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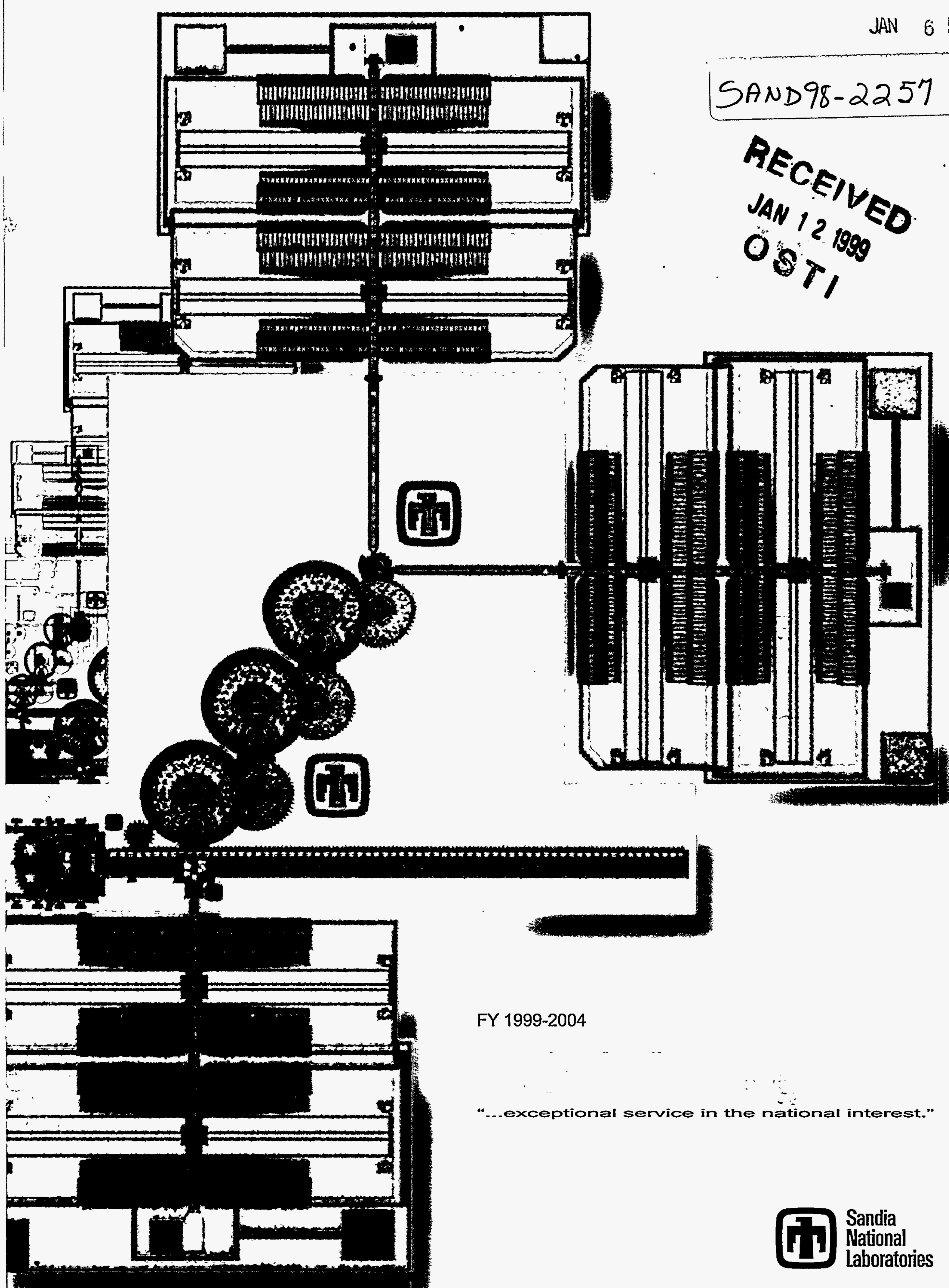


1275 microns

FY 1999-2004

"...exceptional service in the national interest."

