long-range stockpile management as weapons age and old technologies are superseded by new ones. To accomplish this, Sandia provides engineering support for advanced conventional weapons, ballistic missile systems, and military space systems that are key elements of national defense.

Modern military preparedness and commercial production both need to move quickly from initial concept to final product. Sandia engineer and computational expert Arlo Ames devotes his professional life to developing computer algorithms that take three-dimensional designs, such as weapon systems (upper right), to the analytical phase (upper left) without building, testing, analyzing, rebuilding, retesting, and reanalyzing. His work enables other specialists to accurately predict the performance of the product, which involves thermodynamics, mechanical response, fluid flow, chemical reactions, and many other variables that might otherwise lead to failure. Says Arlo, "My specialty is being glue. I'm building bridges between disciplines."

Supercomputers

Sandia is responsible for 97 percent of a nuclear weapon's approximately 6,000 parts. When a nuclear weapon explodes, a tiny bit of mass is converted to energy. The energy released by a 20-kiloton exploding atomic bomb is the result of converting only 1 gram of mass to energy. In achieving our stockpile stewardship mission, it is essential that we understand the underlying physical and chemical properties of the entire weapon system.

With the advent of high-performance computing, we can simulate nuclear detonations and weapon safety tests involving lightning strikes, crashes, fuel fires, and changes in components and materials that occur with aging. We can do this without creating a single nuclear blast or crashing a single aircraft.

Computer models aid the design and production of weapon systems. Ken Chavez (center) adjusts a 7.5-percent scale model of the B61-11 earth-penetrating weapon, built to match a three-dimensional computer model (lower left). The full-scale product (right) was dropped by a B2 bomber in a flight test in Tonopah, Nevada. By modifying an existing weapon with modern safety features, Sandia extended the life of the nuclear arsenal without building new weapons, and completed the modifications well ahead of schedule.

Sandia and two other Department of Energy national laboratories, Los Alamos and Lawrence Livermore, are continually developing new applications for the Accelerated Strategic Computing Initiative. The Sandia teraflops computer is 10 times more powerful than the next-fastest machine in use today and has a peak performance capability of about 1.8 teraflops (1.8 trillion floating point operations per second). Still faster computers are in the planning stages. The capabilities of these "petaflops" computers, which complete 10^{15} floating point operations per second, will achieve advances well into the new millennium. Seemingly intractable problems, tackled for years with conventional computers, can now be solved in minutes or days.

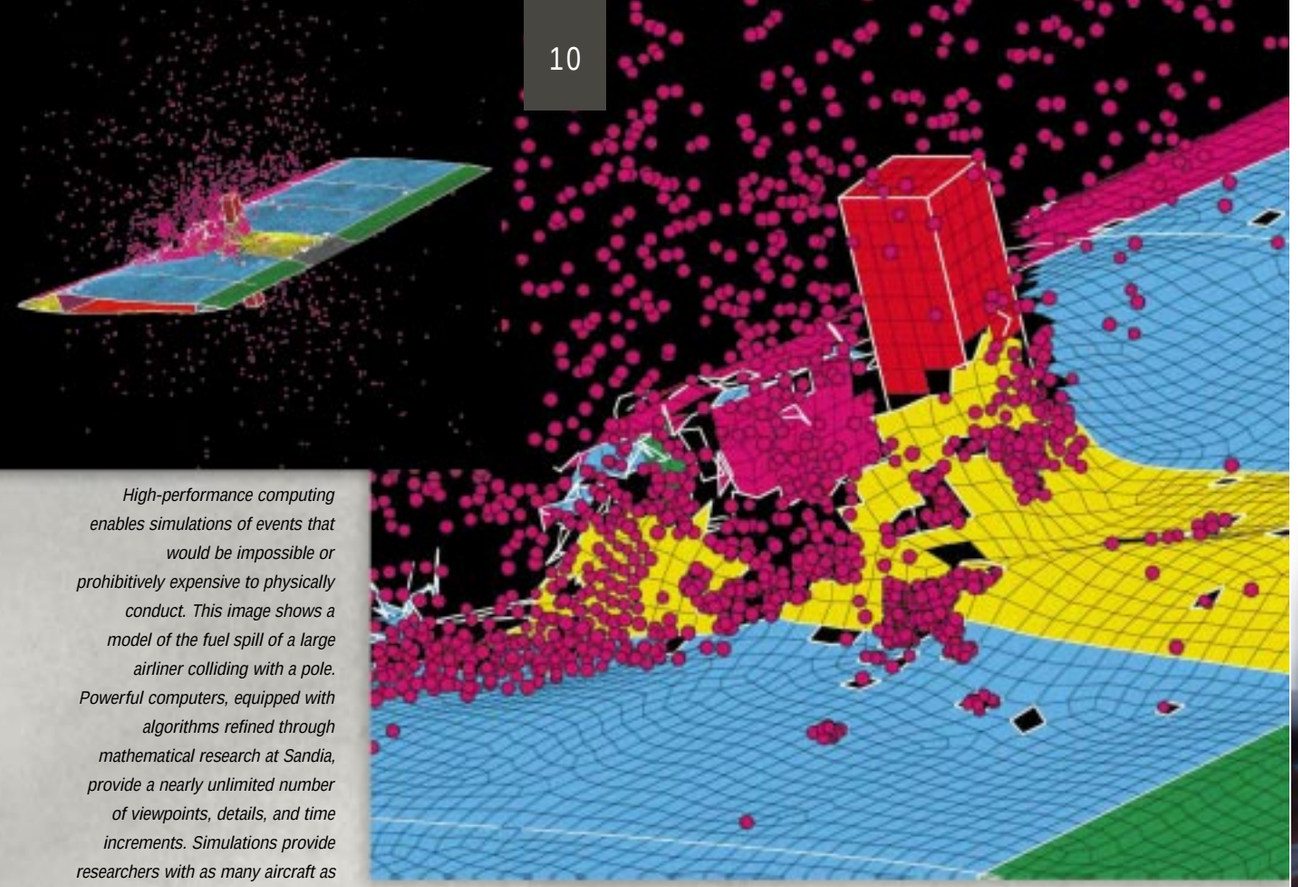
One of the benefits of our research is that applications that simulate the complex dynamics of nuclear weapons can model other processes as well. Instead of "make it, break it, make it better" — the basis of quality assurance since time immemorial — engineering will take place in virtual space in a fraction of the time it takes to physically create, test, remake, and retest. The result is that a new product goes to market in much less time. Designers can model the entire life cycle of a product or process in fine detail. Ultimately, massively parallel computing will revolutionize engineering as a result of the ability to tailor manufacturing processes and optimize performance of new products — in three dimensions, on a computer screen — before they ever reach an assembly line.

