SANDIA

ACCOMPLISHMENTS

A YEAR IN REVIEW

1998

Sandia National Laboratories

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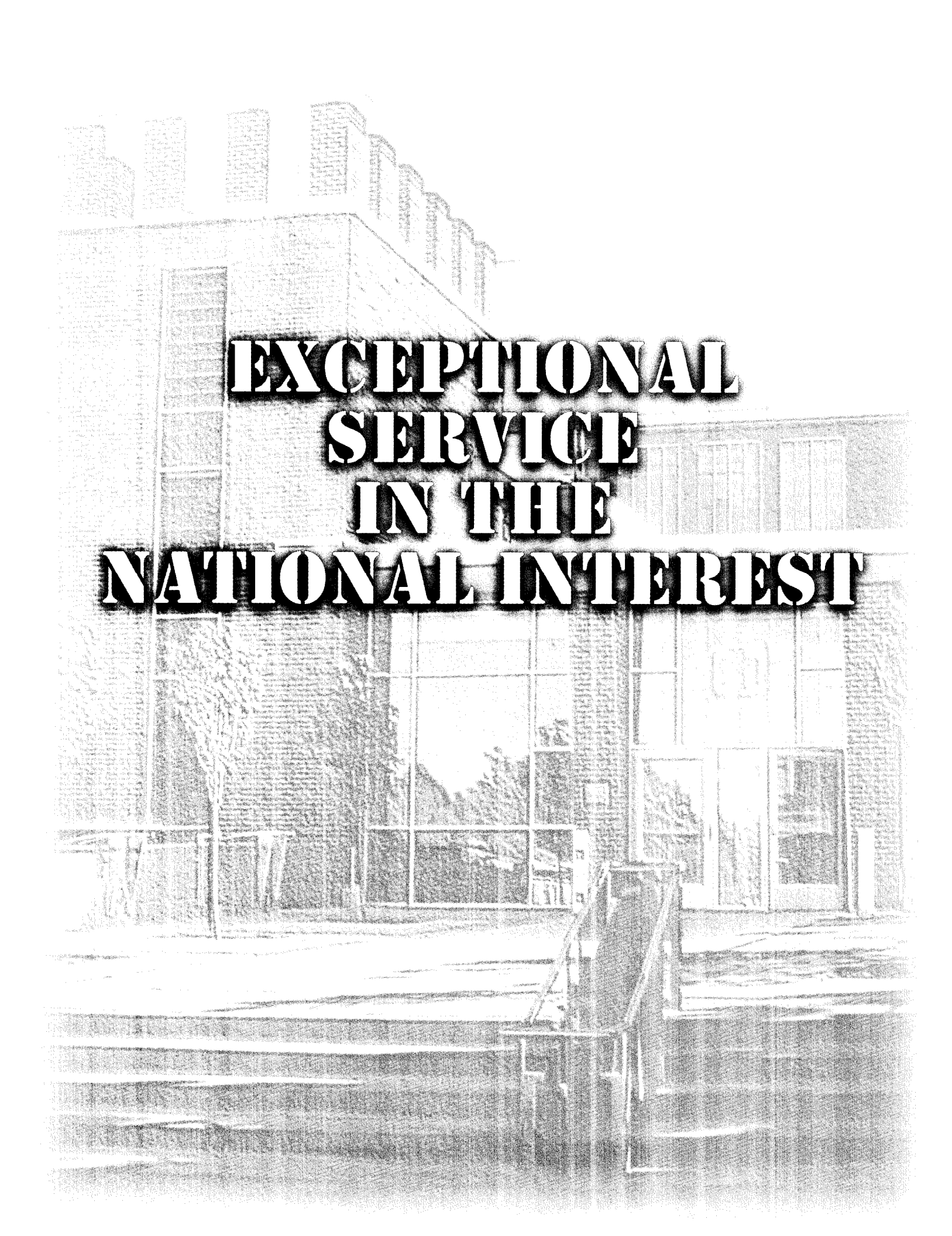
EXCEPTIONAL
SERVICE
IN THE
NATIONAL INTEREST

SANDIA ACCOMPLISHMENTS

To our readers:

Since the end of the Cold War, the role of our national security laboratories has been repeatedly examined. The conclusion reached each time was that "if they did not exist, we would have to invent them." Nothing I have seen could reinforce that conclusion as much as a careful reading of this year's compendium of Sandia's major accomplishments.

Our laboratory was created during the Manhattan Project of World War II and is still fulfilling its mission of uniting science and engineering to serve important national needs. Sandia's research and development portfolio is broad and deep, and the amazing accomplishments of the past year are a tribute to the many Sandia individuals and teams who, day in and day out, apply their intellects and talents to make strategic advances in many fields. Similarly, by applying the best administrative and operational practices we are continuously improving how we do business and enhancing our capabilities.

These accomplishments span nuclear weapons, arms control and nonproliferation, other defense technologies, energy and environment, computing and information technologies, electronics, sensors, monitoring systems, and other major engineering advances. From placing major new satellite instruments into space, to building new high-security networks, to assisting Russia and Ukraine to lock up their nuclear materials, to demonstrating superior computer analyses, to teaching bomb squads from around the world how to counter terrorist devices — Sandians are actively providing solutions for government and industry to use now and in the future. I hope you enjoy reading through this booklet and that you, too, will take pride in this unique laboratory.

C. Paul Robinson
Labs Director and President

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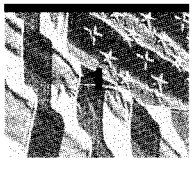
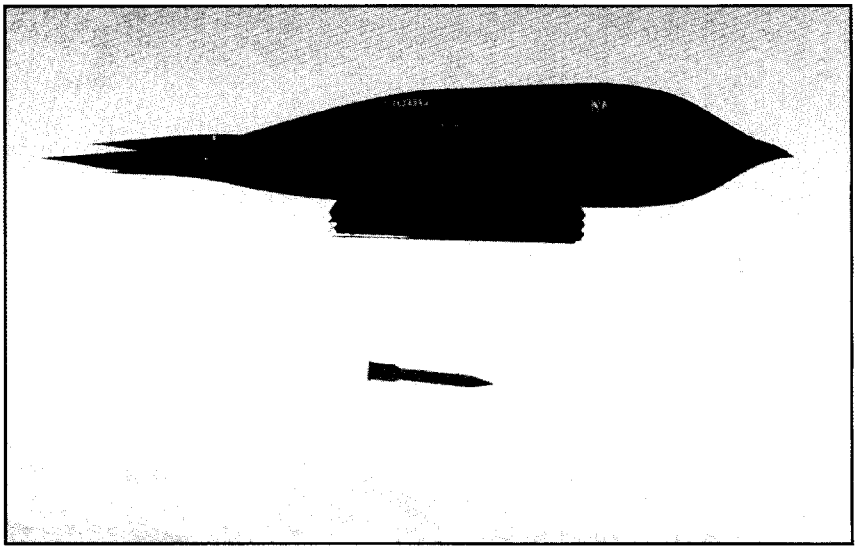


NUCLEAR WEAPONS



B-2A/B61-11 Certification Test at the Tonopah Test Range, November 20, 1996

B61-11 Earth-Penetrating Weapon is Fielded

The B61-11 bomb, an earth-penetrating weapon, entered the stockpile as a field retrofit of the B61-7. The retrofit, performed by a Department of Energy/ Department of Defense team, consisted of repackaging the Los Alamos-designed nuclear device and Sandia's arming, fuzing, and firing electronics into a new, one-piece, earth-penetrating, steel center case designed by Sandia. The aft portion of the bomb was outfitted with ballast to balance the weight of the heavy steel center case, and a drag flare was added to slow the bomb and turn it vertically as it drops. Production and qualification activities within the Nuclear Weapons Complex were completed in half the time normally needed for retrofits of this magnitude. Flight testing was done at the Tonopah and Alaska test ranges with a variety of aircraft, including the B-1B, B-2A, B-52, F-15E, and F-16.

Z Accelerator and the Hohlraum Break Radiation Records

Sandia's Z accelerator (previously called PBFA-Z) is a type of generator that rapidly delivers large amounts of electrical energy to objects smaller than a centimeter. This creates extreme conditions of matter that are normally found only in unusual places such as stars, nuclear explosions, and supernovae. Z is the most powerful generator of X-rays in the world and provides its intense X-ray source for applications such as weapon physics, astrophysics, and atomic physics. This year, Sandia's Z facility produced a record-breaking 290 trillion watts of radiation in a 4-billionth-of-a-second pulse from a tungsten Z-pinch. To put this in perspective, Z can generate — for an instant — 20 times the total electrical power generating capacity of the world. Sandia created another unique radiation source by containing the X-rays produced by a Z-pinch implosion in a special type of radiation case called a hohlraum. Hohlraums are small — only 1 inch in diameter and 1/2 inch long — and are able to confine the X-rays generated by the Z-pinch. The massive bursts of X-ray energy superheat the hohlraum walls, which absorb the X-rays, increase their intensity, and re-emit them onto a target. The hohlraum radiation source has produced a temperature of 1.6 ± 0.1 million degrees Centigrade; 2-3 million degrees are required for nuclear fusion, which may be achieved with Sandia's next-generation accelerator. Sandia is collaborating with scientists from Lawrence Livermore and Los Alamos national laboratories in experi-

ments that use this intense X-ray source to study the physics of nuclear explosions, thereby helping to meet the challenge of science-based stewardship of the nuclear weapons stockpile.

0.5-Micron ICs Fabricated with Radiation-Hardened 'Trenches'

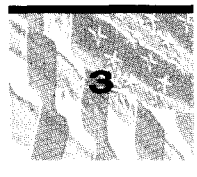
Integrated circuits (ICs) fabricated in Sandia's Microelectronics Development Lab with minimum feature sizes of 0.5 micron have demonstrated radiation hardening to levels in excess of 5 megarad, the highest level of radiation hardness that Sandia has achieved for ICs of this density. The ICs were fabricated using a modern technique of etching "trenches" between transistors to achieve electrical isolation. Trenches are half-micron-deep physical barriers filled with a silicon-oxide insulating material that neutralizes the positive charges that radiation generates when it hits the insulators. Trenching is used on Sandia's dense, radiation-hardened ICs because insulators used on commercial ICs lose their current-blocking capabilities if exposed to radiation. Trenching is rarely used for 0.5-micron ICs, but is common in more advanced, higher density circuits. Consequently, Sandia's new hardening techniques are applicable to future IC generations and represent a major advance in understanding radiation effects on integrated circuits.

New Sandia Computer Code Predicts Weapons' Radiation Vulnerability

A new Sandia-developed Monte Carlo computer code that predicts the transport of electrons and photon radiation is being used for the first time to efficiently assess the radiation vulnerability of weapon systems exposed to hostile X-ray encounters. On the world's fastest computers (teraflops, or trillion-operations-per-second, computers) this code is being used to predict, from many thousands of angles, the dose of radiation that would bombard the vulnerable regions of particular weapon components. The worst-case angle of attack is identified and used in a subsequent analysis to predict the mechanical (shock and thermal) effects that a hostile radiation environment could produce in weapons systems. The new code is being used to help certify the radiation hardness of the MC4380 neutron generator as configured within the W76 system.

Flash Radiographic Approach to Validating the Nuclear Stockpile: Robust, Compact, and Far Less Expensive

The Sandia element of DOE's Advanced Hydrodynamic Radiography Program made stunning progress in 1997. Sandia, Los Alamos, and Lawrence Livermore national laboratories have entered a four-year competition to provide the most feasible radiographic technology to validate, without underground tests, the performance and safety models of stockpiled nuclear weapons. Flash radiography can be visualized as combining a flash bulb, which freezes the motion recorded by a camera, and a medical X-ray, which radiographically probes a person to measure internal density variations. Nuclear weapon detonations move very rapidly, requiring a "flash" of less than 50 billionths of a second; they're also very dense, requiring an extraordinarily intense burst (about 5 million volts) of penetrating X-rays. An approach using robust, compact, high-current particle accelerators (developed for other Sandia missions) was quickly implemented to magnetically focus an electron beam onto a 1.7-millimeter-diameter spot at 10 terawatts/cm^2. This approach produced one of the world's most intense sources of penetrating X-rays and is 30-50% less expensive than the other methods. It will next be demonstrated at the 1-mm, 50-terawatts/cm^2 intensities required for an Advanced Hydrotest Facility — the national capability needed in the early 21st century to validate nuclear weapon design codes without underground tests. Sandia leads



the nation in understanding and managing high energy-density plasma physics technologies used in world-class flash radiography X-ray sources.

116 Nuclear Weapons Evaluated, No Safety Impacts Identified

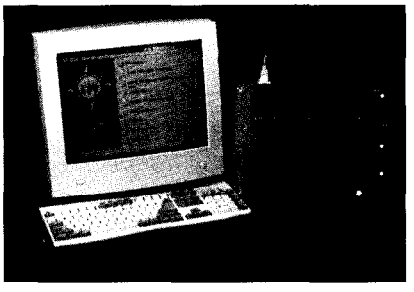
Sandia's Surveillance Program team evaluated 116 nuclear weapons in FY97. All weapons were denuclearized and instrumented in test configurations at Sandia's Weapons Evaluation Test Laboratory at the Pantex Plant in Amarillo, Texas. Sixty-seven weapons underwent environmental testing and 49 warheads underwent flight testing with military operational delivery systems. Eight significant finding investigations were opened to determine reliability and safety impacts and the appropriate corrective actions for anomalies detected during testing. The team conducted 20 significant finding investigations and consequently identified 6 reliability impacts and no safety impacts. Eight sets of corrective actions are being taken.

Safety Assessments: Backbone of a Safe Stockpile

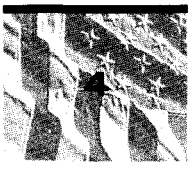
To help fulfill its role in maintaining a safe nuclear weapon stockpile, Sandia conducted independent safety assessments of its components, as well as assessments of more than a dozen nuclear explosive safety operations for the Department of Energy. Sandia also assessed more than a half dozen nuclear weapon system safety operations for the Department of Defense. The results have been used in both nuclear weapon operations and design.

T1565A Headquarters Code Processor Is Delivered

Sandia developed the T1565A Headquarters Code Processor to extend the capability of the U.S. European Command PAL Management Control Team (USEUCOM/PMCT) to perform peacetime Permissive Action Link (PAL) code management for nuclear weapons in Europe beyond the year 2000. The PAL Management Control Team is responsible for nuclear weapon code management and planning. The T1565A consists of a host processor that runs Sandia-developed software, and a cryptographic processor based on a Sandia-designed secure hardware and software architecture. Sandia installed the T1565A at the USEUCOM/PMCT office in August 1997, replacing an antiquated, nonsupportable system. The delivery marks the first step of a long-term Sandia plan to replace aging PAL equipment currently in use around the world.



T1565A Headquarters Code Processor



MC4519 MCCS Encryption Translator Assembly Will Enhance Use Control of Nuclear Stockpile

The MC4519 MCCS Encryption Translator Assembly (MET) is part of the weapon Permissive Action Link (PAL) system. It is a sort of electronic "combination lock" that ensures that a weapon can be armed by authorized users only. The MET device provides a cost-effective way to upgrade use-control weapons systems with cryptographic recode capability. Specifically, it allows periodic recodes of MET-equipped weapons without exposing code information. The device provides an essential step in implementing end-to-end encryption in PAL code management, enhancing security and allowing for more efficient operations. The MET is being produced for B61-3, B61-4, and B61-10 weapons, which were previously equipped with a use-control system that did not have encryption capabilities. Shipments began in June 1997.

Sandia Designs, Builds, Recertifies Neutron Generators

The proper function of a nuclear weapon depends on the presence of neutrons during primary implosion when the plutonium is supercritical. Neutron generators are located close to the warhead primary to produce a sufficient quantity of neutrons at that critical time. During the last year, Sandia began its own neutron generator production operations, designing and building 200 new developmental MC4380 units. Sandia also supported the Department of Energy's W76 recertification program, equipping more than 900 W76 MC2989 Neutron Generators with new hardware. Sandia's recertified neutron generators successfully passed 24 consecutive DOE inspections.

Sandia Team Fabricates W76 Neutron Generators

Sandia's MC4380 Neutron Generator Product Realization Team is responsible for designing, developing, and manufacturing war reserve neutron generators for the W76 warhead on Trident I & II sea-launch ballistic missiles by October 1999. During the previous year, the team fabricated 82 MC4368 Neutron Generator Subassemblies and tested 60 MC4380 Neutron Generators. The team completed first and second qualification evaluations, documentation, and a qualification plan; the team also defined requirements for hostile environment certification of neutron generators. Fabrication of the MC4380s started in Sandia's Neutron Generator Production Facility in December 1996.