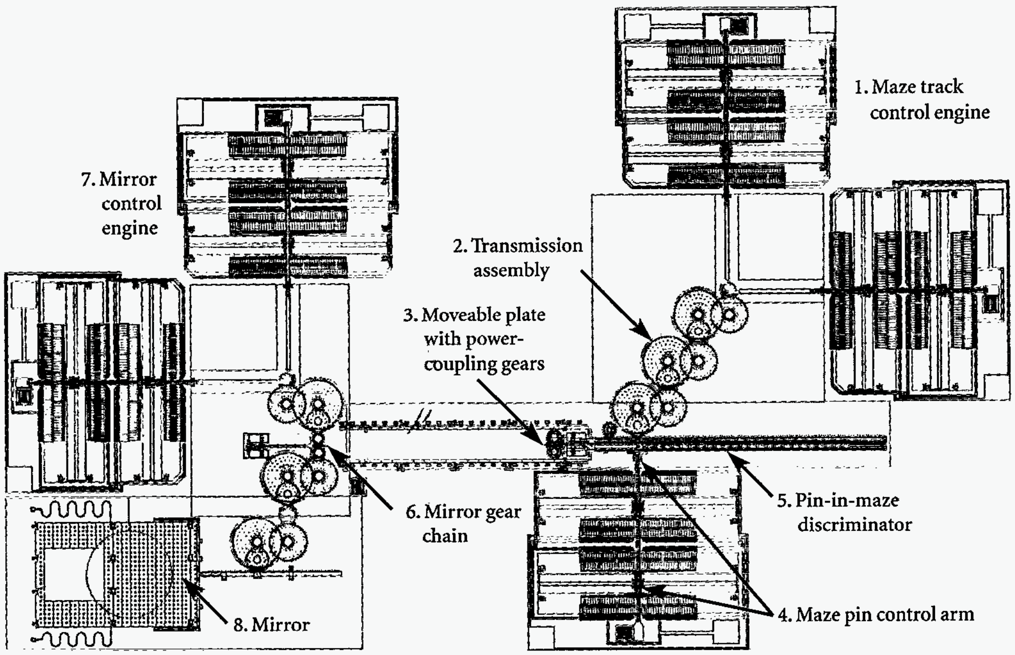
Sandia
National
Laboratories

THE COVER

The machine on the cover is shown in true colors, but the component parts are too small to be seen by the unaided human eye. The gears are the size of pollen grains, the gear teeth the size of human red blood cells. This microelectromechanical system operates in a domain where gravity and inertia are not significant; the effects of atomic forces and surface science prevail.

This machine, designed and manufactured by Sandia, demonstrates that a complete microelectromechanical safety system can be fabricated on a single chip of silicon. It is the first device fabricated with Sandia's state-of-the-art, five-level, polysilicon-surface micromachining technology.

The schematic corresponds to the machine on the cover and is labeled to help explain the components. The device's complex sequence of events completes an optical circuit. The sequence begins when an electric voltage activates the maze track control engine (1), which spins the transmission assembly (2). This assembly drives the moveable plate with power-coupling gears (3). Simultaneously, a 24-bit code is entered to enable the maze pin control arm (4) to move through the pin-in-maze discriminator (5); an incorrect code will lock the device. As the maze is navigated, the plate moves leftward until the power-coupling gears (3) mesh with the mirror gear chain (6). This coupling connects the rotating gears of the mirror control engine (7), which has been activated but not engaged, to stationary gears below. These gears drive a rack-and-pinion mechanism attached to a mirror (8). The mirror is hinged to fold upward, intercepting a laser beam, reflecting it to a target, and completing the optical circuit.



Microelectromechanical systems like this use electrical drive signals, mechanical discriminators, and optical components to achieve exceptional safety. Moreover, these systems are small, lightweight, and inexpensive.

This proof-of-concept system demonstrates that the level of complexity required for advanced weapon safety systems can be provided by surface micromachining technology. A Sandia-wide collaborative effort is under way to develop even more advanced surface micromachined safety systems.

STITUTIONAL PLAN TEAM

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LUSTRATION and PHOTO CREDITS

Special thanks are extended to Sandia's Intelligent Micromachine Initiative (www.mdl.sandia.gov/Micromachine) for providing the cover art, explanatory text, and associated images throughout the document. Also we thank the following people who supplied photos and illustrations: Brien Bopp, Tim George, Lynda Hadley, Diana Helgesen, Randy Montoya, Leroy Perea, Camille Reyes, and Charlene Shepard.

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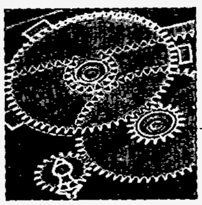
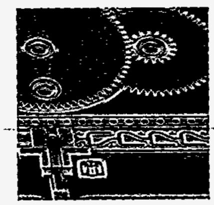
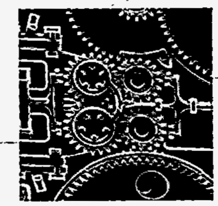
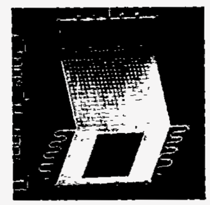
    

FY 1999-2004

INSTITUTIONAL PLAN

Albuquerque, New Mexico
Livermore, California

December 1998

CONTENTS

A Message from Paul Robinson

Sandia's President and Laboratory Director

Welcome to the future—Sandia's Institutional Plan for FY 1999 through 2004.