"This power enables Sandia scientists to begin to solve some of the world's most compute-intensive problems, which were previously unsolvable. The possibilities for scientific applications are unlimited."

— Dick Ammerman, teraflop program manager, Intel Corporation

High-performance computing can be used to evaluate tiny changes in the atmosphere over a broad region and the resulting impact on climate. It can decipher medical data to help cure terminal diseases. A researcher working at a computer terminal can design a catalyst one atom at a time and check its chemical properties each step of the way. The result: more efficient burning of fuel and less air pollution. Sandia has used massively parallel computing to produce three-dimensional models of geological formations for the oil and gas industry.

Sandia is licensing simulation technology to commercial firms. Many of the unique research and development facilities at Sandia are also available for use by private-sector companies.



High-performance computing enables simulations of events that would be impossible or prohibitively expensive to physically conduct. This image shows a model of the fuel spill of a large airliner colliding with a pole. Powerful computers, equipped with algorithms refined through mathematical research at Sandia, provide a nearly unlimited number of viewpoints, details, and time increments. Simulations provide researchers with as many aircraft as they need, at no additional cost.

Microelectronics and semiconductors

Smaller is better not only in the design of electronic devices, but in machines that sense, measure, and report. For example, new sources of ultraviolet light are producing finer semiconductor elements than ever before. In another example, Sandia is using silicon-wafer manufacturing techniques to produce micromachines so tiny that the normal physics of gravity, inertia, and friction no longer dominate. In this alternate universe, gears 100 times thinner than a sheet of paper, together with levers, springs, and sensors controlled by computer circuitry, will drive a new generation of weapon safety, nuclear detection, environmental monitoring, and space systems. Micromachines can render inertial guidance systems oblivious to conventional or electronic countermeasures, yet still hit a target with precision.

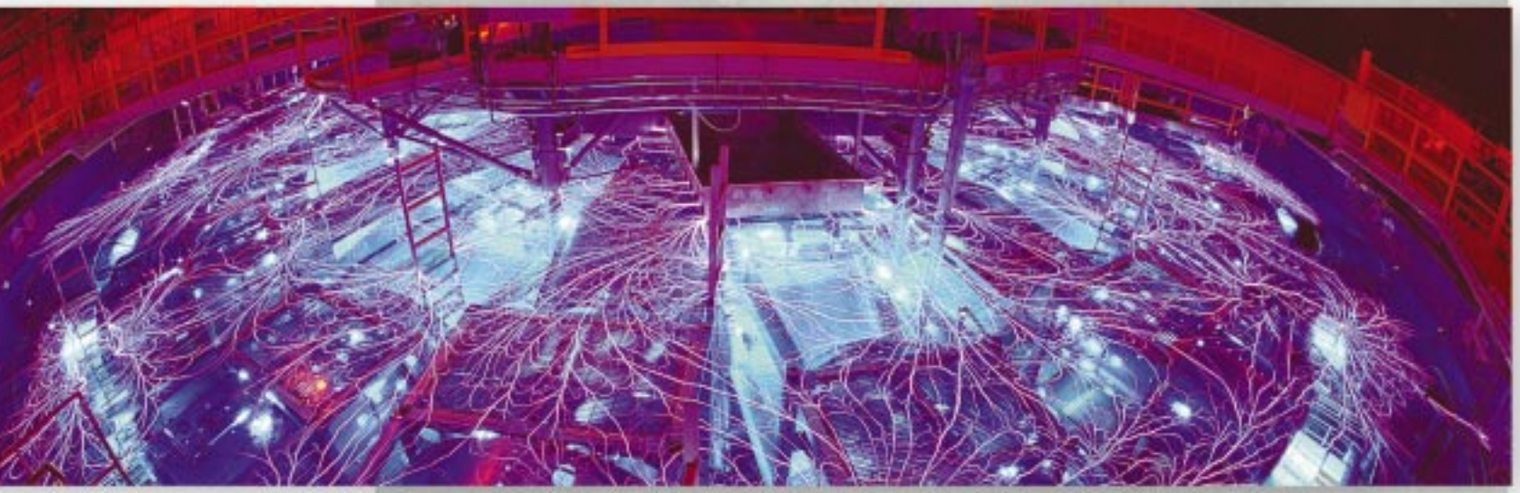
Research facilities

Sandia's unique facilities help us meet the requirements of our mission. This year, we modified a 10-year-old accelerator to produce more than five times the record X-ray output achieved in 1996, going from 40 trillion watts to 210 trillion watts. It took 25 years for a succession of Sandia accelerators to reach 40 trillion watts per shot. The Z Accelerator has achieved a power pulse that is more than 60 times the combined output of the Earth's electric utility plants. These powerful bursts of energy provide data for computer simulations used to predict the physics and the effects of a nuclear blast. This research also moves Sandia closer to achieving sustainable nuclear fusion in the laboratory.

Labs team with industry to build super chip

To help create finer features on microchips, Sandia has assembled the world's first laboratory tool that can print features one-third the size of those on commercial chips. Extreme ultraviolet lithography can print fine lines 0.1 micron in size or smaller, compared with today's industry-leading 0.35 to 0.25 micron. As a result, far more devices — transistors, capacitors, resistors, and diodes — can be packed into a single chip. These chips will be 100 times faster and have 1,000 times more memory.

This technology now constitutes the Department of Energy's largest industrial partnership, begun this year. Mass production could begin in early 2004. A consortium of U.S. chip makers, including Intel Corp., Advanced Micro Devices Inc., and Motorola Inc., is spending up to $250 million to develop this approach at Sandia, Lawrence Livermore, and Lawrence Berkeley national laboratories.



The Z Accelerator has achieved a power pulse that is more than 60 times the combined output of the Earth's electric utility plants.

We transformed the former Tritium Research Lab at our Livermore site in California into a new facility, the Chemical Radiation and Detection Laboratory, for work on advanced sensor systems. We received a Pollution Prevention Award from the Department of Energy for delivering a 500-percent return on investment by restoring and reusing the building rather than demolishing it.