Sandia Fabricates 104 Development Neutron Generator Tubes

As part of its commitment to deliver war reserve neutron generators to the Department of Energy by October 1999, Sandia fabricated 104 development neutron tubes last year. Sandia recently started developing its neutron generator manufacturing capabilities to help ensure the viability of limited-life components in the nuclear stockpile. Sandia has always designed neutron generators, but after DOE restructured the production complex, Sandia received a new mission—to fabricate neutron generators. Before beginning production, Sandia researchers developed new approaches to scheduling and quality control. The goal was to establish robust manufacturing processes that would be affected as little as possible by variations in equipment, processes, raw materials, and human interactions. Sandia resolved tube performance issues, including a problem with neutron tube sources (components that enable tubes to operate) that were not functioning as long as they should. Researchers designed a modification that allowed the tubes to continue functioning. Additional improvements in material handling and control reduced overhead costs and production cycle times. Sandia resolved major problems without jeopardizing the October 1999 delivery date.

Sensor-Based Robotic System Reduces Human Radiation Exposure

The Weigh and Leak Check System (WALS) is a sensor-based robotic system that remotely and automatically handles nuclear materials (stockpile pits) at the Pantex Plant, a DOE facility. WALS unpacks radioactive pits from containers, delivers the pits to testing stations, weighs and leak checks the pits, and repacks them. WALS includes a real-time control computer, which processes data from force and torque sensors, controls nearly 200 workcell input and output devices, and sends commands to a robot controller, which in turn controls robotic activities. WALS uses machine vision to extract geometric features and dimensions in the workcell that are used to move the robot or manipulate the objects it carries. WALS will reduce operator exposure to radi-

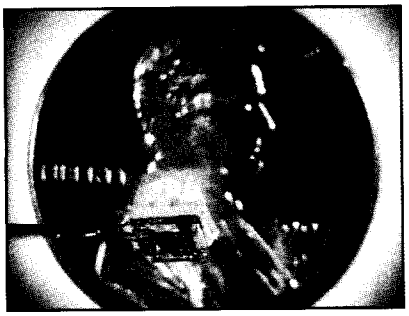
ation, eliminate heavy lifting, and minimize the possibilities for human mishandling. Automated data-entry methods will reduce the need for operator interaction and an automated control system ensures that qualified procedures are performed. In 1997, Sandia completed WALS development, testing, shipment, and installation. Integrated testing will be completed in early 1998. When operational, WALS will be the first robotic system in the Nuclear Weapons Complex that directly handles war-reserve pits.

Robot-Controlled AGGDIS Safely Disassembles Gas Generators

Sandia's Automated Gas Generator Disassembly System (AGGDIS) is a robot system that disassembles gas generators. The generators, designed to eject parachutes from nuclear weapons, have become unsafe after years in the stockpile. The generators could explode, so they cannot be taken apart directly by people. Operators run AGGDIS from a remote location, safe from potential hazards. Before AGGDIS was available, unwanted gas generators were disposed of by igniting them, but this method contaminated the scrap aluminum and steel with lead and required employees to collect unburned propellant. AGGDIS takes apart the gas generators, pours out the propellant, and cleans the scrap metal. The robot system yields better-separated waste than the alternative burning process, enhancing recycling efforts. AGGDIS uses computer vision (computer-processed TV images that help robots locate parts and tools) and force-controlled motion (a technology that measures the forces the robot applies and moves the robot to achieve the desired force) to accommodate process variation and ensure gentle handling of the devices. AGGDIS began operating at the Pantex Plant in Amarillo, Texas, in April 1997 and dismantled 980 MC-1362 explosive gas generators by February 1998.

VCSEL-Based Stronglink Monitor Will Protect Nuclear Weapons

Sandia has developed a new type of stronglink monitor to help keep nuclear weapons safe in case of an accident. The Vertical-Cavity Surface-Emitting Laser (VCSEL)-based stronglink monitor is the first to be based on VCSEL technology. (VCSELs are "grown" on a semiconductor substrate and have a multilayered bottom region of material that acts like a high-performance mirror, a middle region that emits light when electrically charged, and a top region of mirror-like material.) The VCSEL-based stronglink monitor has been assembled into a working prototype of the Colocated Detonator Stronglink (CDSL).



CDSL Monitor on Lucite Mounting Bracket.

The CDSL provides safety in abnormal environments for the Submarine-Launched Ballistic Missile Warhead Protection Program/Pit Reuse weapon system. Colocating two stronglinks at the detonator allows a more compact design with fewer parts. The monitors sense position: a VCSEL emits light, which passes through a microlens, hits a reflective spot on moving parts in the CDSL, reflects back through a second microlens, and hits a detector. Monitors sense the locations of reflective spots and provide feedback to the 8-mm rotary piezoelectric motors that drive the system. The monitors also sense whether the system is in the SAFE, ARMED, or RESET mode. The VCSELs and microlenses for this device were fabricated in Sandia's Compound Semiconductor Research Laboratory and mounted to a Sandia-designed ceramic substrate.

Milliengine Fills Void Between Conventional and Microscopic Motors

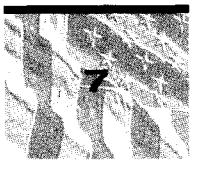
Sandia has successfully designed, fabricated, and operated a new, fundamental magnetic actuator called the Milliengine. This device was designed for mesoscopic ("in-between-sized") machinery, for applications where microscopic motors cannot provide sufficient power and conventionally fabricated motors are unavailable. In other words, the Milliengine's size fits between motors built in conventional machine shops and the nearly invisible silicon micromotors built at Sandia. The Milliengine's soft magnetic material is unique for an engine of its size, as is its slider crank mechanism to convert linear to rotary motion. The Milliengine is fabricated using LIGA techniques (also called High Aspect Ratio Micromachining techniques). LIGA is an X-ray lithography process that can produce both plastic and metal parts with tolerances 10 times smaller than those possible with conventional precision miniature machining. The Milliengine may one day be used as an actuator for nuclear weapon strong-link mechanisms.

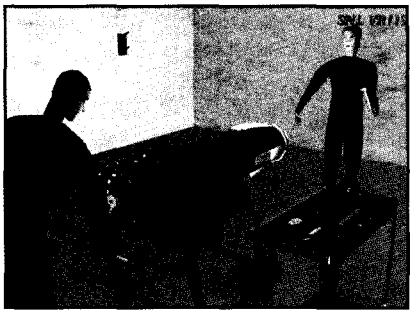
Stockpiled W62/Mk12 Lives On with Sandia's Help

Sandia was a key player in a joint DoD/DOE study to identify options for extending the life of the Minuteman III's W62/Mk12 reentry vehicle well beyond its original design life. The study also provided options for upgrading the weapon to meet modern safety standards and keep the weapon deployable. The study included two phases: a technology phase to identify aging issues and upgrade options and a follow-on phase to determine estimated cost, benefits, and risks. In concert with Lawrence Livermore National Laboratory and DoD partners, Sandia provided design options ranging from minimal modifications of DoD and DOE components to an extensive redesign of the warhead's electrical system. DOE's Albuquerque Operations Office published the technology portion of the study in May 1997. Sandia provided detailed design information and helped coordinate the report for the second part of the study, which was completed in December 1997.

DPAG Advises Federal Decision-Makers

The Department of Energy asked Sandia to form the Defense Programs Analysis Group (DPAG), a systems analysis organization, to carry out long-range defense-program planning, perform feasibility studies, and conduct cost-benefit and technical analyses to support federal decision making. To help perform these analyses, Sandia hosts collaborators from other DOE laboratories and production plants. The group analyzes technical trade-offs in day-to-day defense program operations and develops perspectives on large initiatives. Activities include supporting program planning for the Stockpile Life-Extension Program, assessing procedures for tracking and monitoring warheads taken out of deployment under potential START III Treaty scenarios, and helping the Energy Department evaluate safe and effective testing procedures for addressing stockpile aging issues.





Virtual World: Pantex bay with B61 tail piece, tools, and two participants.

Virtual Reality-Based B61 Software Could Supplement Assembly/Disassembly Training

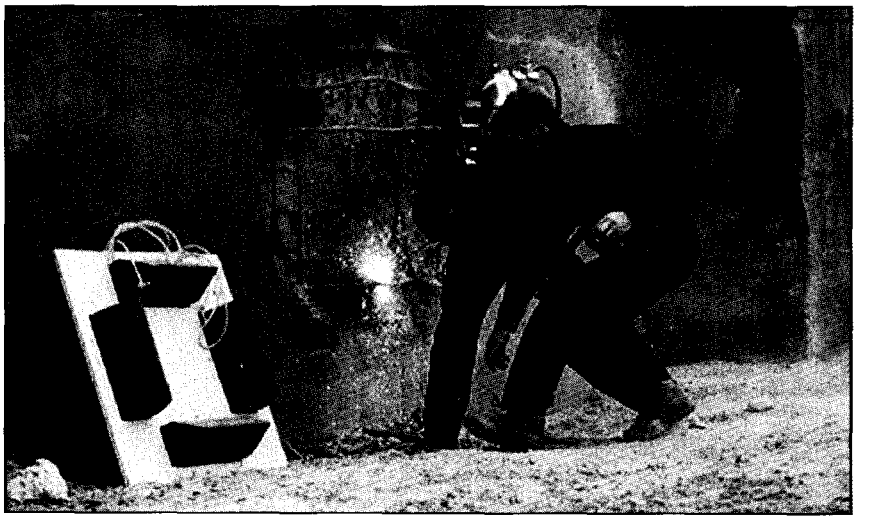
Sandia developed a virtual reality (VR)-based training software prototype for the Pantex Plant in Amarillo, Texas. The prototype system allows two participants to work together to remove the parachute from a B61. Recently delivered to Pantex, the new software could provide a cost-effective supplement to current physical trainers. Virtual-reality training allows participants to get experience with unusual circumstances or conditions that cannot be simulated on a physical model. Participants using the software are fully immersed in a virtual world — a Pantex assembly bay complete with a B61 tail section and the tools and parts required by the procedure. The B61 VR training is the most recent demonstration system in a series of VR products that use the same underlying software and hardware. VR-MediSim, for example, is a system designed to train battlefield medical personnel by immersing them in a virtual world where they are confronted with real-life casualty situations. VRaptor is another VR tool that prepares participants for hostage rescue situations.

Penetrability of Walls Tested with Advanced Security Attack Tools

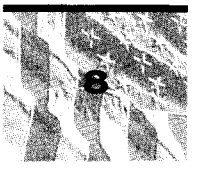
Sandia completed a series of tests of advanced security attack tools for the DOE Office of Safeguards and Security. The project evaluated the performance of explosive standoff weapons and demolition munitions that could be used in potential security-breaching scenarios. Members of a special military entry team completed more than 30 explosive attacks and evaluated the realism of the scenarios. The goal was to penetrate barriers within a specified time. Test results are being incorporated into security evaluations for the DOE Complex and into new facility designs for future storage of special nuclear materials.

ARRAMIS™ Software Integrates Risk-Assessment Tools

Sandia has historically led the development of advanced probabilistic risk assessment (PRA) methodologies with powerful software tools that assess high-risk systems. Sandia developed a variety of PRA tools for modeling nuclear weapons, telecommunications systems, aircraft, and robotic manufacturing systems. Sandia has updated, refined, and integrated these previously separate tools to form ARRAMIS™, the Advanced Risk and Reliability Model Integrated Software. From this single integrated environment, a risk analyst can now, for



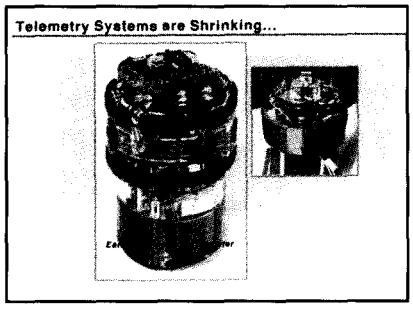
A special military entry team tests advanced security attack tools for the DOE Office of Safeguards and Security.



example, combine computer models of the events surrounding a weapons transportation accident with a detailed model of the weapon's internal safety systems to form a more complete picture of the safety of the weapon. The analysis includes an estimate of the likelihood that each type of accident will occur and the sequence of events that would cause such an accident.

Miniature EFI Telemeter Will Enhance Weapons Surveillance

The Enhanced Fidelity Instrumentation (EFI) system, the first in a series of miniature telemetry systems that Sandia is developing, is a component in the W87 Flight Test Unit (FTU)-12, a simulated warhead that will be flight tested in May 1998. This Sandia telemeter, a type of minimally intrusive flight test instrumentation, gathers and processes sensor data while its reentry vehicle (RV) is in flight and transmits the data to ground-based receivers. As a component in the FTU-12, the EFI telemeter and its associated weapon RV will ultimately be used in DOE weapons testing activity managed by Sandia in coordination with the U.S. military. The EFI telemetry system measures the function and dynamics of the RV for the W87 Life Extension Program while maintaining all of the RV's dynamic characteristics. The FTU-12 has undergone successful qualification testing in preparation for the upcoming flight test.



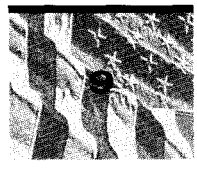
Minimally intrusive flight test instrumentation.

Lab Tests Simulate Shock Wave Blast to Reentry Vehicle

The conical-shaped W76/Mk4 reentry body (RB) must survive the first intense X-ray impulses from a nuclear detonation, as well as the subsequent shock-wave. Sandia has developed new laboratory techniques to simulate this extremely harsh environment and validate computer models developed for the W76/Mk4 RB. For this technique, a steel bar, instrumented with a strain gage and attached to a pendulum, strikes the RB, exciting the components to nearly the shock level they would attain in a hostile environment. Different areas of the RB are point loaded, or impacted, to help predict how RB components will respond to nuclear shocks. Sometimes the deflection-to-force slope for materials in hostile environments is nonlinear — the materials respond differently at lower impacts than at higher impacts. To provide insight into these nonlinear responses, the steel bar strikes the RB at various force levels. The data gathered from these tests is used in finite-element models to characterize the RB's mass, stiffness (a displacement per force input value), and damping capabilities (or how the RB dissipates energy — the higher the damping, the faster the RB vibration stops).

Laboratory Vibrations Duplicate Violent Forces on RVs

Reentry vehicles (RV) entering the Earth's atmosphere develop a turbulent boundary layer, which creates high-level vibrations that RV components must survive. Sandia has designed an experimental technique to better simulate the true environment that the RV experiences during reentry. Reentry vibrations were recreated by combining multiple shaker mechanisms with reverberent sound energy to 10 kHz. The combined vibration and acoustic simulation met STS (stockpile-to-target sequence) requirements for reentry at both the forward and aft ends of the system. STS requirements specify all environments that a weapon system must survive, from its removal from the stockpile, to the various stages of handling, to the launch into space, to reentry. Combining the multiple shakers with sound energy allowed Sandia to simulate for



the first time the separate STS vibration profiles for the forward and aft ends of the RV. Sandia also simulated the ejection shock environment — the significant kick-off shock the RV experiences as it is forced from its payload platform. The kick-off shock simulation was accomplished by impacting a tuned mechanical resonator (attached to the RV) with an air-driven projectile.

Simulated Nuclear Weapon Accident Tests Weapon Recovery Responses, Safety Skills

The Digit Pace II exercise, conducted in May 1997, was a national full-field nuclear weapon accident exercise involving a simulated Safe Secure Trailer (SST) and simulated nuclear weapons. SSTs are specially constructed vehicles used by the Energy Department to transport nuclear weapons, nuclear weapon components, and special nuclear materials. The goal of the Digit Pace II exercise was to verify that some 1,500 players, led by the DOE, know how to respond to a nuclear weapon accident while maintaining public safety. The players came from the DOE and its laboratories (including about 50 Sandians) and contractors, and from other federal, state, and local agencies. National weapons exercises have been conducted for more than 20 years, but the Digit Pace II exercise marked the first time the Department of Energy was the Lead Federal Agency. Until Digit Pace II, the Department of Defense held this position. The Lead Federal Agency has custody of the weapon when an accident occurs and is responsible for interfacing with technical experts and federal, state, and local authorities. To prepare for Digit Pace II and support the DOE in its new role, Sandia provided a series of table-top weapon accident exercises. Sandia provided experts in nuclear weapon design, nuclear weapon safety assessment, radiation health and safety, and SST design groups.

The goal of the Digit Pace II exercise was to verify that some 1,500 players, led by the DOE, know how to respond to a nuclear weapon accident while maintaining public safety.

Sandia Develops Screening Technique to Identify Stockpile Security Soft Spots

Sandia initiated the Sandia Surety Risk Assessment Project (SASRAP) two years ago to integrate nuclear stockpile safety issues (such as the probability of an accidental nuclear detonation) and surety/use-control issues (such as the probability of a deliberate unauthorized nuclear detonation). Last year, Sandia developed a screening technique to determine the extent of security and use-control soft spots across the entire nuclear stockpile and in the various environments where weapons are found. The purpose of this screening technique is to identify common problems or weaknesses across the stockpile,

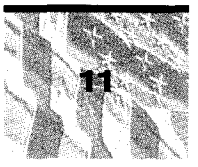
then focus on areas of highest concern. Managers are then able to improve overall stockpile security by allocating resources to technology development, procurement, or policy changes that will provide the best return.