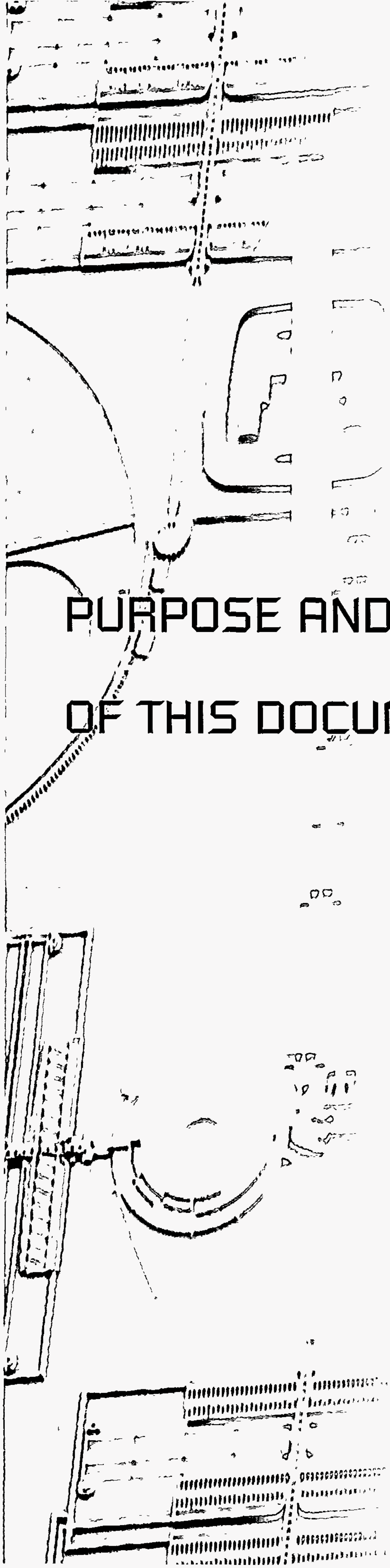
Eric Hoffer, the American longshoreman and philosopher, wrote that "The only way to predict the future is to have the power to shape it." I would add to his view that science and engineering are the best tools with which to shape the future.

Beginning with a vision of twenty years in the future (our strategic plan), the authors of this document have developed plans and objectives for the next five years, plus specific goals and milestones for Fiscal Year 1999.

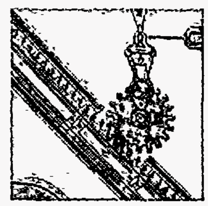
Yet it is clear that plans, goals, science, and engineering, as crucial as they are, cannot assure success in our endeavors. Only with the continued dedication and hard work of the men and women of Sandia National Laboratories can we achieve the better future we seek.

I invite you to read this plan and to join with us in making it a reality.

C. Paul Robinson



PURPOSE AND ORGANIZATION OF THIS DOCUMENT



This Institutional Plan is the most comprehensive yearly "snapshot" available of Sandia National Laboratories' major programs, facilities, human resources, and budget. The document also includes overviews of our missions, organization, capabilities, planning functions, milestones, and accomplishments. The document's purpose is to provide the above information to the US Department of Energy, key congressional committees, Sandia management, and other present and potential customers.

Chapter 2 presents information about Sandia's mission and summarizes our recent revision of Sandia's Strategic Plan.[1]

Chapter 3 presents an overview of Sandia's strategic objectives, chapter 4 lists laboratory goals and milestones for FY 1999, and chapter 5 presents our accomplishments during FY 1998.

Chapters 3 through 5 are organized around our eight strategic objectives. The four primary objectives cover nuclear weapons responsibilities, nonproliferation and materials control, energy and critical infrastructures, and emerging national security threats. The major programmatic initiatives are presented in chapter 7.

However, the programmatic descriptions in chapter 6 and the associated funding tables in chapter 9 continue to be presented by DOE Budget and Reporting Code, as in previous Sandia institutional plans. As an aid to the reader, the four primary strategic objectives in chapter 3 are cross-referenced to the program information in chapter 6.