Intelligent machines

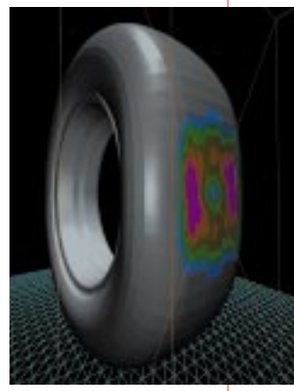
Sandia has the most versatile robotics research and development program in the United States, centered in the 73,000-square-foot Robotic Manufacturing Science and Engineering Laboratory. Dismantlement of thousands of retired nuclear weapons requires speed, delicacy, complete attention to detail, and safety. Intelligent machines are ideal for these tasks. Sandia has designed and delivered three robotic nuclear weapon dismantlement systems to the Department of Energy's Special Nuclear Material Consolidated Storage Facility in Texas, expected to become operational in May 1998.

"I am pleased to inform you that Goodyear announced today that it will be hiring an additional 125 engineers and scientists. ... Our Cooperative Research and Development Agreements with Sandia National Laboratories have produced computational analysis tools in ... areas of technology (that) are now a key element of our leadership strategy."

— R.J. Steichen, vice president, Goodyear Technical Center, in a letter to Sandia

Science-based stewardship will require continued advances in knowledge despite declining resources. With the number of weapon designers projected to decline significantly in the next decade, we've launched projects to preserve our knowledge base. Videotapes, cross-indexing, and software for mapping science knowledge three-dimensionally will help achieve the daunting task of preserving the technological feats of modern engineering.

Goodyear teamwork gets results



In partnership with Goodyear, Sandia researchers are helping develop safer, more durable materials and more efficient manufacturing processes using advanced computational modeling. Together with experiments, the computer models simulate manufacturing, performance, and mechanical response. The resulting solutions shorten development time by reducing the need to build and test prototypes. Goodyear regards the cooperative work so highly that it just signed a fifth cooperative research and development agreement with Sandia valued at $17 million.

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Representatives of 30 countries get a closeup look at technologies used to protect stored nuclear materials. Examples are microwave sensors, cameras, and protective barriers.

Jill Glass studies the microstructure of ceramic materials as part of her work developing models that describe their physical behavior. Research such as this leads to strategies for improving materials used in everything from microscopic sensors to protective coatings to tamper-evident seals.

ASSIGNMENT: GLOBAL SECURITY

The Remote Monitoring System developed at Sandia simultaneously keeps tabs on nuclear depots in the United States and the former Soviet Union — at Russia's Kurchatov Institute (pictured here) and Argonne National Laboratory West in Idaho. The system combines photographic surveillance, burglar alarms, motion detectors, and protective seals that are easily checked on a computer network.

In 1994, a band of criminals threatened to blow up a nuclear power plant in Lithuania if their friends weren't released immediately from jail. Though the Ignalina power plant provided 87 percent of Lithuania's electricity, the government was forced to shut down its Chernobyl-style reactors to search for explosives.

Incidents like this have led many countries to seek international assistance.

The International Atomic Energy Agency in Vienna is the primary gatekeeper for global cooperation to promote the peaceful use of nuclear energy and prevent the misuse of nuclear materials. Sandia National Laboratories has worked with the IAEA for decades to develop protective measures and help monitor for clandestine attempts to acquire nuclear weapons.

International visitors attend workshops hosted by Sandia to learn about security systems for nuclear materials that could be used in nuclear weapons. In 1997, representatives of 30 countries participated in the International Training Course on protecting nuclear materials. It was the 13th time Sandia hosted the three-week course, which was

funded jointly by the U.S. State Department and the IAEA. Participants from Sweden, Korea, Belarus, Kazakhstan, Japan, Argentina, and many other countries discussed arms control issues and modeled security systems that took advantage of the latest technology in computers,

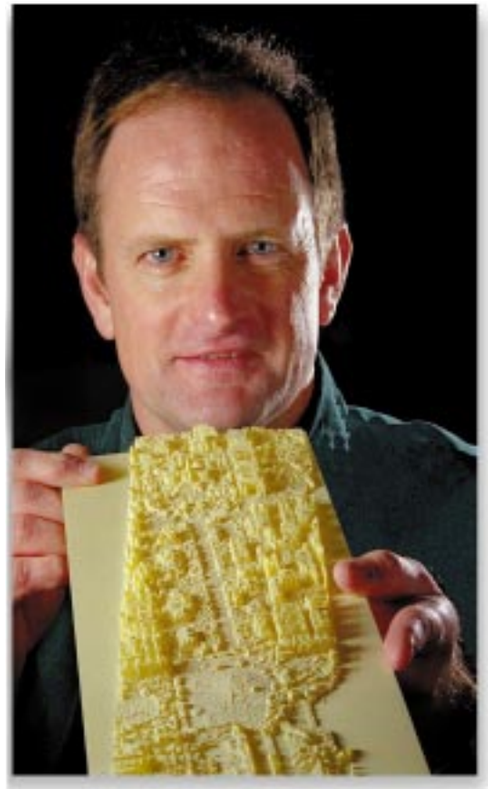
Bob Huelskamp inspects a synthetic aperture radar pod before a flight to collect data about environmental contamination.

sensors, cameras, defensive weapons, and protective barriers. Over the years, representatives of more than 60 countries have participated in the workshop. The course is so much in demand that current plans are to hold it more often.

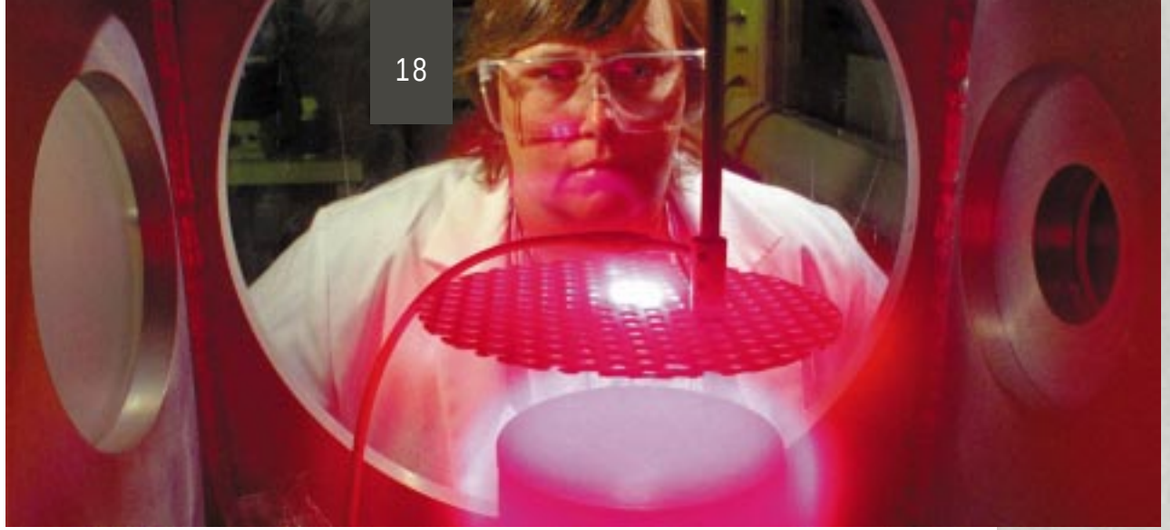
Sandia has a pivotal role in supporting arms control and nonproliferation projects. Working with the Department of Energy, Sandia engineers and technicians have upgraded the security of nuclear materials at 44 sites in the former Soviet Union and have worked at more than 300 facilities in 38 countries. Three Sandians were among those who received Meritorious Service Awards from the Secretary of Energy for their work in protecting nuclear materials in Russia and Eastern Europe. Other activities help channel research into peaceful work rather than the sale of weapon technology. Joint projects with former Soviet Union weapon scientists not only help protect and track nuclear warheads, but also match technical expertise with civilian needs, such as health care databases. These projects are supported by the U.S. Congress.