Linked Computer Codes Predict Behavior of Fire-Engulfed Missile

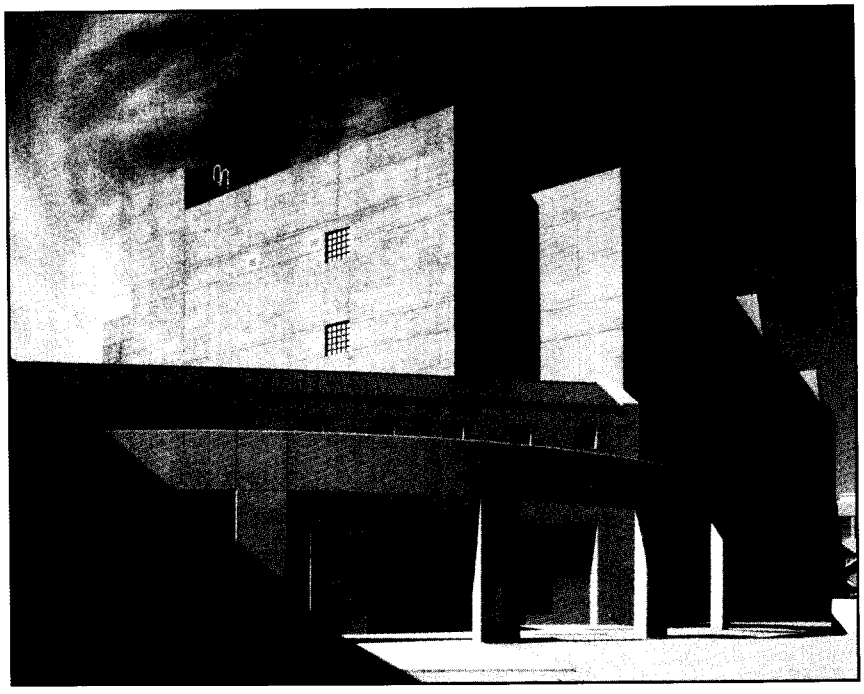
A multidisciplinary Sandia team performed the first complete, coupled, "end-to-end" safety assessment of a missile engulfed in a fuel fire. The weapon Sandia analyzed was the W-80 air-launch cruise missile. This assessment used Sandia computer codes to calculate how the weapon would be affected by a fire originating, for example, from a ruptured airplane wing. The study linked Sandia's VULCAN computer code, which analyzes how heat would be transferred from flames to the weapon, the COYOTE code, which analyzes how quickly components inside the weapon would heat up, and the SABLE/P-RACE code, which identifies the subcomponents that would fail first. Feeding the output of one code into the input of the next code produces a much more realistic analysis of weapons in a fuel fire than using a single code. The study demonstrated that the nonuniform heating predicted to result from realistic fuel fires could significantly impact the perceived safety margin. It also demonstrated the feasibility of coupling these codes using the Accelerated Strategic Computing Initiative's multiple parallel processing computer platform.

Weapon Knowledge Management Plan Preserves Crucial Information

Sandia's weapon knowledge will be crucial to the nation's nuclear deterrence efforts in the 21st century and to the training of successors to today's experienced engineers. Responding to corporate concerns, Sandia established a program office and developed a Weapon Knowledge Management Plan. The objective is to maintain the vitality of the science- and engineering-based knowledge and expertise needed to maintain the nuclear weapons stockpile. The plan documents a knowledge-management process and includes discussions on hiring and internships, a Nuclear Weapons Institute, information access standards, personnel qualifications and certification, skills mentoring, monetary rewards, succession planning, corporate staffing, and resume data. The program includes Sandia's Knowledge Preservation Project, which records, usually on videotape, critical scientific information provided by experienced nuclear weapon scientists and engineers. Last year, 32 interviews were conducted in support of this program.



ARMS CONTROL & NONPROLIFERATION

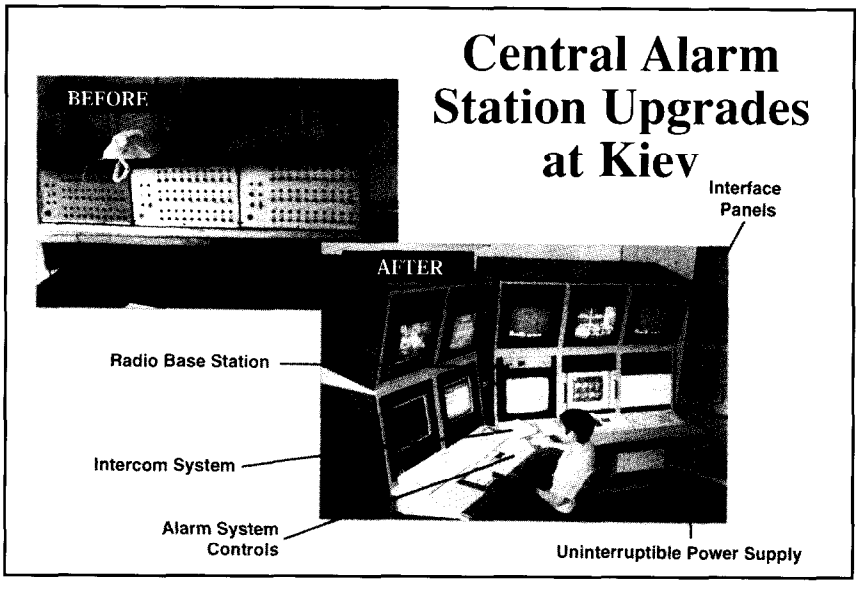


Center for National Security and Arms Control — Waging Peace in the 21st Century

Sandia is addressing the threat posed by weapons of mass destruction through its Center for National Security and Arms Control (CNSAC), a state-of-the-art facility that opened in August 1997. Sandians at CNSAC will further develop sophisticated seismic tools for detecting underground and underwater nuclear testing, satellite monitoring technologies for detecting atmospheric nuclear explosions, and advanced microsensor and microelectronics programs for detecting and identifying chemical and biological weapons. Stopping the proliferation of weapon-grade nuclear materials will continue to be a major challenge. Sandia's remote-monitoring technologies will help verify that nuclear material is not being diverted from peaceful activities into nuclear weapons. And Sandia will continue working with the Former Soviet Union to protect these materials by installing physical security systems, providing monitoring and access-control equipment, and improving railcar transportation security. Another technology that will enhance our future security is Sandia's Interferometric Synthetic Aperture Radar. Data collected from this aircraft-mounted radar is integrated into high-resolution, 3-D images of objects on the ground, images that can provide vital information on the movement of vehicles or other objects. These and many other Sandia technologies will help the United States meet the challenges of arms-control monitoring, treaty verification, and nonproliferation as we enter the 21st century.

Sandia Participates with Physical Protection of Nuclear Materials

Sandia experts continued to play a key role in supporting U.S. participation in arms control and nonproliferation efforts within the Russian Federation and Newly Independent States. Sandia's national security experts worked with their Former Soviet Union colleagues to improve transportation security and enhance the physical protection of nuclear materials at 44 selected sites. One noteworthy site is the Kiev Institute of Nuclear Research in Ukraine, where Sandians helped design and oversee the installation of a physical security system to protect weapon-grade nuclear materials in storage. Along with a training facility now under construction, the institute will be used as a model to teach physical



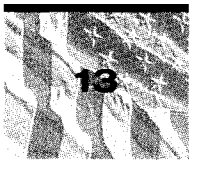
protection concepts in Ukraine. Another notable accomplishment was at the Institute of Theoretical and Experimental Physics in Moscow, where newly upgraded equipment helps protect, control, and account for significant quantities of weapon-grade nuclear materials. A National Security Committee delegation headed by Congressman William Thornberry of Texas visited the site and was very impressed with the security improvements and rapid progress. At the Russian Navy's Northern Fleet Storage Facility in Murmansk, Sandia helped complete substantial upgrades to protect the safety of fresh nuclear fuel stored for submarines.

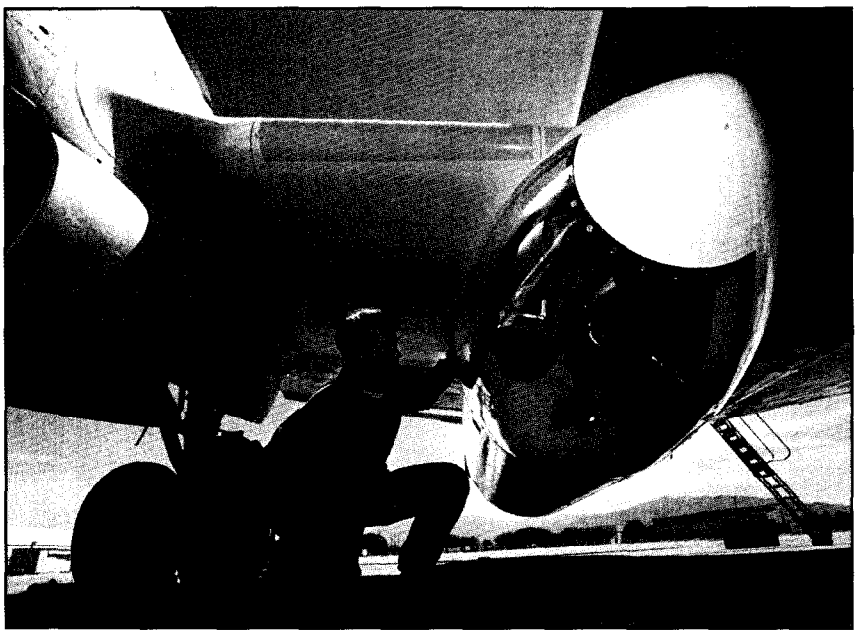
Sandia Sensors Enter Earth's Orbit to Detect Nuclear Blasts

Two satellites carrying Sandia monitoring instrumentation were launched last year. The 18th Defense Support Program satellite was launched on a Titan IVB and maintains a stationary orbit 22,700 nautical miles from Earth. A second satellite became part of the 24-satellite Global Positioning System (GPS) constellation. All GPS satellites carry Sandia instruments for detecting nuclear detonations to verify compliance with the Limited Test Ban Treaty. GPS satellites will be replenished as needed to provide full-time, worldwide nuclear burst detection and navigation capabilities. This was the 32nd launch of a GPS satellite with a nuclear detection payload since 1983. Sandia also delivered six new payloads for GPS replenishment satellites that will be launched over the next several years, and researchers continued designing enhanced sensors for follow-on missions. All of the Sandia payloads have performed to expectation and have exceeded their expected lifetime in orbit.

AMPS Team's Remote Sensing Mission Helps Kazakhstani Government

In support of the Department of Energy's ongoing program of cooperation with the Former Soviet Union, Sandians and other members of a multilab team conducted a 17-day remote sensing mission in the Republic of Kazakhstan. Kazakhstan is one of the most environmentally troubled nations on Earth because of decades of industrial pollution, fertilizer and pesticide use, and detonations of hundreds of Soviet underground nuclear weapons. The Airborne Multisensor Pod System (AMPS) team collected extensive data on the former nuclear weapons test area and other locations in eastern Kazakhstan to help the Kazakhstani government understand the extent of the environmental contamination. The team also mapped untapped coal and mineral deposits within the country's borders and gathered data to support environmental restoration and city planning. The AMPS team collects and





Sandia's airborne Interferometric Synthetic Aperture Radar, capable of producing high-resolution, three-dimensional images, undergoes final inspection before a 17-day mission to Kazakhstan.

integrates thousands of successive readings taken by a variety of sensors mounted to aircraft to produce very high-resolution ground images. The primary objective of the AMPS Program is to help the U.S. and its allies verify that nations involved in arms control treaties are complying with those treaties.

Sandia Demonstrates Smallest Gas Separation Column

Sandia has demonstrated the separation and detection of a volatile solvent (toluene) from a nerve agent simulant in less than one minute, using a gas separation column located on a one-square-centimeter silicon chip. This separation column is the smallest demonstrated to date. Winding back and forth many times on the tiny chip, the column would measure 80 centimeters long if straightened out. The column is produced by etching a very long, winding channel onto a silicon chip substrate, then covering the channel with Pyrex™. Substances are separated and identified by the rate at which they travel down the column — every compound displays a unique travel time. By sending the output from the column to a surface acoustic wave sensor with an active area of only 0.4 square millimeters, Sandians can measure minute quantities (< 1 picogram: 1 picogram is the mass of a single water droplet with a diameter 1/40th that of a human hair) of chemical species as they collect on the device. The acoustic wave sensor, which can detect chemical agents for nonproliferation applications, was funded under the μChemLab Grand Challenge LDRD *(see next entry)*. The goal of developing this sensor and separation column is to integrate on a single chip a chemical laboratory that can separate, detect, and determine the concentrations of many substances.

Sandia Focuses on High-Impact Challenges to Accelerate Breakthroughs

FY97 marked the start of Sandia's Grand Challenge Laboratory Directed Research and Development (LDRD) Program. The goal of Sandia's Grand Challenge program is to develop high-impact projects of national interest that have the potential for rapid breakthroughs. The LDRD office has always supported Sandia's highest-risk projects, but the Grand Challenge team goes beyond this, seeking out high-impact, high-risk projects and focusing substantial amounts of talent and resources on these projects. The first Grand Challenge — the μChemLab Grand Challenge — seeks to wed advances in analytical chemistry, microelectronics, and micro-optics to transform the world of chemical detection by creating a

fully self-contained, hand-held chemistry laboratory. First-year accomplishments include on-chip separation and detection of chemical agents, faster and more selective separations of explosives than with conventional techniques, and a simulation tool for exploring the use of multiple chemical sensors to cooperatively solve complex chemical detection problems.

Nondestructive Detection and Identification of Trace Elements Takes Giant Leap Forward with New Ion-Beam Technology

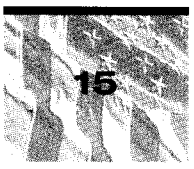
Sandia/California and Lawrence Livermore national laboratories have jointly developed a unique accelerator-based ion beam imaging and analysis system that rapidly scans surfaces, detects micron-scale particles, and nondestructively determines their composition with part-per-million sensitivities. To characterize a material, ions are accelerated and focused onto a sample. Each chemical element produces a characteristic X-ray emission when bombarded by the ion beam, and these emissions are measured to identify the element and determine its concentration. Any material containing elements with atomic numbers higher than sodium's can be rapidly scanned and analyzed with little or no sample preparation. The new ion-beam imaging and analysis system is an extremely sensitive probe for trace element analysis — approximately 100 times more sensitive than the electron microprobe, for example. Other ion-beam techniques can be used at the same time to obtain depth or isotopic information. The primary customers for this technology include national security agencies responsible for verifying compliance with arms control, nuclear smuggling, and nonproliferation treaties. Other potential customers include law-enforcement agencies that collect evidence in forensic investigations and environmental agencies involved in monitoring and restoration.

Control and Communication Device Will Monitor Nuclear Materials

To expand U.S. capabilities in the remote monitoring of nuclear materials in storage containers, Sandians have integrated six sensors into an eight-cubic-inch cylindrical package. The six sensors in this autonomous, radio-frequency electronic device detect radiation dose, dose rate, pressure, humidity, hydrogen, and temperature. The device can perform about 250,000 data acquisition and transmission cycles using a single AA battery and is part of the Integrated Nuclear Materials Monitoring Project at Sandia. The goal of this project is to develop ultra-low-power sensors, communication devices, and control devices for remote monitoring applications. The new device, which has been transferred to Allied Signal Federal Manufacturing and Technologies for production, is the first of a series of monitoring products that will incorporate more complex sensors and communication systems and more modular packaging.

Sandia Supports CTBT with Sensors, Technical Experts, Computer Model

President Clinton forwarded the Comprehensive Test Ban Treaty (CTBT) to the Senate for ratification advice and consent in September 1997. Sandia has supported the CTBT effort by developing sensor and data processing technologies to monitor treaty compliance and by providing technical experts to the CTBT Preparatory Commission. Sandia also completed a computer model, the Integrated Verification System Evaluation Model (IVSEM), which estimates the capability of U.S. and international monitoring networks to detect and locate nuclear explosions. IVSEM models seismic sensors that measure ground movement, infrasound sensors that detect very low-frequency atmospheric sound waves, hydroacoustic



sensors that detect low-frequency pressure waves in the oceans, radionuclide sensors that detect atmospheric nuclear materials, and optical sensors that detect the visible light of a nuclear flash. During preparation for the ratification hearings, IVSEM was used to brief Energy Secretary Federico Peña and Senator Pete Domenici's (R-NM) staff on treaty verifiability.

DOE and Russian Nuclear Weapons Labs Join Forces on Nuclear Warhead Dismantlement

Sandia has developed a comprehensive U.S.-Russian Lab-to-Lab Program to study transparency and nuclear weapons dismantlement. The purpose of this program is to engage the Russian nuclear weapons institutes in intellectual studies of issues associated with Russian nuclear weapons dismantlement. Transparency, in the context of this program, means the technical measures that can be employed to build each side's confidence in understanding and confirming the activities associated with nuclear weapons dismantlement. Participating Russian labs include Chelyabinsk-70, Arzamas-16, and the Institute of Automatics. Sandia contract requirements are highly structured and have generated technical information and assessments of the Russian dismantlement processes, identified technologies to monitor the dismantlement process, evaluated potential technologies against performance criteria, and provided computer modeling capabilities. Technologies include radiation measurement and detection, high-explosive detection and destruction, X-ray imaging, and non-nuclear component destruction. This program focuses on technical issues associated with transparency and nuclear weapons dismantlement and on communication with the Russian institutes.