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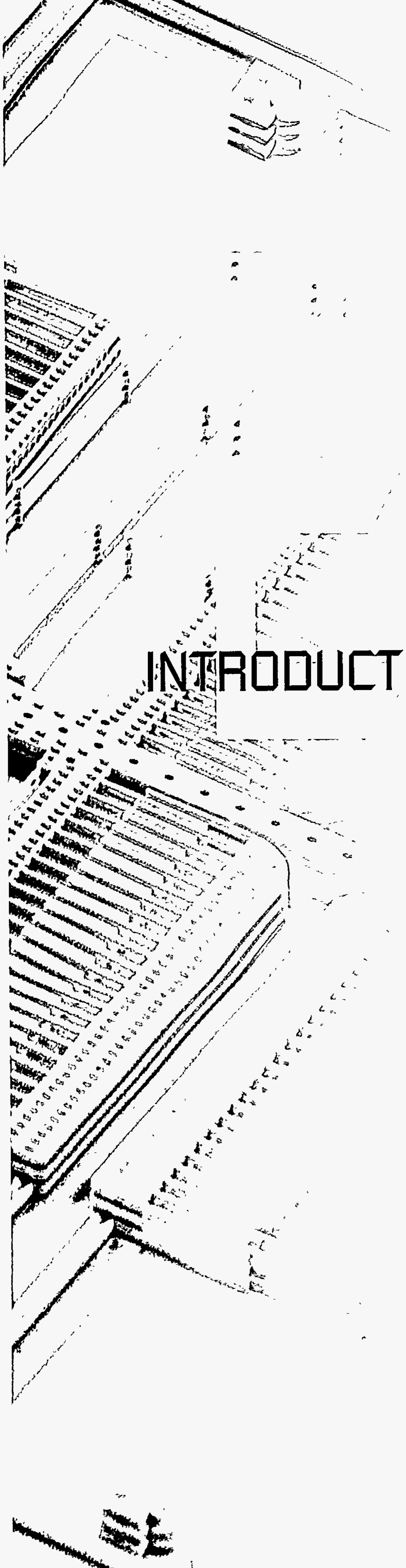
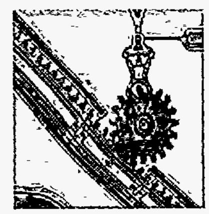
[1] *Strategic Plan 1997: Sandia National Laboratories*. SAND98-0500. Albuquerque, NM: Sandia National Laboratories.



INTRODUCTION



The Sandia Mission Council has completed the initial phase of implementing strategic business units (SBUs) and strategic management units (SMUs) to support our strategic objectives. The SBU/SMU matrix structure (see Figure 2.1) has three main purposes:

- articulating and implementing Sandia's strategic direction,
- coordinating Sandia's interface with our customers, and
- developing new business and new customers.

The SBU structure is only one element of our overall planning and execution process and should be fully implemented beginning in FY 1999.

2.1 Sandia's Mission

Sandia's government missions embody a philosophy of research and development derived from our industrial heritage. Our research is strategic to our missions; we perform "science with the mission in mind" rather than pursuing knowledge for its own sake. Sandia's strategic objectives reflect our philosophy of developing applications of new knowledge and our intent to make increasingly greater contributions to the nation, now and in the future.

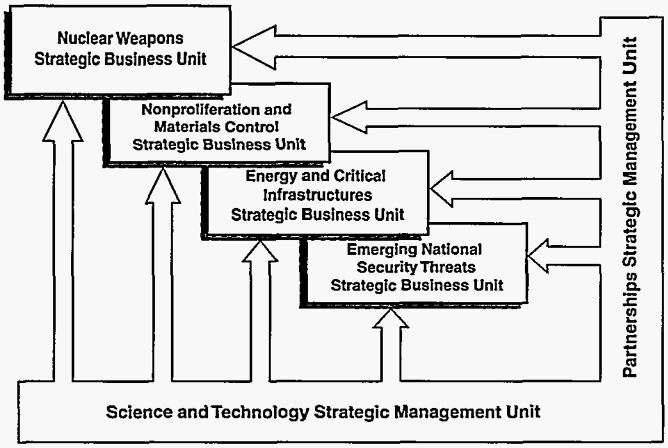


Figure 2-1 Strategic Business Unit/Strategic Management Unit relationship.

2.1.1 Mission Statement

As a Department of Energy national laboratory, Sandia works in partnership with universities and industry to enhance the security, prosperity, and well-being of the nation. We provide scientific and engineering solutions to meet national needs in nuclear weapons and related defense systems, energy security, and environmental integrity—and to address emerging national challenges for both government and industry.