"This cooperation on our first joint American-Ignalina Nuclear Plant project was, I believe, a key factor in finishing our first physical protection upgrade within budget, and within the time schedules outlined in the contracts."

— Viktor Shevaldin, director, Ignalina Nuclear Power Plant, Lithuania



Sandia's contributions to synthetic aperture radar, used by aircraft to observe terrain at night or through cloud cover, have resulted in sharper images, three-dimensional views, and the ability to detect minute changes in objects on the ground. The Department of Energy presented its Ernest O. Lawrence Award to researcher Charles Jakowatz (right) of Sandia for a decade of improvements in SAR technology. Special operations troops have already used rubbery, pocket-size maps produced from SAR images with advanced manufacturing processes.



Engineer Pam Ward and two other engineers, Michael Smith and Joel Stevenson, are taking a leave of absence to start a business that will potentially save microchip manufacturers millions of dollars by preventing product flaws and reworking. Peak Sensor Systems will offer an innovative product developed at Sandia that monitors and corrects for changes in plasma etching, an environmentally sound process for etching materials from components.

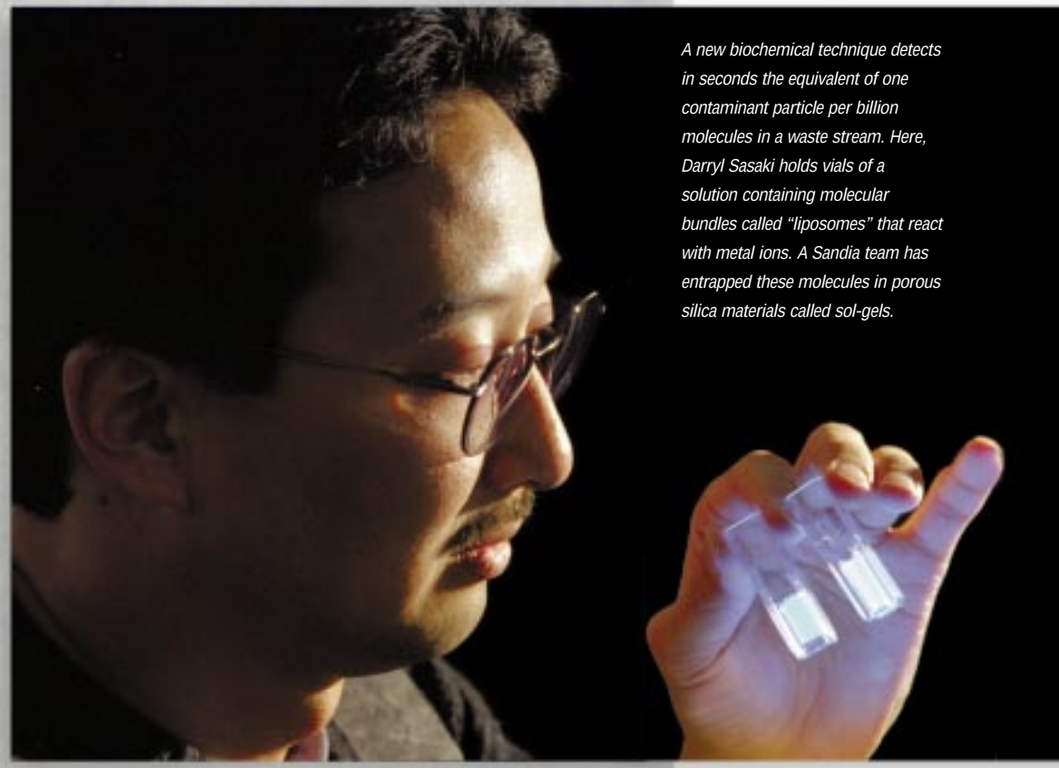
Sandia has nearly five decades of engineering and science expertise in maintaining the U.S. nuclear arsenal. But Sandia's responsibility doesn't stop there.

Technical experts from Sandia assist the United Nations in detecting and monitoring for clandestine attempts to develop weapons of mass destruction, including chemical and biological as well as nuclear weapons.

Diplomats from India, Pakistan, the Middle East, and many other regions of the globe have visited Sandia's Cooperative Monitoring Center to learn about ways to monitor treaty compliance, improve trust, and avoid armed conflict. Such cooperation enhances global security with the help of modern technology. The list of applicable technologies is impressive and includes, but is not limited to, remote monitoring, image processing, seismic monitoring, ecological monitoring, vulnerability assessments, access delay, computerized inspection training, chemical sampling, on-site inspection, nuclear material storage information, data authentication, secure containers, tamper-evident seals, tracking of sensitive items, intrusion detection, and secure communication networks.

"THE NATION IS THE SAFEST IT'S BEEN IN MORE THAN 50 YEARS. BUT WE MUST FIND THE MEANS TO DEFEND OURSELVES AGAINST TERRORISTS AND AGAINST WEAPONS OF MASS DESTRUCTION, ESPECIALLY IF THE ENEMY HAS THE CAPABILITY FOR MISSILE DELIVERY."