Project leads for the 1997 U.S./Russian Technical Interchange Meeting on Nuclear Weapons Dismantlement and Transparency: (left, seated) Rodion Voznyuk from Chelyabinsk-70 in Russia and (right) Sandian Martha Charles.

FORTÉ Satellite Can Spot Secret Testing, May Explain Lightning

Sandia and Los Alamos national laboratories are already analyzing reams of data being downloaded from the 7-foot high FORTÉ (Fast On-Orbit Recording of Transient Events) satellite, orbiting 500 miles above the Earth. Four times a day the satellite passes within communicating distance of the Sandia ground station. Although Sandia has developed and monitored satellites in the past, this is the first time it has actually controlled a satellite's operations. FORTÉ, developed jointly by Sandia and Los Alamos and sponsored by DOE's Office of Nonproliferation and International Security, was launched on a Pegasus XL Rocket from Vandenberg Air Force Base in August 1997. It will test new ways to spot secret nuclear weapons tests and gather data on the physics of lightning and the ionosphere. The Sandia-designed optical lightning sensors

The FORTÉ Satellite (artist's rendition) will help advance technologies that detect nuclear weapons tests and collect lightning data.

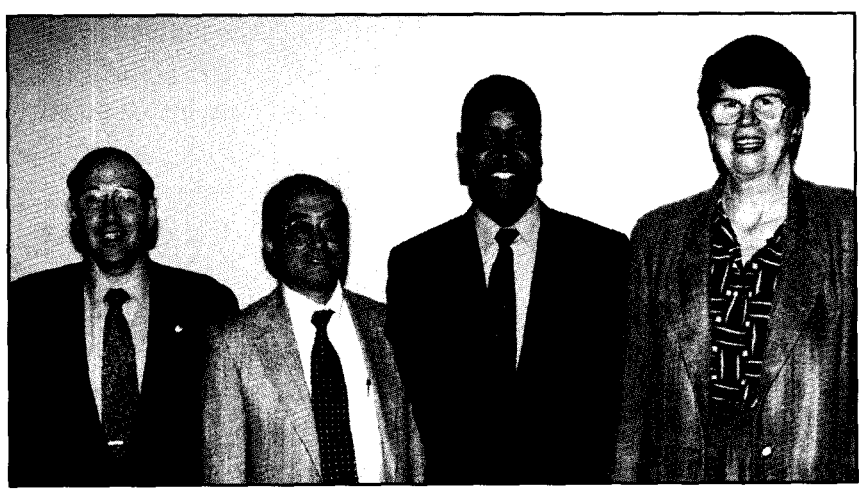
detect, locate, and characterize lightning flashes. This data, combined with information from Sandia's adaptive radio frequency filter, will help global climatologists explain the atmospheric breakdown mechanisms that lead to lightning discharges. Sandia also provided the satellite power unit and on-board communication systems.

New UN Organization Uses Sandia's Project Management Software

The United Nation's newly formed Comprehensive Test Ban Treaty Organization (CTBTO) in Vienna, Austria, is using Sandia-developed software as part of its World Wide Web site. The Sandia-designed tools, developed for the Department of Energy to assist in project management, can automatically generate contact lists, group e-mail lists, searchable document libraries, and document review and comment pages to facilitate communication and cooperation between geographically dispersed parties. These features are a key part of the CTBTO's communication strategy for developing operational procedures and resolving technical issues with the 148 countries that have signed the treaty to date.

Sandia Serves as Satellite Facility for the National Institute of Justice

The National Institute of Justice (NIJ) has named Sandia a satellite facility for testing and evaluating technologies that are applicable to criminal justice, such as the Myotron pulse weapon (a sort of stun gun) and devices that electronically track criminals on probation and parole. Sandia has developed a manual to help law-enforcement agencies purchase explosive-detection technologies and is evaluating technologies for combating terrorism. With help from the Albuquerque Police Department, Sandia developed and hosted



(From left) Representative Steve Schiff (NM) and Sandians Dennis Miyoshi and Basil Steele met with Attorney General Janet Reno to discuss the Justice Department's lead role in the fight against domestic terrorism and the Sandia technologies that could support this effort.

Operation Albuquerque III (jointly sponsored by the NIJ and DOE), an 8-day session for advanced bomb squad training. For this event, Sandia not only provided training for bomb technicians from across the U.S. and several foreign countries, but designed the simulated explosive devices for the exercises and developed the training scenarios.

Cooperative Monitoring Center Holds International Workshops

Sandia's Cooperative Monitoring Center (CMC) promotes communication among political and technical experts from around the world and is a resource for the U.S. government and the international arms control and nonproliferation community. Last year was one of the CMC's most successful since its inception in 1994. The CMC conducted nine training workshops for groups from China, Oman/Qatar, North Korea, Egypt, Japan, Pakistan, and Jordan to emphasize that cooperative monitoring plays a critical role in implementing regional and other cooperative security arrangements. The CMC also provided demonstrations of unclassified and exportable monitoring technologies for many U.S. and foreign visitors. The Directed Research Program welcomed five scholars from India, Pakistan, Germany, and Russia, who drew upon CMC technologies to complete specialized research projects, to be presented internationally.

A Sandia engineer examines a roll of tamper-evident shrink wrap at Sandia. The material provides evidence if sensitive facilities or objects are disturbed. Sandia's Cooperative Monitoring Center demonstrates the shrink wrap and other technologies to visitors from around the world.

CMC Deputy Manager for Operations Dave Barber discusses paper seals with Ms. Raana Rahim, Director of American Affairs, Government of Pakistan. Paper seals, on display in the CMC's Technology Laboratory, indicate whether a sealed item is still intact.

MatSeis Software Improves Verification of Comprehensive Test Ban Treaty

MatSeis software, developed by Sandia to help verify the Comprehensive Test Ban Treaty (CTBT), allows in-depth research in specialized seismic signal processing to detect small events such as nuclear tests that might indicate a treaty violation. Based on the commercial software package MATLab, MatSeis provides a friendly graphical user interface, direct access to treaty monitoring databases, and a simple, cost-effective way for researchers to incorporate their seismic algorithms. MatSeis significantly improves research capabilities in algorithm development for the CTBT and is available on the CTBT Web site for download.

OTHER DEFENSE TECHNOLOGIES

The Joint STARS aircraft played a key role in support of Desert Storm by providing critical and timely surveillance information about enemy forces.

Sandia's ATR System Provides Real-Time Battlefield Information

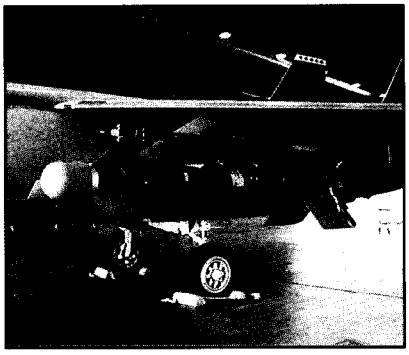
Sandia has successfully demonstrated the first real-time Automatic Target Recognition (ATR) system to be successfully integrated onboard an operational aircraft, the U.S. Air Force's Joint Surveillance Target Attack Radar System (Joint STARS) T3 aircraft. The ATR system incorporates algorithms, software, and hardware that recognize military targets in synthetic aperture radar images *(see next entry)* by their unique signatures, then annotates the imagery to help the image analyst. The ATR is expected to provide commanders with timely and accurate battlefield information. This project culminates a three-year advanced technology demonstration program sponsored by both the Air Force and the Department of Defense.

Intelligent Bandwidth Compression Software Transmits Real-Time Target Information

Sandia has developed software that enhances the effectiveness of synthetic aperture radar (SAR). SAR equipment, mounted on aircraft, emits and receives signals — even at night or through clouds — to produce high-resolution, 2-D images of the landscape below. However, SAR images are too large to transmit in real time over low-cost, readily available communication links. To address this problem, Sandia developed Intelligent Bandwidth Compression (IBC) software, which can be used with affordable datalinks — communication devices that transmit and receive data — to move large amounts of information in real time. IBC software includes advanced detection and compression algorithms to accomplish the necessary bandwidth reduction: Detector software examines each SAR image for targets of interest, then divides each image into target areas that will be saved and target-free background areas that will be compressed. The compressor software then works separately on the target areas and the background, compressing the background without changing the basic character of the image. An on-ground computer reconstructs the compressed image for analysis in real time with virtually no loss of critical target information.

ITAG Autonomously Guides Weapons to Preprogrammed Targets

ITAG (Inertial Terrain-Aided Guidance) is an advanced, all-weather, day-night, radar-guidance system, currently being implemented as a nose-kit that can be mounted to the front of conventional penetrator weapons. Sandia is developing ITAG for the



An ITAG all-weather, day-night, radar-guidance system is mounted to the front of a penetrator warhead.

Defense Special Weapons Agency as part of the DoD-funded Counterproliferation Technology Demonstration Program, which looks at all aspects of countering weapons of mass destruction. ITAG uses an inertial measurement unit (a traditional navigation device that indicates a weapon's location) in conjunction with a high-altitude, Doppler-sharpened radar altimeter (a radar-based instrument that provides greater accuracy in determining a weapon's location) to autonomously guide the weapon to a preprogrammed target. An ITAG-guided weapon can be delivered through fog, clouds, smoke, and even rain or snow and will provide the military with a significant new capability.

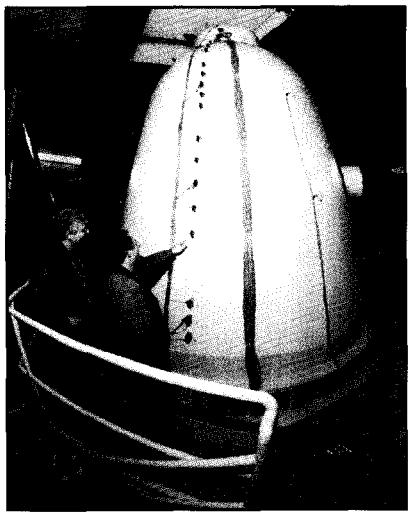
Concrete Cratering Model Wins Competition

A Sandia-developed computational model for determining the dynamic response of brittle materials won a recent DoD-sponsored computer code benchmarking competition. Participants predicted the exact geometry of the crater formed in a reinforced concrete wall from explosive charges embedded in the concrete. Several DoD organizations and DOE laboratories participated in the competition and submitted their calculated results before an actual explosive cratering test was conducted on the slabs. The models were designed to calculate how much concrete would be shattered and the geometry of the resultant hole. Sandia used a shock-wave physics code and applied a new material-response model for the behavior of concrete under dynamic loading. The Sandia geometry prediction very closely matched the test results. The model can be applied to situations such as rapid entry into concrete structures to rescue hostages or disable threats. Sandia is pursuing a follow-on project to use its model for counterterrorist operations.

Sensors on Interceptor Missiles Differentiate Reentry Vehicles from Decoys

To test how well an interceptor missile can differentiate between a reentry vehicle (RV) and a decoy in space, two interceptor tests were performed, the first in a series of National Missile Defense Integrated Flight Tests to evaluate competing interceptor concepts. For both tests, a Lockheed Martin, Air Force-modified Minuteman II missile was launched, carrying a Sandia-designed target payload. The payload included a 400-pound reentry vehicle and eight decoy-like, lightweight targets. The reentry vehicle and targets were deployed in mid-flight to test how well optical sensors onboard a second interceptor missile, launched from Kwajalein in the Marshall Islands, could differentiate between the real RV and the decoy traffic in space. The purpose of these successful tests was to gather data for intercept algorithms. For upcoming missions, the interceptor missile will be required to strike the primary target.

ENERGY & ENVIRONMENT



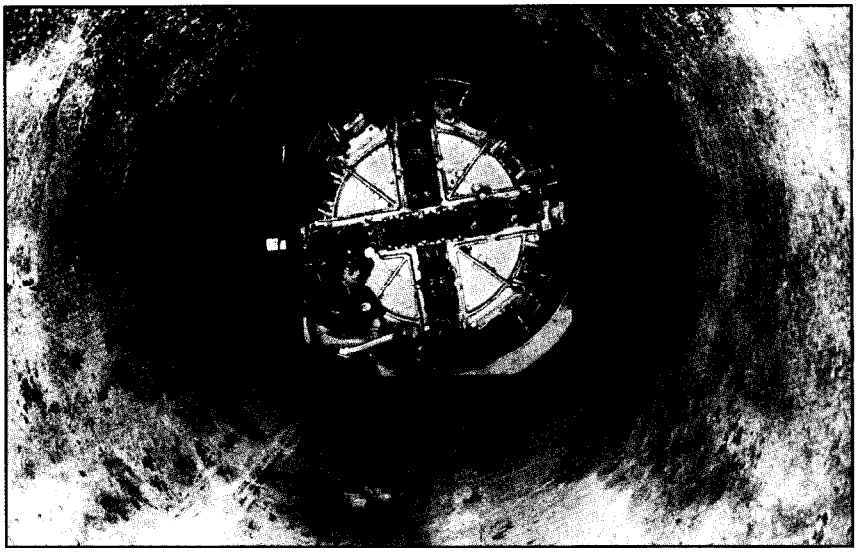
Sandia engineers check out a scale model of a nuclear reactor steel containment vessel prior to a major pressurization test.

Scaled-Down Model of Steel Containment Vessel Benchmarks Sandia Analysis Tools

Sandia engineers have demonstrated that a one-tenth-scale model of the steel containment vessels used in Mark II-type commercial nuclear reactors can withstand pressures significantly higher than their designed limit. Reactor pressure vessels contain reactor cores, as well as the coolant that passes over the cores to harvest the heat generated by nuclear fission. An unplanned loss of coolant can lead to a core meltdown accident. In such an accident, radioactive material in the molten reactor core could collect and melt through the lower part of the reactor pressure vessel. The containment vessel surrounds the reactor and provides the final barrier against these radioactive materials reaching the outside environment. To ensure that containment vessels can safely withstand the tremendous thermal and pressure loads that an accident would produce, researchers conduct tests to determine the maximum pressure the vessels can withstand. Containment vessels used in commercial nuclear reactors typically cannot be tested at full scale, so researchers must rely on computer simulations and tests of small-scale physical models to predict the pressure limits of the vessels. Sandia researchers developed computer models to characterize how the physical model would deform before rupturing. A Japanese power plant vendor built the one-tenth physical model of the containment vessel, which failed at 676 psi — six times higher than its designed pressure capacity and 24 psi higher than a pretest prediction performed by Sandia. The next step under this $22-million, multiyear contract for the U.S. Nuclear Regulatory Commission and the Nuclear Power Engineering Corporation of Japan will be to test a one-quarter-scale, prestressed concrete containment vessel. Lessons learned from these tests may be combined with analyses of other operational components in the system to predict nuclear power plant behavior.

EPA Preliminary Rule: WIPP Can Safely Isolate Nuclear Waste for 10,000 Years

In October 1997, the Environmental Protection Agency (EPA) issued a preliminary rule concluding that the Waste Isolation Pilot Plant (WIPP) can safely isolate nuclear waste for 10,000 years. This rule followed a National Academy of Science report, affirming the ability of WIPP to safely contain radioactive waste and recommending WIPP be opened. Sandia supplied the key material on which the EPA based its rule: geotechnical analyses and performance assessment models that predicted the behavior of the WIPP. For more than 20 years, Sandia has directed all the scientific studies for WIPP and incorporated its findings in performance assessments that predict that WIPP will comply with EPA standards. In the past year, Sandia worked with the EPA to defend the models and conduct



A worker inspects a 10-foot-diameter tunnel at the Waste Isolation Pilot Plant in southeastern New Mexico. In the background is a special tunnel-boring machine that was used for brine-seepage and rock mechanics tests.

new analyses. The EPA, which has conducted public hearings, will issue its final ruling by May 1, 1998. If favorable, the Energy Department may begin operations 30 days later.

AC Battery PQ2000 Prevents Power Failures, Production Losses

Researchers estimate that tens of billions of dollars in production losses occur annually because of electrical power sags and momentary, 100% power failures. Sandia's AC Battery PQ2000, a two-megawatt, battery-based energy storage and delivery system, prevents power losses by continually monitoring utility lines for momentary interruptions and transferring power as needed from its stored battery energy. The transfer is seamless to the customer and occurs in about 1/400th of a second. The system can deliver power for up to 15 seconds. The PQ2000 is invaluable to the microprocessor, pharmaceutical, metal plate lithography, and other industries that rely on machinery so sensitive that a single electrical hiccup could be disastrous. The device is mounted at a company's electrical service entrance and is typically inserted in the lines that provide electrical energy to a company's critical loads. The PQ2000 has been proven effective in actual use. In Georgia, for example, the PQ2000 prevented eight electrical outages to a metal plate lithography plant during a single, severe lightning storm.