2.1.2 Commitment to Mission Success

Sandia meets or exceeds customer expectations for program performance, cost, and schedule.

2.1.3 Commitment to Working Safely and Effectively

We work safely—ensuring the protection of employees, the public, and the environment. We also work effectively and efficiently, using minimum overhead loads and good management practices to ensure that customers receive maximum value for each dollar spent.

2.1.4 National Security Laboratory Mission

Sandia is a federally funded national security laboratory that provides engineering and science to ensure the security of our nation. To most Americans, national security historically has meant defense against foreign military threats. However, over time the threats to our nation have become increasingly varied and complex. Our security is now challenged from within as well as without, by economic as well as military action, by rogue groups as well as by foreign states, and by threats to global distribution of energy, information, and other vital resources (infrastructures).

Sandia is a formally designated federally funded research and development center that responds to a wide range of national security threats. Most often, we undertake national security assignments for our principal customer, the DOE, and when appropriate for other government agencies such as the Department of Defense. Our investments in new capabilities and programs will continue to be dominated by our customers' needs to respond effectively to threats to national security. Sandia's systems view, our approach and expertise, our engineering roots, and our practice of "science with the mission in mind" combine to make Sandia a unique national resource.

2.2 Strategic Plan Summary

Sandia's Laboratory Leadership Team redefined Sandia's strategic objectives in early 1996 using a process that involved Sandia managers at all levels. The Laboratory Leadership Team appraised Sandia's near- and long-term future. In the near term, increases in regional security threats may be caused by cultural animosities, competition for resources, and proliferation of weapons of mass destruction. If we effectively manage such threats, the long-term outlook may be one of increasing stability and prosperity.

The strategic objectives comprise the highest-level statement of Sandia's long-term objectives, which will guide our future decisions. These objectives identify areas of strategic focus but are not intended as an all-inclusive list of Sandia's programs. Eight new strategic objectives were identified for Sandia to achieve during the next decade. The first four objectives focus on *what* Sandia will accomplish in the areas of

- nuclear weapons responsibilities,
- nonproliferation and materials control,
- energy and critical infrastructures, and
- emerging national security threats.

The second four strategic objectives focus on *how* Sandia will accomplish its work in the areas of

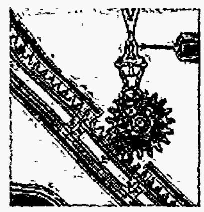
- recruiting and retaining the very best people,
- solving customers' technical problems with advances in science and technology,
- making Sandia's infrastructure an advantage for our strategic missions, and
- using strategic partnerships to produce the greatest return for our taxpayer dollars.

Detailed explanations of these strategic objectives are given in chapter 3.

In 1997 the Sandia Strategic Plan was expanded to include three-

Table 2.1. Values in Common

Sandia Corporate Values	Shared Lockheed Martin Value Statements	Shared DOE Core Values
Teamwork: • Ensure shared values and focus, • Conduct internal and external teaming, and • Create mutual benefits and mutual respect.	We multiply the creativity, talents, and contributions of both individuals and businesses by focusing on team goals. Our teams assume collective accountability for their actions, share trust and leadership, embrace diversity, and accent responsibility for prudent risk-taking.	We work as a team and advocate teamwork.
Integrity: • Honesty, • Openness and candor, • Objectivity, and • Fairness.	We embrace truthfulness and trust.... We ... will adhere to the highest standards of ethical conduct in all that we do.	We pursue the highest standards of ethical behavior.
Quality: • Exceed customer expectations for performance, cost effectiveness, and schedule; and • Explicitly plan for and achieve continuous improvement.	We demonstrate ... a restless determination to continually improve upon our personal bests. We ... add value for our customers with ingenuity, determination, and a positive attitude.	We are committed to excellence. We are customer-oriented.
Leadership: • Anticipate the needs of the nation; • Convey a vision; • Execute innovative and integrated solutions; • Encourage creativity, innovation, and initiative; • Set the standard; • Be courageous. Understand and manage risk; • Be driven by a desire to be the best; and • Have a passion for excellence and success.	We demonstrate leadership by advancing new technologies, innovative manufacturing techniques, enhanced customer service, inspired management, and the application of best practices throughout our organization. We demonstrate individual leadership through a positive approach to every task, a "can-do" spirit...	We recognize that leadership, empowerment, and accountability are essential. We value creativity and innovation.
Respect for the Individual: • Trust and empower the individual; • Benefit from individuality and diversity; • Be sensitive to individual needs and aspirations; • Expect, encourage, and reward accomplishment; and • Maintain a safe and healthful workplace.	Outstanding people make Lockheed Martin unique. We embrace lifelong learning through individual initiative, combined with company-sponsored education and development programs, as well as challenging work and growth opportunities.	We believe people are our most important resource. We value public safety and respect the environment.