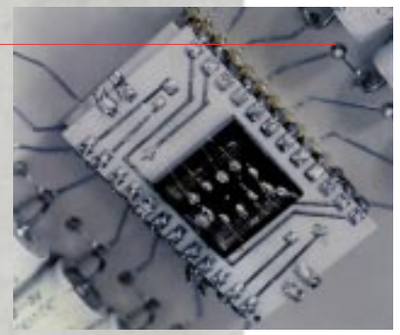
— Retired Gen. Colin Powell, former chairman, Joint Chiefs of Staff, at a news conference in New Mexico in 1997

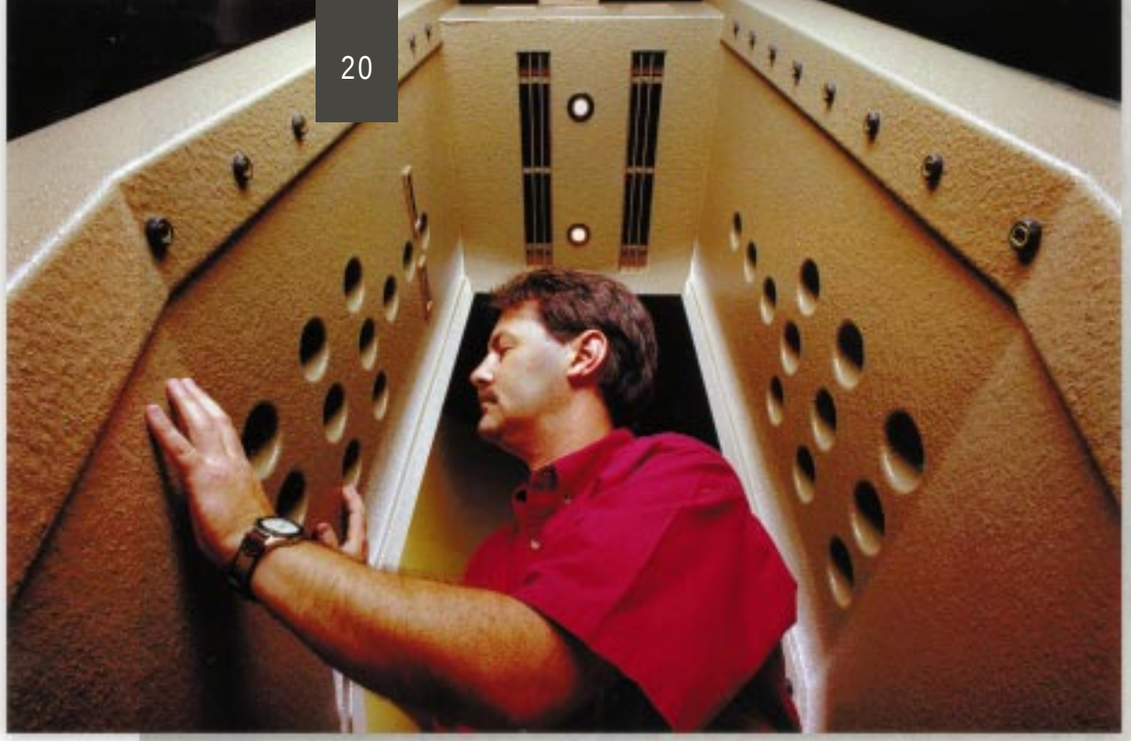


A new biochemical technique detects in seconds the equivalent of one contaminant particle per billion molecules in a waste stream. Here, Darryl Sasaki holds vials of a solution containing molecular bundles called "liposomes" that react with metal ions. A Sandia team has entrapped these molecules in porous silica materials called sol-gels.

Device senses harmful radiation

A wristwatch-size detector that senses gamma ray emissions won *Discover Magazine's* 1997 Award for Technological Innovation. Developed at Sandia by a team led by Ralph James, the device can image hidden sources of radiation and can recognize the presence of smuggled nuclear materials as opposed to natural background radiation. It is also being used to image radioactively labeled tumors, detect radioactive waste, and identify alloys during the sorting of scrap metal. Until recently, detecting radiation required bulky and expensive cryogenic devices. The Sandia invention uses large, flawless crystals of cadmium zinc telluride that emit a tiny electronic signal when hit by gamma rays. CZT detectors are already standing guard over dismantled atomic weapons. Cancer-detection applications could be next.





Kevin Linker examines a new walkthrough portal that will improve the safety of the traveling public by detecting minute traces of explosives on airline passengers.

TECHNOLOGY FOR PROTECTING CITIZENS

Technologies developed at Sandia National Laboratories are helping law enforcement agencies thwart criminal and terrorist activity. Explosives detection and mitigation and vulnerability analysis tools are examples of technological advances that are now becoming available to local law enforcement agencies through a partnership with the National Institute of Justice. In fact, the NIJ has designated Sandia a satellite facility to act as a liaison with local government.

Elite bomb squads from around the nation and the world get help from Sandia in a special course on managing bomb threats. Sandia again cohosted *Operation Albuquerque* in August 1997, a workshop for training explosives experts in the use of new technologies for defeating criminal activity and protecting the public. One of Sandia's technical innovations is equipment that safely disables bombs.

A new forensic device under development at Sandia will enable investigators to detect fluorescent materials at a crime scene, even during broad daylight.

Security systems and sensors developed by Sandia for the Federal Aviation Administration are improving safety for the traveling public. A new walkthrough explosives sensor that detects infinitesimal amounts of explosives residue on clothing and other surfaces is now being tested at an airport. The sensor is a descendant of the laminar air-flow clean room developed at Sandia in the 1960s.