Study Shows Risks Extremely Small for Maritime Shipment of Nuclear Materials

The DOE SeaRAM program has evaluated the risks associated with transporting nuclear materials by ship. Before this evaluation, no U.S. government organization had thoroughly studied these risks. Sandia's role was to provide a technical basis for answering questions about the risks. A review of 15 years of maritime accident data showed that ships infrequently collide. Researchers referred to a study that correlated collision penetration depths with collision energy, indicating that during most collisions, the radioactive material cask would not be subjected to impact or crush forces. Finite-element calculations showed that even if the cask — which is stronger than almost all ship hulls — were contacted, it would be pushed through the hull and into the sea.

Study results from the SeaRAM program confirm that the environmental risks of transporting radioactive materials by ship are extremely small.

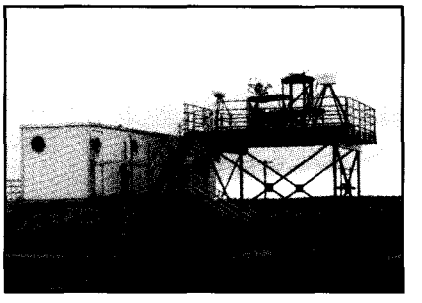
Thus, very few ship collisions would be severe enough to pose a threat to the nuclear materials cask. Sandia also conducted and modeled fire tests on land and on ships, showing that ship fires are unlikely to start in the hold where the cask is stowed, are unlikely to spread to the hold, and if they do spread to the hold are unlikely to burn long enough or at a high enough temperature to damage the cask. The results of the Sandia studies confirm that the risks associated with the maritime shipment of radioactive materials are extremely small.

Microseismic Imaging Techniques Monitor Size and Growth of Gas and Oil Well Fractures

Each year in the United States, approximately 25,000 oil and gas wells (80% of all U.S. wells) must be fractured to create permeability in the subsurface rocks. Hydraulic fractures are created when fluids are rapidly injected down the well. Sand transported with the fluid keeps the fractures open for oil and gas flow. Sandia performed six hydraulic fracturing experiments in 1997, concluding four years of gas-production optimization testing (funded by the DOE and the Gas Research Institute) at a research site in Colorado. During the experimental program, investigators created numerous hydraulic fractures at depths of 4,000 to 5,000 feet. Advanced microseismic imaging techniques monitored the growth and size of the fractures. The techniques take advantage of seismic energy emitted by the failure and stressing of the rocks surrounding the fracture. A highly sensitive receiver using advanced-accelerometer technology detects the seismic signals and images the size of the fracture and the direction in which it propagates. This technology is important for the oil and gas industry because long fractures are desirable, but money is lost when the fractures propagate outside the reservoir and enter shales. The techniques have yielded spectacular results demonstrating the feasibility of real-time fracture mapping for gas-production stimulation — a vast improvement over earlier fracture-mapping techniques that required weeks of laboratory work.

New Climate Change Research Station Will Refine Worldwide Climate Models

Sandia led the national laboratory team that developed the Energy Department's newest global climate change research station — the North Slope of Alaska/ Adjacent Arctic Ocean (NSA/AAO) Cloud and Radiation Testbed (CART) site. Researchers at the NSA/AAO CART site will develop and verify better computer models for cloud evolution and radiant



Global climate change research station on the North Slope of Alaska

energy flows (which determine the Earth's energy balance) in cold conditions where water exists primarily as ice. The information will help refine computer climate models as they relate to northern and southern high-latitude areas and to the upper atmosphere worldwide. The new facility is one of three CART sites created for DOE's Atmospheric Radiation Measurement program to improve our understanding of global climate change. The North Slope site, along with the other two sites located in the Southern Great Plains of the United States and in the tropical western Pacific, are designed to span the range of interactions of sunlight, infrared radiation, and clouds that occur in the Earth's atmosphere and affect global weather and climate. Martha Krebs, Director of the Office of Energy Research, together with local North Slope officials, dedicated the NSA/AAO facility on July 1, 1997.

Unmanned Aerospace Vehicle for Climate Measurements Sets New Altitude Records

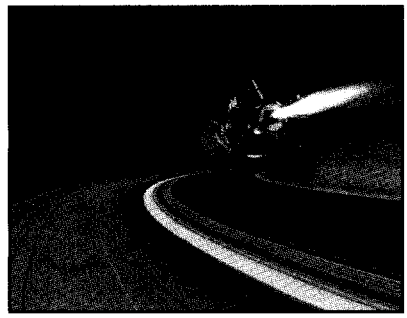
A Sandia-led multilaboratory team, working for the Atmospheric Radiation Measurement-Unmanned Aerospace Vehicle (ARM-UAV) program, set new altitude records when it sent a high-altitude, instrumented Unmanned Aerospace Vehicle (UAV) into the earth's atmosphere to take climate measurements. The UAV conducted a first-ever nonstop scientific flight of 26 hours in October 1996. A year later it reached an altitude of 45,000 feet, a record for single-stage turbo-charged engines. A second stage of turbo-charging is currently being added to the UAV and should enable flights of up to 65,000 feet — the top of the lower layer of the atmosphere where most weather occurs. The goal is to conduct measurements at these altitudes for a full day-night cycle, a feat that would be difficult with manned vehicles. The data provided by the ARM-UAV program (supported by the Department of Energy and previously by the Department of Defense) will help improve large-scale meteorological and climate computer models and improve satellite calibration.

Brine Injection System Helps Recover Millions of Barrels of Oil from Leaking Mine

Sandia's unique brine injection system has helped the Energy Department and site operations contractor DynMcDermott remove nearly all of the 72 million barrels of oil stored in an underground Strategic Petroleum Reserve mine at Weeks Island, Louisiana. The oil, stored in a former salt mine, had to be removed when an inward water leak threatened to dissolve a major hole into the salt storage facility. More than 70 million barrels of the oil have been removed so far with the aid of Sandia's brine injection system. To start the brine injection process, many holes were drilled into the sediments above the mine and the suspect leakage area to identify and flood the area with a saturated salt solution. This concentrated brine solution greatly delayed additional leak enlargement and eventually pooled beneath the oil, releasing otherwise unrecoverable oil from loose salt. The remaining oil floated to the brine surface and is being skimmed. The old salt mine, which stretches for more than a mile, is now 70 feet deep in brine and has only 5 inches of oil remaining. The objective is to fill the mine with brine after all the oil is removed. The mine that contained the oil would certainly have failed without the brine injection system, which accelerated the oil-removal process by three years.

Sandia Analyzes Risks of Cassini Spacecraft, Now Heading for Saturn

NASA's Cassini spacecraft, launched October 15, 1997, has begun its long journey to Saturn. Electricity for the mission is provided by radioisotope thermoelectric generators fueled by plutonium-238, which provides electricity through conversion devices as it decays. Computers and other instrumentation for NASA space missions to the outer planets cannot use batteries or solar power sources because of the length of the journey — about seven years — and the distance from the sun. In response to requirements established by the Interagency Nuclear Safety Review Panel, Lockheed Martin Missiles and Space Systems asked Sandia to develop a mathematical technique to analyze the



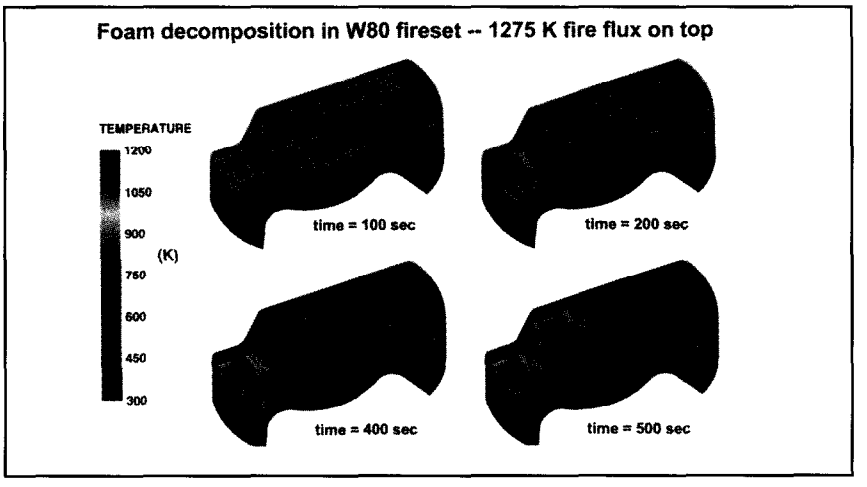
Cassini spacecraft near the rings of Saturn. (Artist's rendition courtesy of NASA)

probability of a radiation release during a launch or re-entry accident. The Sandia technique analyzed comprehensive accident scenarios and included a detailed time- and temperature-dependent thermochemical kinetics model of a theoretically possible launch accident involving a rocket fuel fireball and the plutonium transformations within it.

Sandia Commits to Pollution Prevention, Recycling, and Water Conservation Goals

Sandia adopted pollution prevention goals last year aimed at reducing wastes and increasing recycling by 1999. Compared to 1993 waste levels, the goal is to reduce routine sanitary waste by 93%, radioactive waste by 85%, and hazardous waste by 69%. Sandia is also working toward a 33% increase in recycling. Twenty-six pollution prevention projects will save several million gallons of water per year and prevent 53,000 pounds of wastes from being generated. In New Mexico, Sandia committed to reduce water consumption by 30% by 2004. Five projects will save between 59 and 92 million gallons of water per year. Two additional proposals for future water conservation are being developed, which could result in savings of 50 million to 75 million more gallons of water per year.

COMPUTING & INFORMATION TECHNOLOGIES



Simulation of foam decomposition in the W80 Fireset. After 100 seconds elapse in a fire environment, the embedded weapon safety systems remain encapsulated in foam. After 400 seconds, objects begin to appear and at 500 seconds, the objects are fully exposed.

Sandia Models the Effects of Foam Decomposition in W80 Fireset

Sandia performed complex simulations to assess the W80 Fireset thermal response to a fire environment. This work was performed under the Accelerated Strategic Computing Initiative (ASCI) program, in support of Sandia's surety mission. The primary technical challenge was to include the effects of the fireset foam, which provides structural and thermal protection for the weapon safety systems embedded in it. In such accidents, the foam can thermally decompose and transform from a solid to a gas, exposing the stronglink and weaklink safety systems within. Using 256 processors on the ASCI Janus teraflops computer, Sandia completed an unprecedented number of computations to simulate the fireset's response to fire. During a 600-second simulation of the fireset response, one-half trillion radiation calculations were needed to compute the amount of energy transferred between surface areas of the foam enclosure — areas that are increasingly exposed as the foam

transforms from a solid to a gas. Previously, such simulations for safety-critical nuclear weapons components were not feasible because of prohibitively large requirements for computer time and memory. The objectives of this research were to determine how quickly the embedded components heat up and to make sure they fail in a way that does not compromise weapon safety. These studies demonstrated the capability of computational models to resolve accident problems that were previously impossible to predict and prohibitively expensive to measure. Sandia's next task will be to evaluate how the fireset within the W80 system would respond to other potential accidents during handling, transport, deployment, and storage.

Teraflops Computer Achieves Record-Breaking Weapon Simulations

Over the last year, Sandia brought the Intel teraflops computer, the fastest supercomputer in the world, into a production environment for high-fidelity modeling and simulation. This massively parallel computer was developed for DOE's Accelerated Strategic Computing Initiative, a 10-year program designed to develop higher-resolution, 3-D physics modeling to evaluate the aging nuclear stockpile without actual testing. The teraflops (trillion floating point operations per second) computer has more than 9,100 Pentium Pro processors and nearly 600 billion bytes of memory. It has set new world speed records, performing at 1.34 teraflops. To put this in perspective, a person operating a hand-held calculator would need more than 42,000 years to calculate what the teraflops computes in just one second. Objects are modeled by dividing them into discrete elements, or cells, before they are analyzed with the teraflops computer — the more cells and the smaller their size, the higher the accuracy and the larger the computation. Sandia recently completed more detailed simulations than ever before for several weapons applications, including a record-setting, 1.3-billion-cell simulation of an impact detonation of 200,000 explosive grains in a porous surface and a 100-million-cell simulation of a weapon in a contact fuze mode.

Sandia Assembles Prototype Next-Generation Parallel Computing System

As part of a new R&D project initiated in 1997, Sandia assembled a prototype, next-generation parallel computing system capable of 0.1 teraflops (trillion floating point operations per second) performance at 1/4 the cost of a comparable, fully integrated, parallel supercomputer. The system integrates 128 Miata personal computers from Digital Equipment Corporation with an interconnection network from Myricom and a Linux operating system. A team of Sandia researchers from New Mexico and California developed a robust, scalable design for configuring very large future systems using commercial hardware and software. The team developed its own operating software and assembled a system with 96 nodes in Albuquerque, New Mexico, and 32 nodes in Livermore, California.

Hepatitis-C Monitoring System Could Track Worldwide Disease Outbreaks

The Hepatitis-C virus is emerging in the southern Ural region of Russia and in rural New Mexico. This newly recognized disease is believed to be the most common cause of liver failure in the United States, but risk factors for acquiring it are not fully understood. Sandia is working with the Russian Federal Nuclear Center at Chelyabinsk-70 to monitor the emergence of the virus in Russia and New Mexico. One goal of the project is to discover how the disease is transmitted. Another goal is to determine how widespread the virus has become. The monitoring team wants to determine whether cooperative

disease monitoring will be acceptable to the international community. Team members are recommending incorporation of the disease monitoring system into the Biological Weapons Convention, where it could become an extremely powerful tool for tracking disease outbreaks around the world and monitoring the possible use of biological and chemical weapons. Three New Mexico hospitals and a Chelyabinsk-70 hospital are using Internet-based telecommunications to exchange patient data, do clinical consultation, and manage this novel research. The project is sponsored by DOE's Initiatives for Proliferation Prevention and by the Chemical and Biological Weapons Proliferation Initiative.

SecureNet Links Design Labs and Production Plants

A secure, wide-area network now interconnects the local classified networks at each of the nuclear weapon design laboratories — Lawrence Livermore, Los Alamos, and Sandia national laboratories — and connects them to production plants. Sandia led the team of experts who interconnected the classified networks. The wide-area network, a critical element in DOE's plan for science-based stockpile stewardship, is called SecureNet and began operation in October 1995 as part of the Accelerated Strategic Computing Initiative to support remote access to teraflops computing resources. In connection with the Advanced Design and Production Technology Initiative, SecureNet has been enlarged to include the Y-12, Allied Signal, Pantex, and — in the immediate future — Savannah River production plants. SecureNet has already enabled significant enhancements in the flow of classified design and production information between the laboratories and plants.

MDE Extranet Links Sandia and Its Suppliers

Sandia has developed a Web-based, encrypted system — the Manufacturing Development Engineering (MDE) Extranet — which provides a timely, accurate, and unified approach to the secure sharing of information between Sandia and its external weapon components suppliers. This system ensures secure transmission by encrypting every message before it is sent over the Internet. It not only replaces paper procedures for test and inspection data, drawings, annotations, and sign-offs, but also provides the basis for future enhanced capabilities with respect to need-to-know and electronic commerce. The capability was extended to five suppliers in less than six months. The MDE Extranet has significantly reduced travel time for Sandians and contractors and reduced the need for faxes and surface mail.

Sandia Develops New Document-Management System

An electronic need-to-know document-management system, developed for national security, is on the way to becoming a corporate document-management system. Users can easily contribute information to the system and designate how the information is to be shared. Features include automatic conformance to DOE guidelines for archiving weapons information, automatic encryption of information across the Internet, and access to reference information that all password holders can review, such as lists and descriptions of access-controlled libraries. The new document-management system operates within the corporate security system, based on user authentication and authorization. Planned enhancements include a full-text search capability and a process to automatically convert large Word, PowerPoint, or other native application files into much smaller Acrobat (PDF) archive files, the chosen archiving format for the Nuclear Weapons Complex.

PRE and PRIME: Flexible, Dynamic Electronic Tracking Tools

Sandia has developed two new manufacturing information systems: Product Realization Environment (PRS), and Product Realization Information Management Environment (PRIME). PRE is based on Common Object Request Broker Architecture (CORBA), the industry standard for "plug and play" computer software. PRE is a communication and software integration framework that includes security features, file-transfer protocol, and other core services. PRE also has a software library that facilitates the integration of design, planning, and shop floor functions. PRIME is a data management tool that enables engineers, technicians, and shop personnel to easily manage, archive, and retrieve product-related information using a standard browser interface. Unlike traditional database tracking systems, which are upset when changes are made to some, but not all, manufacturing records, PRIME includes a dynamic document concept that enables efficient tracking of changing engineering and manufacturing processes. PRIME uses the Sandia Intranet for e-mail and for access to financial and human resource data. Both PRE and PRIME are being used by key CRADA partners.

Pilot Project Unites Geographically Distributed Diesel Combustion Partners

The Diesel Combustion Collaboratory pilot project is a partnership that allows researchers at national laboratories, DOE offices, universities, and diesel engine manufacturing plants to collaborate regardless of physical location. This three-year pilot project was funded last year under the DOE2000 initiative. This initiative provides significant cost savings while making research and development more productive by enabling nationwide use of unique computational and experimental resources such as Sandia's Combustion Research Facility (CRF). A distributed network using Sandia's Product Realization Environment (PRE) *(see previous entry)* will incorporate collaboration, archives, and combustion modeling tools to facilitate the DOE's Heavy Duty Diesel Combustion CRADA. This CRADA is led by the CRF and has helped engine manufacturers meet increasingly stringent government emissions controls. One early achievement was developing an electronic workspace on the World Wide Web, where CRADA partners can access easy-to-use tools, images, computer codes, and other information. Advances such as these will greatly facilitate geographically distributed scientific collaborations and enhance the value provided by DOE facilities.