to five-year goals and strategies that support the strategic objectives. In 1998 Sandia's Laboratory Leadership Team revised the implementing goals and strategies for each strategic objective for the three- to five-year time frame. As in previous years, these implementing goals and strategies are supported by sets of specific milestones for FY 1999 (see chapter 4). In addition to the eight strategic objectives, we strive to achieve a number of business results that represent metrics for success (see section 4.2).

Sandia's Strategic Plan, objectives, and goals support implementation of the Government Performance and Results Act.

2.3 Corporate Values

Sandia's corporate values, first identified in *Strategic Plan 1990*[1], remain valid today. In fact, experience has confirmed their relevance and utility. They have been a significant force behind Sandia's cultural changes during the last few years.

[1] *Strategic Plan 1990: Sandia National Laboratories.* SAND90-0562. Albuquerque, NM: Sandia National Laboratories.

These values are more than guidance. They are a challenge, and we use them to challenge our decisions and actions at every level and in every circumstance. Some discomfort and anxiety may be generated in the process, but the outcome will be a more flexible organizational culture, a better working environment, and better performance.

Sandia's corporate values are very similar to Lockheed Martin's value statements and the DOE's core values. Table 2.1 presents the relevant language from each organization's statement of values. It is easy to see that we share ideals and motivations with our parent company and our principal customer.

We think that these values are crucially important to realizing our strategic plan.

2.4 Summary of Capabilities

Sandia's engineering excellence is built on a foundation of science and engineering research (see figures 2.2 and 2.3). Our commitment to research started in the 1960s in response to the need for assuring the safety, security, and reliability of increasingly complex nuclear weapons. Sandia's commitment to excellence in this mission remains the focus of much of our research, but the challenges have become greater. Nuclear weapons can no longer be tested, and national security threats include other weapons of mass destruction and attacks on critical infrastructures. Moreover, we must assure the nation a credible nuclear deterrent by using modern manufacturing capabilities to replace lost capabilities and to reduce life-cycle costs.

Our research programs support critical mission areas. Sandia performs "science with the mission in mind" to achieve breakthrough advances in engineering design and manufacturing, simulation-based life-cycle engineering, intelligent integrated microsystems, and surety science and technology. We want our customers and external appraisers to recognize Sandia as the leader in each of these areas.

Revolutionary advances in engineering design, validation, and manufacturing (enabled by the DOE's Accelerated Strategic Computing Initiative and the Advanced Design and Production Technologies Initiative) are being used to improve the processes used to sustain the nation's nuclear weapon stockpile. The possibility of understanding the entire life cycle of a nuclear weapon or other complex devices and systems lies in simulation-based models of components, subsystems, and systems performance and in models of materials synthesis, manufacturing processes, aging, and disposition.

The invention and application of integrated circuits has had enormous impact on all aspects of human enterprise, including national security. Radiation-hardened integrated circuits remain essential to the nation's nuclear stockpile, ensuring that such systems will work reliably. The next "silicon revolution" involves the use of integrated circuits (intelligence) with devices that can sense (detect vibration, chemicals, temperature), act (perform mechanical work), and talk (communicate without wires or fibers). This revolution will increase surety (reliability, safety, and security) for nuclear weapons while greatly reducing the cost of building and maintaining them. External reviewer assessments have shown that Sandia is uniquely equipped to lead this effort. These new technologies are key elements of our systems design organization's plans for inclusion in the DOE Stockpile Life Extension Program and are a natural extension of our ongoing mission in radiation-hardened microelectronics.

Sandia has also advanced risk assessment by developing tools for analyzing hazards from complex systems (e.g., nuclear reactors). We have developed analytic and diagnostic techniques for detecting failures and are establishing protocols and models for predicting the behavior of materials based on an understanding of first principles. Surety combines these studies to focus on issues involved in predicting the performance of complex systems to assure they will function in all circumstances.

Success in the above major science and technology endeavors and in other important projects requires talented people and modern facilities. Partnerships with industrial laboratories and universities help to maintain Sandia's modern capabilities. Industrial partnerships that bring tangible benefits to Sandia are increasing because collaboration is mutually beneficial. Similar results are achieved by teaming with universities to execute our principal missions.