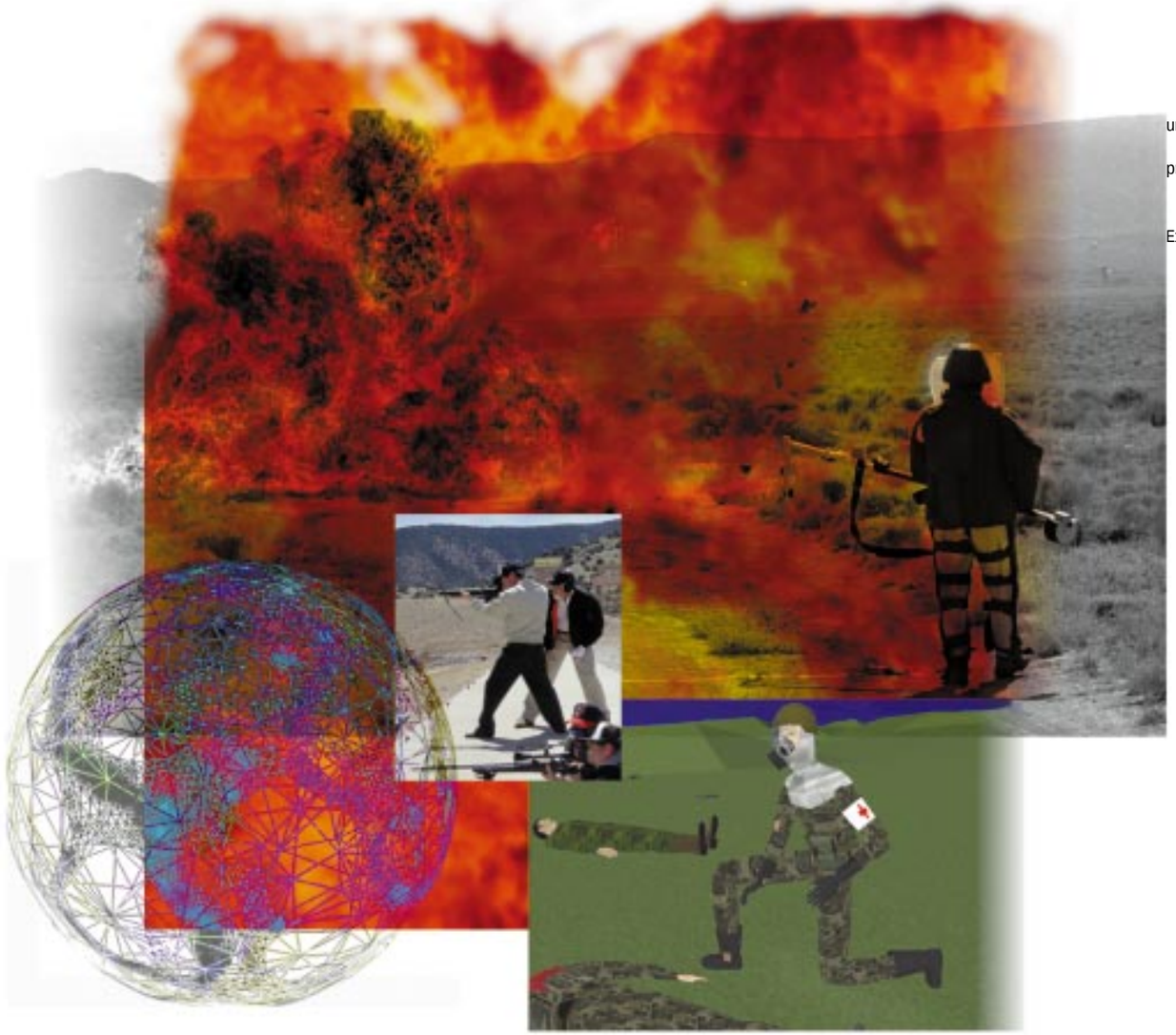
Building safety is another area where Sandia's expertise is making a positive difference. Computer models help predict the effects of explosions on physical structures, providing a basis for managing risk and making design improvements, such as window glass that minimizes injury to occupants. A mobile instrumentation package developed at Sandia can be deployed prior to a hurricane to measure building response. In addition, Sandia has developed and taught

"Are we glad Belen was chosen to be their pilot project for testing high-tech security in schools."

— Letter to President Clinton from community leaders

Simulations for countering terrorist attacks *are a lot like the real thing. From local police to international counterterrorist teams, security officers need extensive training to make the split-second judgments that save lives, rescue the innocent, and disarm or disable hostage-takers. Virtual Reality Assault Planning, Training, Or Rehearsal — also called VRaptor — allows law enforcement teams to grip guns, don virtual reality glasses, and burst into the harsh environment of hostage-takers and their victims. Sandia applied its expertise in security and advanced computing to develop the simulation.*

An explosives expert demonstrates new equipment that safely disables bombs.



university-level civil engineering courses that incorporate the safety principles learned from nuclear weapons management.

Examples of other Sandia technologies that can be applied to public safety:

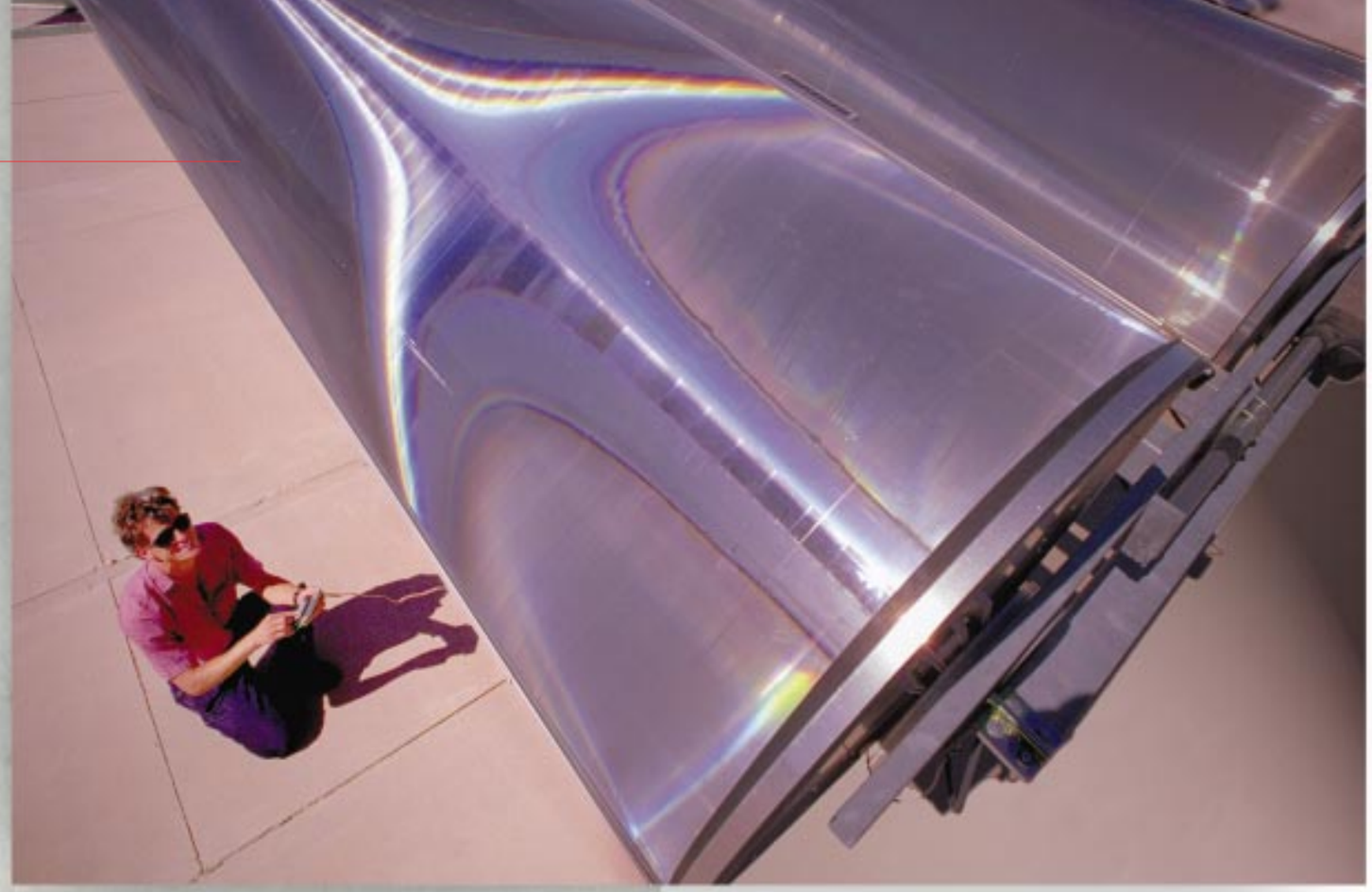
- Predictive fire codes for nuclear safety can help fight aircraft fires.
- Techniques for tracking sensitive materials can improve security at border crossings.
- Chemical analysis can identify counterfeit bills or toxic chemicals.