Sandia and Oak Ridge Demonstrate the Power of Distributed Computing

Computer scientists at Sandia and Oak Ridge national laboratories demonstrated the power of distributed computing when they linked two Intel Paragon supercomputers to solve a combustion problem. The simulation was performed by linking particle dynamics software developed at Sandia to model chemically reacting turbulent flow problems, with CUMULVS, a computational steering package developed at Oak Ridge to visualize how simulations are running, determine whether changes are needed, and if necessary, interactively change the direction of simulations in real-time. By coupling the two supercomputers over the network, scientists achieved a larger simulation than was possible using a single computer. One application for this powerful computing capability is elementary particle research — analyzing how particles will move in response to various forces to understand how materials change as they age.

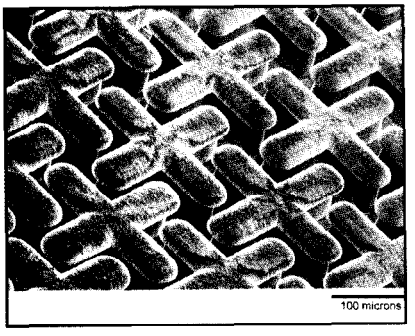
Classified Network Can Tap Unclassified Network with FTP Guard

Sandia has developed a multilevel gateway, the FTP Guard, to connect Sandia's classified Internal Secure Network with its unclassified Internal Restricted Network, allowing classified users to access unclassified files. Before the FTP Guard, data could be moved from the unclassified network to the classified network only on disks and tapes. The multilevel gateway — a Pentium-based PC running Sandia-developed software packages — is the first of its kind to receive accreditation from DOE. The gateway accepts requests from the classified environment, ensures their validity, then gets the requested information from the unclassified environment. This message response protocol can eventually be extended to give classified users access to Sandia's internal unclassified Web or to other systems.

Technical Library's Center of Excellence Service Is Implemented

Sandia's Technical Library implemented the Imaging Center of Excellence service last year to help researchers manage their document collections in an electronic world. The Library digitizes collections of informal program documents to make them more useful, manageable, sharable, and retrievable. The Library delivers the digitized work to the customer and offers guidance to help the customer establish an information retrieval system.

ELECTRONICS, SENSORS, & MONITORING SYSTEMS



A heat pipe substrate contains a quarter million of these micromachined wick structures, which optimize capillary action for cooling an electronic chip.

Metal Micro Heat Pipe Substrate Cools Microelectronic Devices

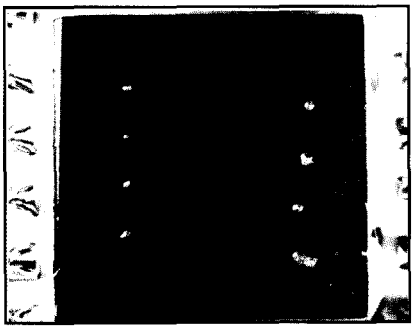
Sandia has developed a high-performance metal heat pipe substrate, approximately 2 inches square, for microelectronic cooling applications. The novel design uses embedded micro heat pipes to cool components such as microprocessors by transferring large amounts of heat without active fans or pumps. Sandia developed new micromachining processes for manufacturing the device, using photolithographic processes to create patterns on the substrate and electroplating processes to fill the patterns with metal. The devices underwent thermal testing at Sandia to characterize their performance. Sandia is partnering with a microprocessor manufacturer and considering other applications for the new technology, such as cooling the components of computer, cellular phone, and radar systems.

Proton-Based Memory Chip Retains Critical Computer Data

A new class of memory technology saves computer data in the event of a power failure by making protons the primary information storage mechanism. Protons sandwiched between silicon layers in the memory-retentive chip — the Protonic Nonvolatile Memory Chip — maintain the memory state when power is removed. Earlier nonvolatile memory technologies, which use electrons as the primary storage mechanism, require a relatively high programming voltage, take more time to program, and can be reprogrammed only a limited number of times. The new protonic chip uses a lower voltage, is rapidly programmable, and can be written to and erased more than 1 million times. The new chip is fully compatible with existing manufacturing processes. In addition, the new technology could potentially impact the $1 billion/year commercial nonvolatile memory business and may become invaluable wherever critical information must be protected, such as in weapons and satellite systems. This technology received a 1997 *R&D 100* Award and an *Industry Week* Top-25 Technology-of-the-Year Award.

Analysis of CZT Crystals Leads to New Class of Room-Temperature, Gamma-Ray Detectors

Cadmium zinc telluride (CZT) crystals, which can detect gamma rays, are now being used in a new class of room-temperature, gamma-ray detectors. Sandia has produced the first detailed characterizations of the properties and performance of these crystals, leading to an explanation of their behavior. The new gamma-ray detectors are operational at room temperature, so have an advantage over previous radiation detectors that could be used only after being cooled to liquid nitrogen temperatures. The new detectors are smaller, more autonomous, and can be left unattended for much



CZT sensor array for detecting and imaging nuclear radiation

longer periods. Understanding of the behavior of the gamma-ray detecting crystals has led to improved crystal growth and detector fabrication — the bigger and the higher the quality of the crystal, the better its detector capabilities. Sandia's understanding of CZT crystals could potentially impact the way nuclear materials are monitored as well as accelerate an emerging billion-dollar-per-year medical imaging business. In honor of this achievement, Sandia team leader Ralph James was recognized as Innovator of the Year by *Discover Magazine* in the Sight category.

Enzymes and Transistors Are Bonded to Detect Chemical Warfare Agents

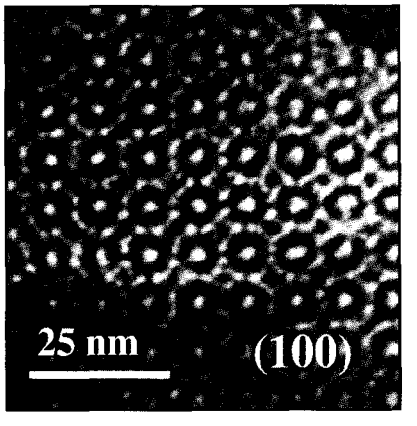
Biological enzymes combined with field effect transistors produce a very simple but highly sensitive detector for chemical warfare agents. The detector is smaller than one square inch and relies on enzymes that were developed to digest chemical agents. To test a substance, a drop of solution is placed on the detector. If a chemical agent is present, the enzymes start digesting it. During the digestion process, protons are released, changing the pH of the immediate area. Transistors bonded to the immobilized enzymes behave like pH meters to detect the byproducts of digestion — the indicators that chemical agents are present.

Infrared Laser Imaging Makes 'Invisible' Gases 'Visible'

Sandia has advanced its capabilities in infrared laser imaging of leaks. The technique, known as backscatter imaging, shines an infrared laser on the areas to be probed. Part of this laser light is reflected back to the system by the ground or adjacent walls. If a gas plume is present between the laser and the ground or wall, it will absorb part of this laser energy and appear on a TV-like screen. During the past year, Sandia has taken advantage of a new class of lasers to increase both the range of such measurements and the number of gases that can be detected. The goal is to detect small leaks from a distance of hundreds of meters, enabling laser-equipped vans or low-flying aircraft to rapidly scan large areas such as natural gas pipelines. Other Sandia activities include using laser-based sensing to measure emissions of metallic particles from industrial stacks, provide process control in steel production, characterize emissions from destroyed explosives, and detect weapons of mass destruction.

Breakthrough Process Yields Versatile Super-Porous Films

A new thin-film process represents a breakthrough in the preparation of porous films. New thin films developed at Sandia consist of precisely arranged pores that could become effective gas and liquid separators, or high-surface-area sensor coatings that could absorb chemical warfare agents, or low-dielectric-constant films for microelectronics applications. The process for making these super-porous films is called organic/inorganic self-assembly. Self-assembly is a spontaneous molecular arrangement process that occurs when detergent-like organic molecules



A new thin-film process represents a breakthrough in the preparation of inorganic membranes.

chemically interact with silica-based inorganic components. The organic and inorganic components spontaneously organize into uniform cell-like structures, each cell a sort of silica coating surrounding an organic core. The next part of the process is to submit the organic/inorganic material to an oxidative heat treatment, which removes all of the organic material and leaves the silica skeleton — a three-dimensional network of precisely defined pores. The thin-film process is described in detail in the September 25, 1997, issue of *Nature* magazine.

Paul Gourley and a VCSEL-based system that detects blood disorders in only minutes.

Biological Microcavity Laser Analyzes Blood Samples in Minutes

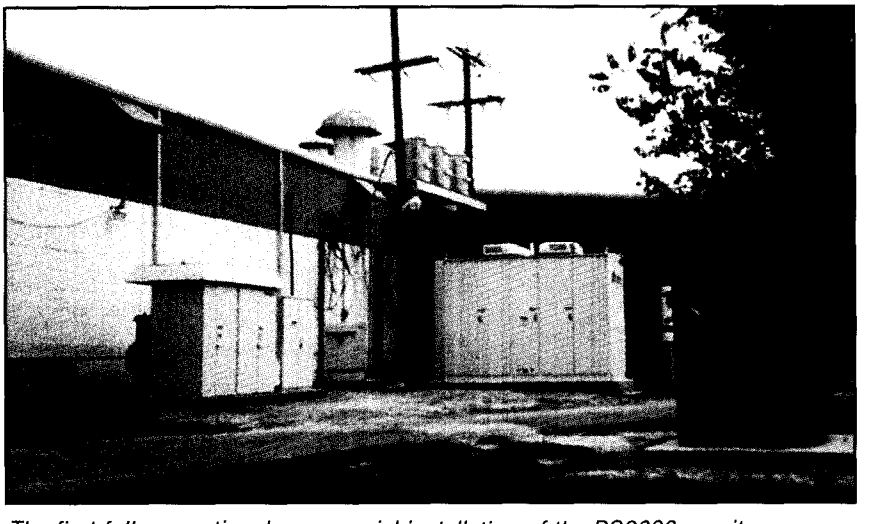
A revolutionary, hand-held device that analyzes blood samples in minutes rather than the current turnaround time of hours to weeks has been patented by scientists at Sandia and the National Institutes of Health. The Biological Microcavity Laser can immediately detect sickle-cell anemia as well as other blood anemias, and may be able to detect tiny changes in cell structure such as those caused by the AIDS virus. The device can distinguish between cancerous and noncancerous cells and should allow observers to monitor cancer cell growth and death as these processes take place. The device, based on the Sandia-developed VCSEL (Vertical-Cavity Surface-Emitting Laser) technology, generates laser light with individual blood cells from a drop of blood in the VCSEL microcavity. The blood cell becomes a light guide in the process of generating the VCSEL laser beams. The light reflects many times through a sample, so deviations in the image created by the blood particle are magnified, greatly increasing the chances of errorless identification. The device eliminates the need to kill or stain blood cells for better visibility, as traditional medical labs do. The Biological Microcavity Laser may potentially impact health care by leveraging the low cost and small size of semiconductors with the high speed and sensitivity of laser microtechnology.

R&D 100 AWARDS

R&D Magazine annually selects 100 technologies or products that represent the year's best advances in science and engineering. Sandia has accumulated more than 50 prestigious *R&D 100* Awards over the years, including this year's eight awards for the following technologies:

AC Battery PQ2000 Prevents Power Failures, Production Losses

Researchers estimate that tens of billions of dollars in production losses occur annually because of electrical power sags and momentary, 100% power failures. Sandia's AC Battery PQ2000, a two-megawatt, battery-based energy storage and delivery system, prevents power losses by continually monitoring utility lines for momentary interruptions and transferring power as needed from its stored battery energy. The transfer is seamless to the customer and occurs in about 1/400th of a second. The system can deliver power for up to 15 seconds. The PQ2000 is invaluable to the microprocessor, pharmaceutical, metal plate lithography, and other industries that rely on machinery so sensitive that a single electrical hiccup could be disastrous. The device is mounted at a company's electrical service entrance and is typically inserted in the lines that provide electrical energy to a company's critical loads. The PQ2000 has been proven effective in actual use. In Georgia, for example, the PQ2000 prevented eight electrical outages to a metal plate lithography plant during a single, severe lightning storm.



The first fully operational commercial installation of the PQ2000 monitors power at a lithography plant in southern Georgia.

Proton-Based Memory Chip Retains Critical Computer Data

A new class of memory technology saves computer data in the event of a power failure by making protons the primary information storage mechanism. Protons sandwiched between silicon layers in the memory-retentive chip — the Protonic Nonvolatile Memory Chip — maintain the memory state when power is removed. Earlier nonvolatile memory technologies, which use electrons as the primary storage mechanism, require a relatively high programming voltage, take more time to program, and can be reprogrammed only a limited number of times. The new protonic chip uses a lower voltage, is rapidly programmable, and can be written to and erased more than 1 million times. The new chip is fully compatible with existing manufacturing processes. In addition, the new technology could potentially impact the $1 billion/year commercial nonvolatile memory business and may become invaluable wherever critical information must be protected, such as in weapons and satellite systems. This technology received a 1997 *R&D 100* Award and an *Industry Week* Top-25 Technology-of-the-Year Award.

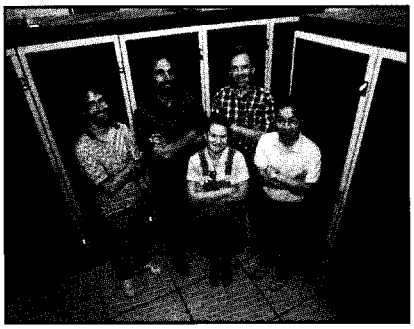
Filmetrics F-30 Optical Probe: Unprecedented Thin-Film Process Control

Until Sandia and Filmetrics, Inc. of San Diego, California, jointly developed the Filmetrics F-30 optical probe, there was no simple, inexpensive way for growers of thin films (essential components of modern microelectronics) to modify their recipe as the film was being deposited. Today, the F-30, an in situ device, enables film growers to immediately measure the thickness and chemical composition of very thin films, detect failure in a growth run, and identify the source of the failure. The device employs a novel "virtual interface" method, which allows the recipe to be modified without stopping production. This has led to unprecedented process control in the manufacture of complex devices involving many hundreds of thin-film layers. The F-30 works by reflecting visible or near-infrared light from films to measure their growth rates.

GEOSEIS™ Mini-Hole Seismic Blast Initiation System Expands Geophysical Exploration

Sandia has improved the precision of oil and mineral exploration with the invention of a new semiconductor bridge (SCB) used in seismic detonators. Seismic detonators with the new SCB offer far greater precision and faster response times than traditional seismic detonators. An array of tiny detonators transmits sound waves into the ground; the returning waves indicate the presence of underground structures. The more accurate the detonator timing, the better the data collected from the returning echoes. The new detonator is used in the GEOSEIS™ Mini-Hole Seismic Blast Initiation System, an oil and mineral exploration system that was trademarked, designed, manufactured, and marketed by the Ensign Bickford Company in Connecticut. The accurate timing of GEOSEIS results in substantial cost savings to geophysical exploration companies. The SCB chip is processed and manufactured in New Mexico by SCB Technologies, Inc., the exclusive licensee for commercializing the SCB technology. The GEOSEIS Mini-Hole Seismic Blast Initiation System was awarded a 1997 *R&D 100* Award, shared by Ensign-Bickford, SCB Technologies, and Sandia.

Semiconductor bridge allows precision mapping for oil exploration.



Aztec Solves Millions of Equations for a Wide Range of Computer Codes

Increasingly, scientists need to solve problems with several million algebraic equations and unknowns. Aztec, a software library of equation solvers, takes on much of the computational burden by helping other software codes solve these large linear systems. By providing sophisticated software tools for engineering applications, Aztec makes high-performance computing practical for cutting-edge simulations and design problems. Aztec has helped solve equations for the Alegra computer code, which computationally simulates the quasistatic electric field in the neutron generator power supply. Aztec has also worked with the MPSalsa code to perform plasma flow simulations for the neutron generator ion source tube, with the GOMA code to simulate the physics governing the liquid-film coating of substrates, and with the COYOTE code to conduct radiation heat transfer analyses of the W-80 fireset. Aztec has

allowed Sandia to solve previously unsolvable scientific computing problems for the Department of Energy and U.S. industry.