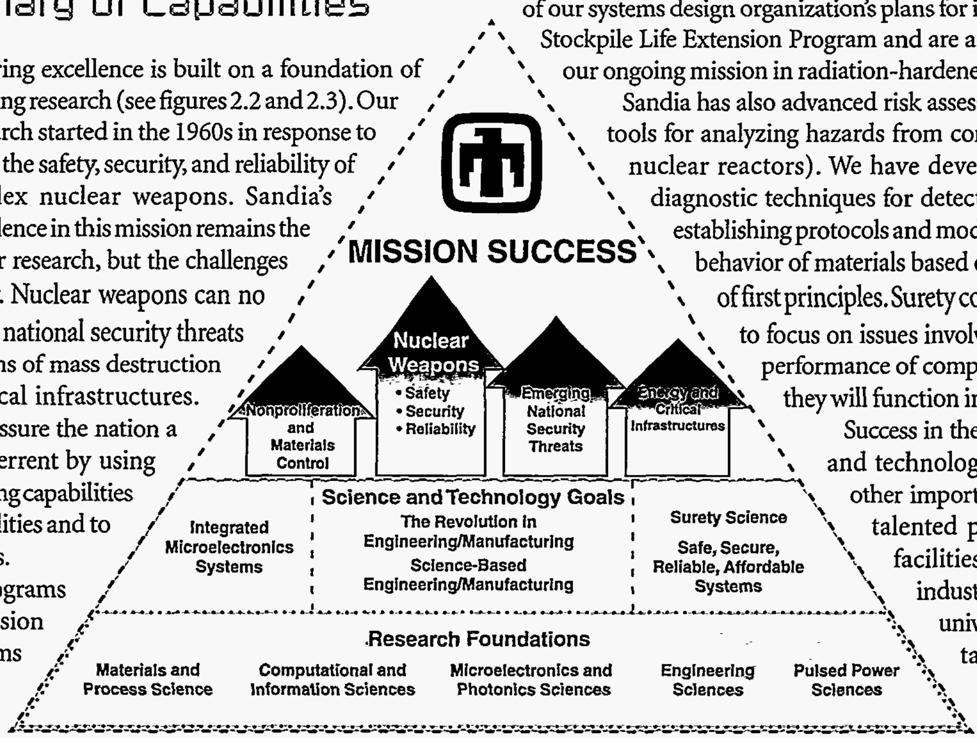


Figure 2.2. Science and technology: our foundation for success.

2.5 Research Foundations

Sandia addresses technical issues of critical national importance. To assure that the solutions we provide are both innovative and sound, we sustain areas of scientific depth that provide technical excellence in various disciplines. This ensures each discipline a "critical mass" of experts to test new ideas and attract new talent to

Sandia. These research foundations, which differentiate Sandia from universities and many other federal laboratories, are

- materials and process science,
- computational and information sciences,
- microelectronics and photonics sciences,
- engineering sciences, and
- pulsed power sciences.

2.5.1 Materials and Process Science

Sandia's research foundation in materials and process science provides the scientific basis for technical options and decisions about polymers, ceramics, and metals in nonnuclear components for the stockpile. Our decisions include estimating times for component replacement, choosing replacement materials, and determining the means of manufacturing replacement components. We synthesize and process materials and select methods of determining the resultant microstructure and chemical composition. Our goal is to quantitatively determine materials properties of importance and understand how these properties change with time.

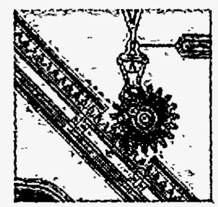
Three major types of research subprograms support this research foundation: scientifically tailored materials, materials processing, and materials aging and reliability. The scientifically tailored materials subprogram addresses the need for materials with specific properties or performance characteristics for use in the enduring stockpile. We seek to understand how the materials' properties depend on composition and microstructure. The materials processing subprogram seeks to understand new and existing processes anticipated to be critical for DOE Defense Programs needs. Emphasis is on the means of processing and on faster fabrication of parts, with fewer defects and at lower cost. The materials aging and reliability subprogram is identifying the chemical and physical mechanisms that cause materials properties to change with time. Mechanisms involve both the intrinsic thermodynamic drivers associated with the materials and extrinsic drivers associated with the environments in which the materials are used. The results from this subprogram become the basis for quantitative predictions of component reliability as a function of time in the stockpile.