A new generation of field-ready microsensors will detect and identify minute amounts of chemicals on demand. Sandia is teaming with other national labs and the Department of Energy to develop a "chemistry lab on a chip" that will have applications from detecting explosives in demining operations to identifying contaminants in industrial processes.

School vandalism down, thefts declining

Mary Green confers with a student at Belen High School, 40 miles south of Albuquerque, New Mexico, about ways to improve school security. The pilot program has reduced vandalism by more than 75 percent, vehicle theft by more than 80 percent, and truancy by 30 percent. Fights, previously a weekly occurrence, are down to one per month, and what was once a daily false fire alarm is now a monthly incident. Sandia applied its security and systems expertise to identify vulnerabilities, problems, and issues, and involved the community in the process.

CRITICAL SYSTEMS THAT SERVE HUMANITY



Sandia engineer Alex Maish adjusts a computer system that tracks the sun's position any time of day or year in any kind of weather. The system maximizes the efficiency of solar arrays and is being commercialized by private industry.

Each year, the world's economic balance, energy sources, commerce policies, and environmental concerns are more strongly interlinked. Failures in any of these areas, whether accidental or deliberate, could cripple commerce or lead to regional or global armed conflict.

Energy

Sandia's advances during the past year toward ensuring adequate energy supplies ranged from dramatic improvements in the efficiency of household appliances and automobiles to increasingly powerful and sophisticated computer tools that help map underground oil reserves.

At Sandia's Combustion Research Facility in Livermore, California, scientists invented and patented a method that not only raises the efficiency of gas water heaters but reduces nitrous oxide emissions to much less than the maximum permitted by air quality standards. For automobiles, researchers are unveiling the details of the early stages of diesel combustion using a special research engine and advanced laser-sheet imaging.

Sandia completed a three-year research project to understand how pollutants originate in burning hydrocarbon fuels and what ultimately happens to them in industrial processes and atmospheric dispersion. The research revealed how deviations from normal combustion conditions produced harmful and carcinogenic substances. This information will contribute significantly to the next generation of air quality standards.

Program produces energy from waste

The Chernobyl reactor accident unleashed 200 times more radiation than the Hiroshima and Nagasaki atomic bombs, severely contaminating 25 percent of the total area of heavily forested Belarus. Sandia, the Belarus Institute of Power Engineering Problems, and the U.S. corporation Wheelabrator are building a biomass energy plant that will convert contaminated wood and litter into electricity while capturing cesium, strontium and other radionuclides in the ash. Besides eliminating the health hazards of the contaminated forest, the project will give Belarus, which imports 90 percent of its power, an affordable alternative to nuclear power. The project is funded in part by the Department of Energy's Initiatives for Proliferation Prevention.

A worker checks instrumentation on an unmanned aerial vehicle prior to an early morning flight to collect climate data. Sandia scientists working on a Department of Energy climate research program received Lockheed Martin Corporation's NOVA award for teamwork.

Sandia led the development of the Russian/American Fuel Cell Consortium, an international program to develop an environmentally friendly source of power and heat for buildings. Transportation may also benefit, as fuel cells can be used to power internal combustion engines.

Tens of billions of dollars in production losses occur annually because of power sags and momentary, 100-percent power losses that shut down computer-controlled systems. This year Sandia developed a battery-based energy storage and delivery system that, rather than acting like a circuit breaker and shutting down a utility line, monitors the line for momentary interruptions. When it senses something amiss, the system transfers the line in 1/400th of a second to stored battery energy for up to 10 seconds before returning the equipment to normal power as the momentary disturbance passes.

Near Barstow, California, Solar Two, the world's largest solar power plant, is operating with molten salt technology developed at Sandia. This year Sandia provided photovoltaic arrays that provide electricity to Arches National Park in Utah and the Salinas National Monument in New Mexico. These installations represent a clean, renewable, and silent alternative to diesel generators.

"Sandia's role was paramount to the success of the project. Every time we encountered a problem, Sandia attacked the problem and solved it."
— Bob Martin, Department of Energy, Solar Two power plant conversion project

In exploring for energy reserves, Sandia researchers used a semiconductor bridge, coinvented at Sandia, to more precisely initiate the explosions that aid in mapping underground reservoirs. The sharper and more powerful the seismic wave, the better the data collected from return echoes. A detonator ignites the energetic material pressed against the bridge in a few microseconds to achieve unprecedented accuracy.

Sandia's nuclear reactors and accelerators provided continued insight into nuclear energy, especially inertial confinement fusion.

Environment

Sandia's contributions to environmental research progressed on both molecular and global fronts. A new biochemical technique can rapidly detect contaminants in the parts-per-billion range. Large-scale tests of the reliability of nuclear reactor vessels have attracted international interest. From these tests Sandia is

Unsightly power lines and smoking diesel engines have been replaced by solar power arrays at Arches National Park through a partnership between Sandia, the Department of Energy, and the National Park Service.