Biological Microcavity Laser Analyzes Blood Samples in Minutes

A revolutionary, hand-held device that analyzes blood samples in minutes rather than the current turnaround time of hours to weeks has been patented by scientists at Sandia and the National Institutes of Health. The Biological Microcavity Laser can immediately detect sickle-cell anemia as well as other blood anemias, and may be able to detect tiny changes in cell structure such as those caused by the AIDS virus. The device can distinguish between cancerous and noncancerous cells and should allow observers to monitor cancer cell growth and death as these processes take place. The device, based on the Sandia-developed VCSEL (Vertical-Cavity Surface-Emitting Laser) technology, generates laser light with individual blood cells from a drop of blood in the VCSEL microcavity. The blood cell becomes a light guide in the process of generating the VCSEL laser beams. The light reflects many times through a sample, so deviations in the image created by the blood particle are magnified, greatly increasing the chances of errorless identification. The device eliminates the need to kill or stain blood cells for better visibility, as traditional medical labs do. The Biological Microcavity Laser may potentially impact health care by leveraging the low cost and small size of semiconductors with the high speed and sensitivity of laser microtechnology.

CLIP-C Provides Real-Time Control of Induction Heat-Treatment Process

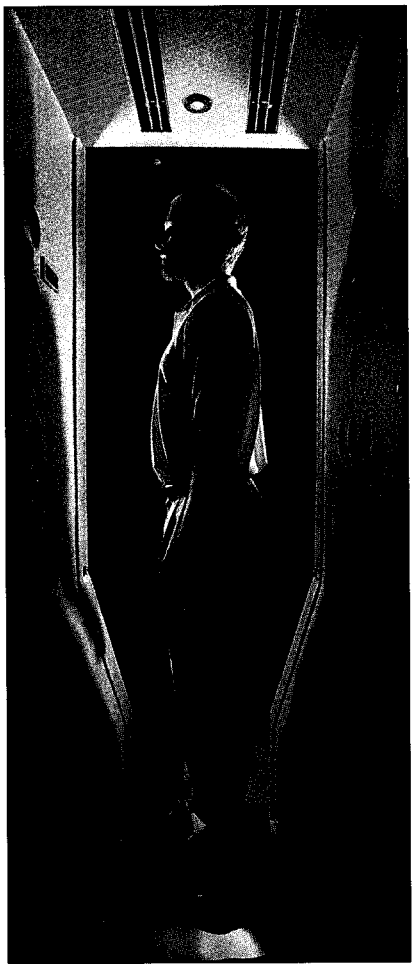
Under a cooperative R&D agreement between Sandia and Delphi Saginaw Steering Systems (part of Delphi Automotive Systems, a wholly owned subsidiary of General Motors), researchers developed and patented the CLIP-C (Closed Loop Induction Process Controller), a new and unique "closed-loop" control system for regulating the induction heat-treatment process. For induction heating, eddy currents are generated in the surface regions of steel and cast-iron parts. The parts are heated to an appropriate temperature and depth by the eddy currents and are then quenched with spray to achieve the desired balance of surface strength and component toughness. Although induction heat treatment has been used since before World War II, the process was "open-looped" — production parts had to be sectioned frequently so that process and product quality could be assessed. Thus good parts were often scrapped and an unknown number of bad parts were accepted. The CLIP-C system, however, assesses the heating depth of every part during manufacture and makes immediate process adjustments so that bad parts are not produced. The CLIP-C system achieves this by interpreting the electromagnetic signals generated during induction heating and hardening. The CLIP-C is now being used to control the case depth of axle shafts in Saturn automobiles with a precision five times better than industry standards. The system is now being installed in Ford and Chrysler plants and can be retrofitted for a broad range of induction-hardening systems to heat-treat components requiring high wear resistance, as well as high fatigue, bending, and impact strengths. Sandia applications of induction heating and hardening include controlled-erosion components and components requiring improved bending and joint strength.

Hierarchical High-Performance Storage System Stores and Moves Data 100 Times Faster

The Internet puts vast amounts of information at a computer user's fingertips — information from business, government, industry,

universities, and individuals. The challenge is how to store and use so much data. The Hierarchical High-Performance Storage System, developed jointly by industry, universities, and national laboratories, fills the need for secure, efficient storage system software. The new system stores and moves large amounts of data between high-performance computers and storage libraries 100 times faster than previously possible. It does this with its distributed architecture, which allows many pieces of a file to be moved at the same time. In contrast to this parallel movement, existing data storage systems transfer data in a more serial fashion. The new, high-performance storage system transfers files at a rate of billions of bytes per second and can store millions of gigabytes of data. It has been used at DOE laboratories to store data from nuclear stockpile simulations. The *R&D 100* Award-winning system exhibits great potential to help solve other data-rich problems in engineering, climate modeling, medical, and financial applications being addressed at high-performance computing centers around the country.

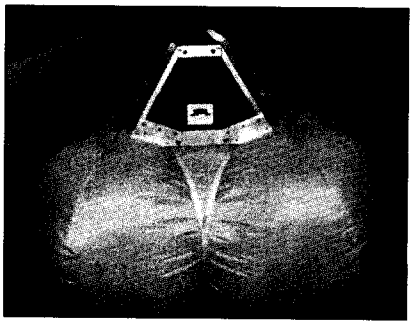
OTHER ACCOMPLISHMENTS



Sandia's explosives-detection portal is tested by volunteers at the Albuquerque International Airport.

Explosives-Detection Portal Could Prevent Hijackings and Bombings

Airports across the country may one day be using Sandia's explosives-detection portal to help prevent airliner hijackings and bombings. The portal, sponsored by the Federal Aviation Administration, can identify passengers, visitors, and employees who have recently worked with or have been exposed to any of a wide variety of explosive chemicals. The portal detector passes a gentle puff of air over a person, then collects and analyzes the air sample. If even a minute concentration of explosives residue is present on a person's skin or clothing, the detector can determine both the type and quantity of the chemical and display this information on an adjacent computer screen. Researchers tested the portal with the help of 2,400 volunteers at the Albuquerque International Airport. An alarm sounded on one volunteer, who had been in contact the previous week with explosives as part of his normal job. The FAA will be conducting further tests on the portal as part of a more complete characterization of the technology. Sandia is currently transferring the technology for manufacture and marketing. The same technology can be adapted to detect narcotics and chemical agents at other screening locations, such as border crossings and federal buildings, or it can be used for environmental monitoring.



Sandia designed this 3/8th-scale prototype airbag to demonstrate the feasibility of an airbag landing on Mars.

Mars Airbags Born of Sandia Parachute Technology

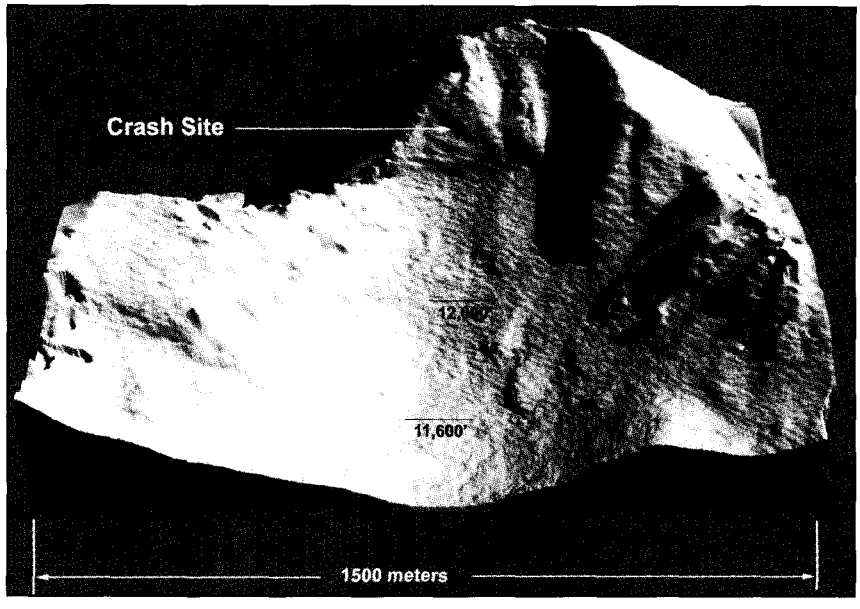
When the Pathfinder spacecraft hit the surface of Mars on July 4, 1997, it bounced and rolled to a safe stop without damaging its precious science cargo. The 40-mile-per-hour landing was cushioned by a cluster of airbags, which caused the craft to bounce about 15 times, then tumble and roll for 2-1/2 minutes before stopping about a half mile from the point of impact. Sandia teamed with NASA's Jet Propulsion Laboratory to develop a prototype of the Mars airbags and assess its suitability for Pathfinder's mission. The airbags were designed and developed using Sandia's nuclear weapon parachute technology. A 3/8-scale prototype airbag, designed and constructed in Sandia's Parachute Laboratory, was tested in conditions that simulated Mars' low atmospheric pressure. To do this, a Sandia team devised a guillotine-like structure to impact the airbag cluster inside a vacuum chamber that replicated Mars' atmosphere. Researchers slammed a metal plate into the airbags to simulate the impact of landing. A finite-element structural model of Sandia's prototype designs predicted the stresses and strains the airbag material would have to endure on impact. After the July 4 landing, NASA chief Dan Goldin told ABC News, "This is a 'thank you' to the wonderful people at Sandia National Laboratories. The first four minutes [of the landing] were on them."

Sandia Explosives Experts Disable Unabomber's Last Bomb

Sandia explosives experts Chris Cherry and Rod Owenby successfully disabled "Unabomber" Theodore Kaczynski's last bomb, which had been assembled, wrapped, and ready to address when discovered in Kaczynski's Montana cabin. One of the tools the Sandians used was the Percussion-Actuated Nonelectric Disrupter, designed by Chris to remotely disrupt a bomb's internal gadgetry so instantaneously that it never has a chance to detonate. Over a three-day period, the Sandians "surgically defused" Kaczynski's sophisticated bomb to ensure that all the evidence was preserved and to understand the bomb's working mechanisms. President Clinton, during an Albuquerque visit in February 1998, praised Chris and Rod for assisting FBI and ATF agents during the search of Kaczynski's cabin. Says Clinton, "They, at considerable risk to themselves, helped to lead to the capture and conviction of Mr. Kaczynski and put an end to his deadly attacks."

Sandia Radar Successfully Locates and Characterizes A-10 Crash Site

In April 1997, the U.S. Air Force requested Sandia's support to precisely locate and characterize an A-10 crash site in central Colorado. Winter weather conditions in the area had severely hampered Air Force efforts to pinpoint the location of the deceased pilot and four 500-pound bombs carried by the aircraft. Within 72 hours of the call, the Sandia Airborne Multisensor Pod System (AMPS) team planned and executed two remote sensing missions over the crash site in a Navy P-3 Orion research aircraft. The first sortie included a multitude of low-altitude, daytime passes to collect optical, spectral, and thermal data at the site. Then the Navy and Sandia prepared the aircraft and its sensors for a high-altitude, nighttime radar sortie. For several hours into the night at an altitude of 22,000 feet, the team collected images using a Sandia-developed radar designed to make high-resolution three-



This radar image of the A-10 crash site, collected by the Sandia AMPS team, provided accurate terrain elevation details for the Air Force recovery team.

dimensional maps. After the flight, a Sandia radar processing team developed the imagery into 3-D models that were used by the Air Force recovery team.

Sandia Models Characterize TWA Flight 800 Fuel Tank Explosion

Sandia supported the National Transportation Safety Board's (NTSB) efforts to characterize the center fuel tank explosion of TWA Flight 800. Sandia developed flame-front propagation models of the fuel-air ignition and the subsequent explosion. One conclusion derived from these simulation models was that a fire could have produced enough pressure in the fuel tank to cause the explosion. Another conclusion was that the configuration of the tank itself may have increased the rate of pressure rise in the tank during the burn. The results of NTSB tests performed by a Caltech experimental team and the Norwegian Christian Michelson modeling team agreed with the Sandia model. The same NTSB team is investigating the actual cause of the crash; Sandia has been asked to support the testing program for this effort as well, and to perform sensitivity calculations to locate the ignition source.

Washington, D.C., Feels Impact of 'Revolution in Engineering'

The fastest computer in the world, the teraflops computer, is fueling a "revolution in engineering," allowing scientists to perform calculations that were never before possible. This ultra-high-performance computer was developed by Intel for the Department of Energy and is housed at Sandia. The computer is a critical component of DOE's Science-Based Stockpile Stewardship Program to ensure the safety, security, and reliability of the nation's nuclear stockpile without actual testing. The computer also will allow prototype products to be designed, built, tested, and redesigned in virtual space, in a tiny fraction of the time previously required. To demonstrate how this revolution in engineering is impacting manufacturing and product development, oil and gas exploration, scientific visualization, and the forecasting of catastrophic events, Sandia sponsored a day-long event in Washington, D.C., last June for the news media, industry, academia, and Congressional representatives.

Capitol Hill Expo Generates Support for National Intelligent Machines Initiative

Scores of legislators, Congressional staffers, industry representatives, and media attended the Intelligent Machines Expo last September on Capitol Hill. The goal of the event was to inform Congress on the importance of the rapidly emerging intelligent machines industry to the nation's competitiveness. The Expo gained support for a national intelligent machines initiative and resulted in a call from Congress to establish Sandia's new Robotic Manufacturing Science and Engineering Laboratory as one of several national testbeds. In these testbeds, government, industry, and academia can collaborate to commercialize new robotics products. The Washington event was sponsored jointly by Sandia, the Department of Energy, and the Robotics and Intelligent Machines Cooperative Council at the request of the House and Senate Manufacturing Task Forces.

SEAtrace™ Assesses Leaks in Submerged Barriers

Sandia and Science and Engineering Associates (SEA) Inc. have developed and demonstrated an assessment system called SEAtrace™, which determines the magnitude and location of leaks in subsurface barriers placed in the soil, usually to prevent the migration of hazardous wastes. SEAtrace uses benign gas tracers and an innovative computer code to provide early leak detection and real-time data analysis of the leak. A benign gas, such as carbon dioxide, is injected into the soil and moves through the underground barrier if leaks exist. Gas samples collected around the barrier provide information about these leaks. In demonstrations conducted at Brookhaven National Laboratory and Dover Air Force Base, five technologies were evaluated side by side to verify two barrier types — one formed from high-pressure injections of cement-like grout and the other by low-pressure applications of grout that permeate the ground and solidify. In both demonstrations, the Sandia/SEA-developed system detected, located, and measured the size of the leaks sooner, faster, and better than the other technologies.

Sandia Helps Test and Evaluate NASA's Ultra-High-Temperature Ceramic

A NASA Ames project called SHARP-B (Slender Hypervelocity Aerothermodynamic Research Probe-Ballistic) seeks to demonstrate the viability of using sharp leading edges for future space vehicles. Because sharp geometries get hotter when they slice through the atmosphere, reentry craft traditionally have featured blunted edges that minimize heat buildup but also increase aerodynamic drag and reduce flight performance. NASA Ames devel-

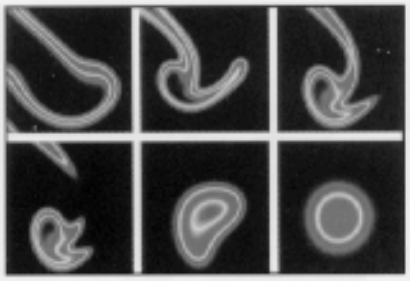
oped an ultra-high-temperature ceramic material to endure the rigors of atmospheric reentry. The material's potential to withstand temperatures exceeding 5,000°F on sharp leading edges makes it an attractive candidate for launch and reentry vehicles. To test the new ceramic, researchers shaped it into a new, sharper nose tip for the Mk12A reentry vehicle and successfully flew it on a Minuteman III Missile on May 21, 1997. Sandia modified the Mk12A nose cone to accept NASA's new ceramic nose tip, integrated sensor and telemetry instrumentation into the reentry vehicle, and conducted flight-qualification tests on the vehicle. Sandians also helped ready the payload and participated in the launch and data analysis. The successful completion of this project in less than 5 months has led to discussions of follow-on work with NASA.

Sandia Hosts High-Consequence Engineering Conference Series

High-consequence engineering refers to those engineering projects in which a failure would lead to extreme consequences such as loss of life, severe financial loss, endangerment of the environment, or a compromise to national security. Issues include performance reliability in normal environments, safety in abnormal environments, and security in the face of malevolent attacks. Since most of Sandia's work has a very high consequence of failure, Sandia has developed expertise in high-consequence engineering. To foster communication and collaboration, Sandia hosted a six-part High-Consequence Engineering Conference Series in 1997. Seminars focused on understanding, predicting, and preventing failures in a variety of critical applications. Conference topics included "Assuring the Performance of Buildings and Infrastructures," "High-Consequence Operations Safety," "Risk Management for Critical Infrastructures," "High Integrity Software," "Using Integrated Circuits in Critical Applications," and "Material-based Life Prediction." The large number of participants, including foreign attendees, indicated the widespread interest in the subject. Strategic partnerships and business arrangements are expected to emerge from this inaugural event. The conference was an important step in realizing Sandia's vision of being "The Nation's Surety Lab."

FAA Benefits from Sandia's High-Consequence Operations Experience

Sandia's weapon surety engineering process was applied for the first time to another important high-consequence operation *(see previous entry)* — aviation surveillance. A Federal Aviation Administration team, which included Sandia researchers, developed an improved aviation surveillance process that incorporated process feedback.
The team demonstrated the concepts of Sandia's nuclear weapons system safety and surety processes to improve the FAA's Air Transportation System. The new surveillance process will begin its first phase of implementation on October 1, 1998, and will involve the ten largest air carriers.
This project is part of Sandia's Aviation Safety Critical Elements and Necessary Tasks (ASCENT) program, an integrated effort for the FAA that includes data quality, human factors, system safety, and business modeling.



Direct numerical simulation is used to study the turbulence and chemical interactions of combustion.

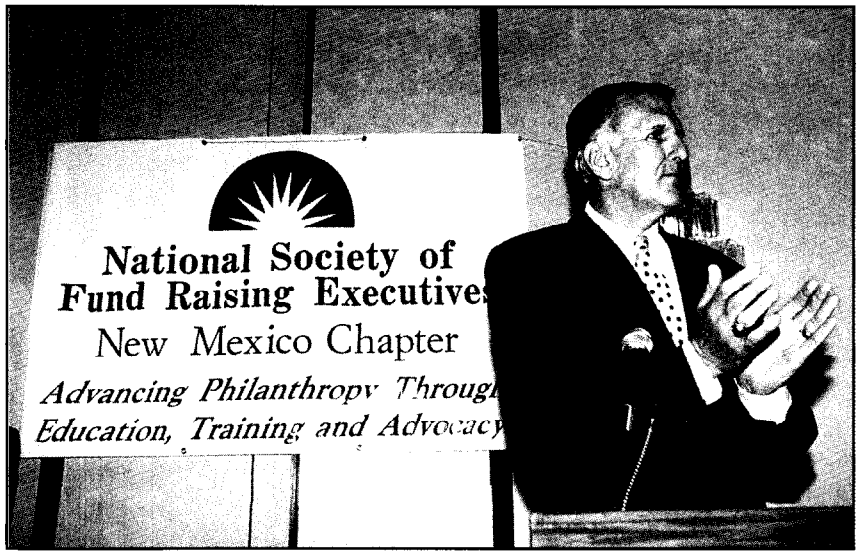
Direct Numerical Simulations Answer Combustion Questions

Direct numerical simulations are high-fidelity computations used to gain a fundamental understanding of the relationship between chemical reactions and turbulent mixing during combustion. These computations use detailed descriptions of the chemistry associated with burning hydrocarbon fuels. The present study analyzed 18 chemical species and 68 reversible reactions of methane and air combustion. For strong turbulence conditions, highly wrinkled flames interact with neighboring flames, often resulting in the formation of isolated pockets of unburned fuel. The process of pocket formation is affected by the diffusion of light hydrogen molecules into the reaction zone, which sustain the production of radical species that break down the fuel. The process is also affected by large changes in the speed at which the flame advances into the reactants. Sandians found that the chemical imbalance during the highly transient event of pocket formation creates strong local concentrations of radical species.

Scientists Replicate Dinosaur Sounds

Scientists at Sandia and the New Mexico Museum of Natural History and Science collaborated to recreate the sound made by the rare *Parasaurolophus* dinosaur 75 million years ago. The dinosaur had a bony tubular crest that extended back from the top of its head. Many scientists believe that the crest, which contains a labyrinth of air cavities, might have been used to produce distinct sounds. Since scientists do not know whether *Parasaurolophus* had vocal cords, a variation of sounds with and without vocal cords was simulated. Low-frequency sounds were produced with computed tomography scans and powerful computers. Developing the 3-D computer-modeling techniques to create the dinosaur sound allowed Sandia scientists to expand their computing skills.

The same complicated techniques can be used to analyze and predict the structural integrity of aging aircraft, the internal structures of aging weapons, and the forces and mechanical failures associated with the crash of an airplane carrying nuclear weapons.
To hear the recreated dinosaur sounds, visit Sandia's Web site at <http://www.sandia.gov> and select *News Center, News Releases,* and the Dec. 5, 1997, news release called "Scientists Use Digital Paleontology to Produce Voice of *Parasaurolophus* Dinosaur."



Don Carson, Director of Sandia's Public Relations and Communications Center, accepts the Outstanding Business in Philanthropy Award on behalf of Sandia. Sandia and Lockheed Martin were recognized for their participation in community outreach programs.

Sandia Wins 'Outstanding Business in Philanthropy Award'

Sandians have always been generous with their time and money to help others in their local communities, and last year was no exception. Sandia and Lockheed Martin Corporation received the National Society of Fundraising Executives' 1997 Outstanding Business in Philanthropy Award in recognition of their participation in community outreach programs. For example:

- Sandians contributed more this year to the Employee Contribution Plan/United Way Campaign than ever before, exceeding $1.6 million.
- More than 1,700 employees in the nationally recognized Sandia Volunteer Program donated approximately 50,000 hours of service to their local communities.
- Sandia's Laboratory Management Performance Groups received an "Outstanding" rating in DOE's annual appraisal. Each group establishes annual goals, completes a self-assessment, and receives a DOE assessment. Sandia's overall rating was 92.5%, with the Community Involvement and Issues Management team receiving a 98% because of Sandia's outstanding volunteerism, contribution programs, and public involvement.

Sandia's World Wide Web Site Receives 'Best of Industry' Award

The Web Marketing Association selected Sandia's World Wide Web site to receive a "Best of Industry" award in the government agency category in the association's 1997 WebAward competition. More than 200 sites in all categories were judged on design, innovation, content, interactivity, navigation, ease of use, and use of technology. Sandia's Web site is located at <http://www.sandia.gov>

TECHNOLOGY PARTNERSHIPS & COMMERCIALIZATION

National Labs and Top U.S. IC Manufacturers Aim for 0.1-Micron ICs

Sandia, Lawrence Livermore, and Lawrence Berkeley national laboratories signed DOE's largest funds-in CRADA in 1997 with a private sector consortium of leading-edge integrated circuit (IC) manufacturers — AMD, Intel, and Motorola. Under the agreement, the three labs created a Virtual National Laboratory (VNL) to develop an alpha-class, extreme ultraviolet lithography (EUVL) tool for the 0.1-micron generation of ICs. The tool, called the Engineering Test Stand, uses a Sandia-developed, 13-nanometer light source. This shorter wavelength is roughly 20 times smaller than what is used in today's lithography tools for printing 0.25-micron features. The much shorter wavelength source and multilayer, coated reflective optics (developed and tested by Lawrence Livermore and Lawrence Berkeley national laboratories) enable the printing of extremely fine lines on ICs. The VNL is also developing and integrating all the necessary component technologies. In addition to machine components, Sandia is developing new photoresists that are sensitive to extreme ultraviolet light. At the completion of the CRADA, the VNL will demonstrate the project at Sandia's Integrated Manufacturing Technology Laboratory.

Sandia Semiconductor Bridge Expands Oil and Mineral Exploration

Sandia has improved the precision of oil and mineral exploration with the invention of a new semiconductor bridge (SCB) used in seismic detonators. Seismic detonators with the new SCB offer far greater precision and faster response times than traditional seismic detonators. An array of tiny detonators transmits sound waves into the ground; the returning waves indicate the presence of underground structures. The more accurate the detonator timing, the better the data collected from the returning echoes. The new detonator is used in the GEOSEIS™ Mini-Hole Seismic Blast Initiation System, an oil and mineral exploration system that was trademarked, designed, manufactured, and marketed by the Ensign Bickford Company in Connecticut. The accurate timing of GEOSEIS results in substantial cost savings to geophysical exploration companies. The SCB chip is processed and manufactured in New Mexico by SCB Technologies, Inc., the exclusive licensee for commercializing the SCB technology. The GEOSEIS Mini-Hole Seismic Blast Initiation System was awarded a 1997 *R&D 100* Award, shared by Ensign-Bickford, SCB Technologies, and Sandia.

$2.5-Million CRADA Signed to Advance Sandia's GOMA Code

Sandia and the Coating and Related Manufacturing Processes Consortium signed a $2.5-million CRADA to advance GOMA, the Sandia-developed finite-element code that analyzes fluid-dominated manufacturing processes that are critical to DOE Defense Programs and to the consortium. One of these manufacturing processes is the application of coatings to paper, film, adhesive tape, and other substrates. GOMA simulates the physics governing the liquid-film coating of substrates along with the subsequent drying and solidification of the film. The code simulates coupled fluid, thermal, and structural responses of the fluid and substrate during drying and curing. Consortium members include 3M, Imation, PPG Industries, Kodak,

Polaroid, Avery Dennison, and Xerox. The CRADA is supported by the consortium, DOE, and member companies who also fund their own testing and code-verifications.

Photovoltaic Projects Introduce Millions of Americans to Renewable Energy Technologies

Sandia's Photovoltaic Systems Assistance Center (PVSAC) partnered with several federal agencies to provide design and engineering support for new photovoltaic power systems that reduce fossil fuel use and environmental pollution. For these efforts, the PVSAC earned the 1997 National Park Partnership Leadership Award for Resource Stewardship and Preservation from the National Park Service and National Park Foundation.

The Bureau of Land Management (BLM) also honored the PVSAC as a "tremendous driving force in promoting photovoltaic use and helping introduce three million BLM visitors a year to renewable energy technologies." Sandia's partnerships with the National Park Service, Bureau of Land Management, and USDA Forest Service have resulted in more than 130 ongoing projects involving photovoltaic power system installations.

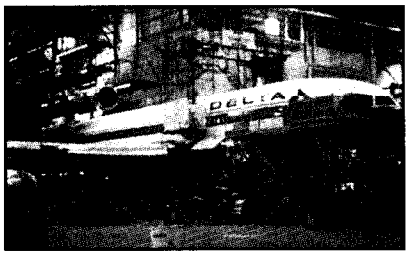
U.S. and Russia Benefit from Nuclear Weapons Surety Experience

The presidents of Sandia and VNIIEF, a Russian nuclear research center, signed a memorandum of understanding in July 1997 that encourages the U.S. and Russia to collaborate in applying Sandia- and VNIIEF-developed nuclear weapons surety principles to all U.S. and Russian critical infrastructures. The agreement, which resulted from discussions among scientists at both institutions, will lead to improved safety, security, and reliability of, for example, gas pipelines in the U.S. and Russia. Another major project will be to establish an organization at VNIIEF that is similar in concept to the U.S. Underwriters Laboratory. This entity will certify exports, imports, large systems such as a planned isotope production facility, and the components that go into these systems. The joint International Surety Center will assist both countries in ensuring the safety, security, and reliability of nuclear energy and air transportation systems.

Sandians hold a photovoltaic module amid ruins at the Salinas Pueblo Missions National Monument near Mountainair, New Mexico. A Sandia-designed photovoltaic array, consisting of 24 modules, powers the monument's visitor center.

Delta Aircraft Successfully Repaired with Sandia's Bonded Composite Doubler

A Sandia-led team repaired the door corner of a Delta Air Lines L-1011 aircraft using a bonded composite doubler in lieu of a conventional, riveted metallic patch — the first such application on a commercial aircraft. The bonded composite doubler is a fiber-reinforced, synthetic material that bonds to an airplane to create a very strong repair. The primary advantage of this new technique is that it eliminates



This Delta L-1011 aircraft was fitted in February 1997 with a new type of fuselage patch called a bonded composite doubler. The doubler was installed near the right-side access door, seen here cloaked behind a plastic tarp. Subsequent inspections have shown that the repair was a success.

rivet holes, which can create stresses and potential crack sites. The bonded composite doubler also provides a high strength-to-weight ratio, corrosion resistance, improved aerodynamics, and time savings in installation. It is flexible until cured by applying heat and pressure and can be bent around complex shapes such as the leading edge of a wing. The Delta aircraft, repaired in February 1997, returned to trans-Atlantic service, and two subsequent Sandia inspections have shown that the composite repair was successful. Spin-off activities stemming from this project include the repair of oil recovery equipment and railroad tank cars.

Goodyear and Sandia Sign CRADA to Improve Tire Manufacture

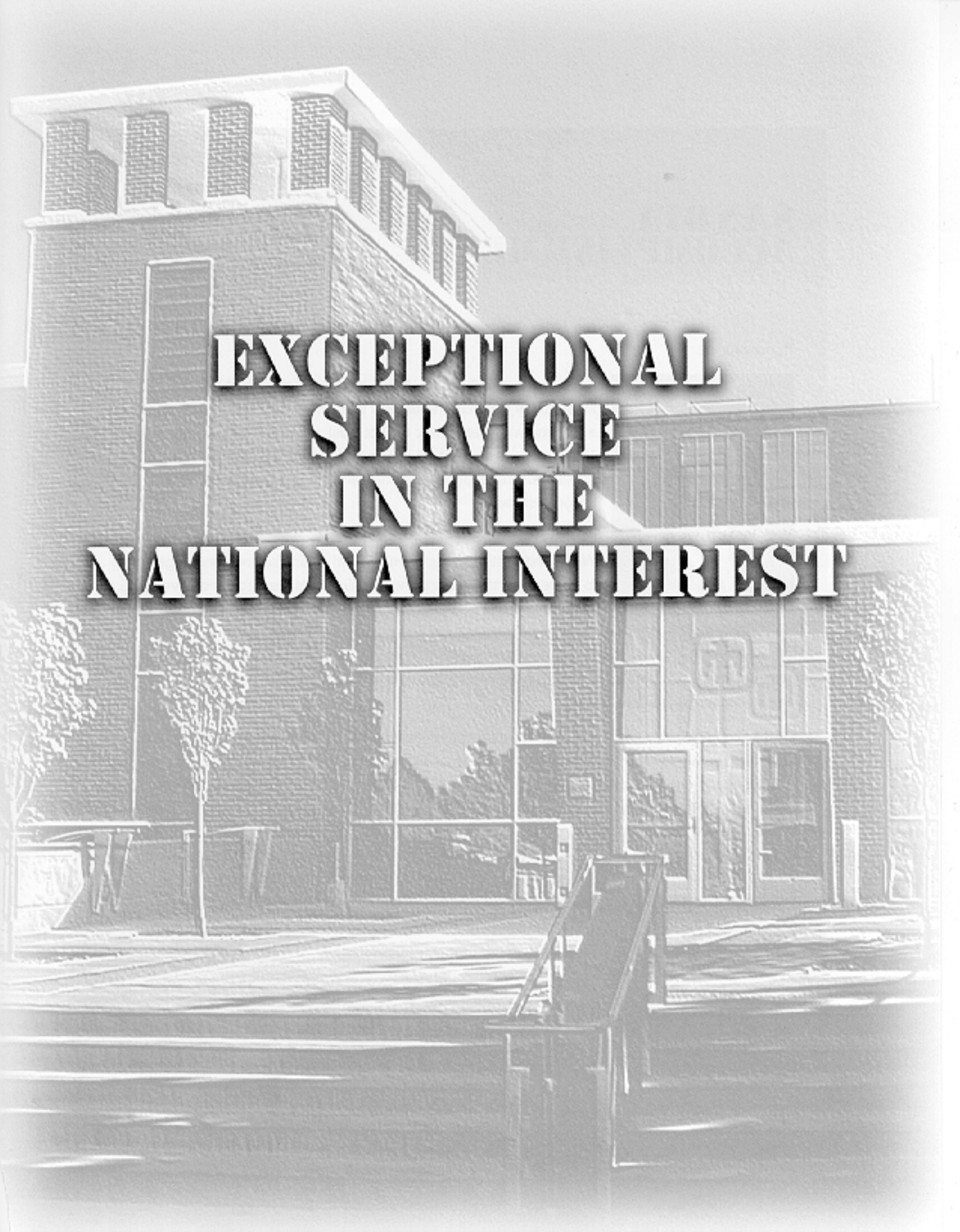
Goodyear Tire and Rubber Company and Sandia negotiated a new $15-million CRADA to address manufacturing issues. This is the fifth CRADA between Goodyear and Sandia, evidence of Goodyear's continuing faith that Sandia can help them solve their technical issues. Under this new agreement, Sandia will develop new manufacturing and fabrication processes leading to an improved understanding of various steps in the tire-making process.

R&D Funding from Industry Partners Reaches Record High

R&D funding to Sandia from industry partners reached an all-time high of $44 million for FY97: $27.2 million from Cooperative Research and Development Agreements that govern collaborative R&D activities between Sandia and industry; $14.3 million from Work for Others/Non-federal Entity Agreements sponsored by entities such as industry, state and local governments, and foreign governments; $579,000 from User Facility Agreements with partners who use Sandia's unique facilities for research, testing, and development; $55,000 from Technical Assistance Agreements provided to businesses; $332,000 from Personnel Exchange agreements; and $1.7 million from intra-work technology agreements (Lockheed Martin). Licensing income approached $1.6 million; patent applications were steady at 107; and invention disclosures declined slightly to 208.

More than 1,000 Small-Business Initiative Projects Completed over Life of Program

Under the sponsorship of the Small-Business Initiative, Sandians completed 209 technical assistance projects with small businesses in FY97, bringing the number of projects completed to more than 1,000 since the program began in 1991. Forty-eight Sandians have taken entrepreneurial leave to start their own businesses. During a day-long tour last October, Senator Pete Domenici, R-N.M., toured four of the Sandia technology-spawned businesses — WaveFront Sciences, MuSE Technologies, MicroOptical Devices, and QM Technologies, all in Albuquerque.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