Engineer Jill Fahrenholtz checks an automated pit packaging system, an intelligent machine that handles hazardous materials. Sandia has delivered three similar systems to the Department of Energy's Pantex Plant in Texas for use in dismantling retired nuclear weapons. Fahrenholtz received the 1997 Distinguished New Engineer Award from the Society of Women Engineers.

developing better models to predict how pressure vessels will perform in the event of an accident.

Nuclear reactor safety and the storage of nuclear waste remain worldwide concerns. This year Sandia completed the final certification for opening the Waste Isolation Pilot Plant for low-level transuranic waste. Research continued on hydrothermal and thermomechanical modeling of the proposed high-level repository at Yucca Mountain in Nevada. To assure the safe use of nuclear materials as a power source for spacecraft, Sandia developed a mathematical technique for analyzing accident scenarios during launch and reentry. At the Department of Energy's Pantex Plant in Texas, Sandia nuclear weapon safety experts teamed with reactor accident experts and computer scientists to assess the potential for off-site radiation release in the event of a plane crash or an employee accident during weapon disassembly.

Climate researchers on a Sandia-led, multilaboratory team completed a 26-hour, record-setting scientific flight with an unmanned aerial vehicle. This work is sponsored by the Department of Energy's Atmospheric Radiation Measurement-Unmanned Aerospace Vehicle program. Its goal is to understand how clouds interact with sunlight and heat from the Earth to improve the atmospheric models used to predict global climate change.

Lighter engines reduce fuel consumption

Engineer Mark Smith uses a supersonic spray jet with a temperature of more than 3,000 degrees F to apply droplets of molten steel to aluminum. In partnership with General Motors Corp., Sandia researchers have developed an economical way to make durable aluminum engines by spraying a wear-resistant coating onto cylinder walls. Aluminum reduces engine weight, improves mileage, and reduces emissions. Sandia is using the technology in defense-related applications, such as the manufacture of neutron generators, and in process control.

"There has been an excellent spirit of cooperation and collaboration in the General Motors/Sandia ... team, and it has given us a better understanding of how the thermal spray process works."

— Mark Gillman, manager, advanced manufacturing engineering, GM Powertrain Group

PARTNERING WITH THE COMMUNITY

RECOGNIZING THEIR COMMITMENT TO COMMUNITY INVOLVEMENT, THE NEW MEXICO CHAPTER OF THE NATIONAL SOCIETY OF FUNDRAISING EXECUTIVES SELECTED BOTH SANDIA AND LOCKHEED MARTIN CORPORATION TO RECEIVE THE 1997 AWARD FOR OUTSTANDING BUSINESS IN PHILANTHROPY.

Bruce Fetzer reads to youngsters at Christina Kent Day Nursery, who received new books through Sandia's contributions to United Way. In another project, schoolchildren are fitted with footwear in the annual Shoes for Kids drive.

A critical event in the development of young children is learning to read. Newspapers, comics, novels, business contracts, Internet documents — all are accessible to those who read. Statistics show that if children do not learn to read at their grade level by the end of the third grade, chances are they will continue to have difficulty reading throughout their lives.

To help solve this problem, Lockheed Martin Corporation is donating, on behalf of Sandia, $50,000 to a three-year literacy program in New Mexico in partnership with the United Way. The goal of the program, which will involve Sandia volunteers, schoolteachers, and students, is to have third-graders reading at third-grade level or better by the end of the school year.

This program is just one of many in which Sandia and Lockheed Martin participate, continuing a long-standing tradition of community service.

More than 1,600 employees and retirees of Sandia National Laboratories, together with family members, serve as volunteers in the communities where they live and work. During 1996, volunteers donated more than 45,000 hours of time to community projects. Sandia's volunteer program was recently featured in a National Points of Light Foundation publication as an exemplary community partnership.

SANDIA NATIONAL LABORATORIES AND THE DEPARTMENT OF ENERGY ARE COMMITTED TO IMPROVING THE QUALITY OF LIFE IN THE LOCAL COMMUNITY.

Sandia volunteers work for nearly 250 different agencies in New Mexico and California. They provide academic tutoring for children of low-income families, deliver meals to the elderly, and clear brush and debris from forest trails. They build new, affordable homes for growing families and clean and repair emergency shelters for the homeless and for victims of domestic violence. They raise money for medical research and serve on volunteer advisory boards. Some of the hardiest donate long hours day and night searching the backcountry and carrying emergency equipment to find people who are lost. There is rarely a volunteer activity that does not have a Sandia employee on the team.

Sandia has long been the largest supporter of Central New Mexico United Way. This year, Sandia employees contributed more than $1.4 million to the 1997 campaign. For more than a decade, Sandia has been the only company whose employees contributed more than $1 million each year. In California this year, Sandians contributed $155,000 to Bay Area charities.

The Shoes for Kids project, which provides warm, durable shoes to grade-school youngsters, received more than $9,000 in donations this year from Sandians, and another $2,000 from Lockheed Martin Corporation, which manages Sandia for the Department of Energy. More than 450 students from 17 Albuquerque public schools received new shoes through the program. In California, employees donated thousands of pounds of food and hundreds of toys to low-income families.

Lockheed Martin Corporation sponsored this aquarium exhibit at the Albuquerque Biological Park on behalf of Sandia.

Two Albuquerque youngsters grin for the camera with volunteer administrator Redd Torres Eakin, who represented New Mexico at the Presidents' Summit for America's Future in Philadelphia in 1997.

Lockheed Martin contributions on behalf of Sandia included the $2,000 Thunderbird Awards, given to high school seniors from each of Albuquerque's high schools and from Bay Area high schools who overcome obstacles or adversity to succeed; an annual grant of $15,000 to the Albuquerque Public Schools Foundation; and yearly donations of more than $300,000 to schools and other organizations, such as the Albuquerque Aquarium and the New Mexico Museum of Natural History.

In California, the Lockheed Martin Foundation donated $10,000 to "Crayons to Computers," qualifying the nonprofit organization for matching funds from the state to provide Pentium computers to area schools. A total of 1,500 computers, along with teaching supplies, will be donated to support computer education.

Sandia contributed to the local economies with more than $980 million in New Mexico and more than $190 million in California. These figures represent salaries, medical and dental benefits, retiree pensions, commercial purchases, and taxes.

Sandia is actively involved in local business and civic organizations that address needs such as economic development, transportation, and air and water quality. Sandia and the Department of Energy are committed to improving the quality of life in their local communities.