2.5.2 Computational and Information Sciences

Sandia's research foundation in computational and information sciences develops technology that will revolutionize engineering. Tremendous increases in supercomputing capabilities are needed to analyze complicated accident scenarios, to monitor and assess weapons components and systems, to predict the aging of key stockpile materials, and to design replacement components as warranted. We are developing the base technology that the Accelerated Strategic Computing Initiative and other weapons programs will use to ensure the safety and reliability of the stockpile.

An important area is development of new mathematical methods, algorithms, and software tools. Developmental efforts range from discovery of new methods for meshing and load balancing to the creation of immersive visualization environments. Such work has won national awards and major patents and has led to numerous commercial licenses. Sandia and Intel researchers have set world records for computational speed. A broad range of massively parallel applications is also being developed. Areas of importance include shock physics, chemically reacting flows, electromagnetics, the computer design of materials, and materials aging.

Heterogeneous computing techniques are being developed to allow interaction over long distances. Emphasis is placed on high-speed networking, storage systems, encryption, and scalable operating systems. Sandia's initiative in distributed computing will provide the basis for next-generation computing at faster speeds. We anticipate that computing at this level will require greater use of high-volume commodity building blocks. Furthermore, such computers will be constructed over greater lengths of time, leading to more heterogeneous systems than in the past. Sandia is now prototyping such a "computational plant," portions of which are located in New Mexico and California.



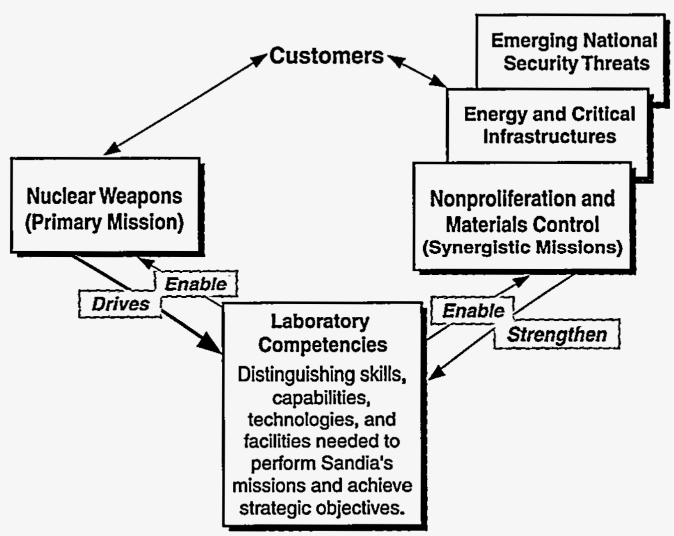


Figure 2.3. Sandia's business model.

2.5.3 Microelectronics and Photonics Sciences

Sandia's research foundation in microelectronics and photonics provides the underlying science and technology to ensure state-of-the-art implementation of Sandia's electronics systems. This research foundation includes activities ranging from fundamental solid-state physics to the design and fabrication of radiation-hardened integrated circuits and integrated microsystems. It includes the complete computer-aided design, fabrication, testing, packaging, and reliability infrastructure necessary to transition research concepts into qualified products. Continued advancement of radiation-hardened technologies, microelectromechanical systems, sensors, and optoelectronics remains a driving element of our microelectronics and photonics sciences.

In 1996 Sandia identified a major strategy for electronics centered on creating the small, low-power, high-functionality devices called integrated microsystems. These devices use integrated circuit fabrication technology to put many functions (including processing electronics, sensors, communication devices, and microelectromechanical systems) on a single substrate or in very small multichip modules. An external review committee of experts in microtechnologies from industry, universities, and other federal laboratories reviewed Sandia's microtechnology capabilities in April 1998 and concluded that we have unique capabilities to realize integrated microsystems and are recognized leaders in this emerging field. Consequently, Sandia's microelectronics and photonics sciences are organized to support the major technologies for integrated microsystems—silicon microelectronics, sensors, microelectromechanical systems, and compound semiconductor devices—along with the associated infrastructure.

2.5.4 Engineering Sciences

Sandia's research foundation in engineering sciences is focused on Sandia's revolution in engineering and manufacturing. The engineering sciences imperative is the creation of model- and simulation-based life-cycle engineering. Life-cycle engineering is a comprehensive and validated modeling and simulation environment that provides "cradle-to-grave" stewardship of nuclear weapons. This concept is changing the way we engineer products, from a test-driven process supported by limited computational modeling to a computation-driven process supported by computational modeling and simulation. The process is led and validated by fundamental experiments and laboratory-determined material behavior.

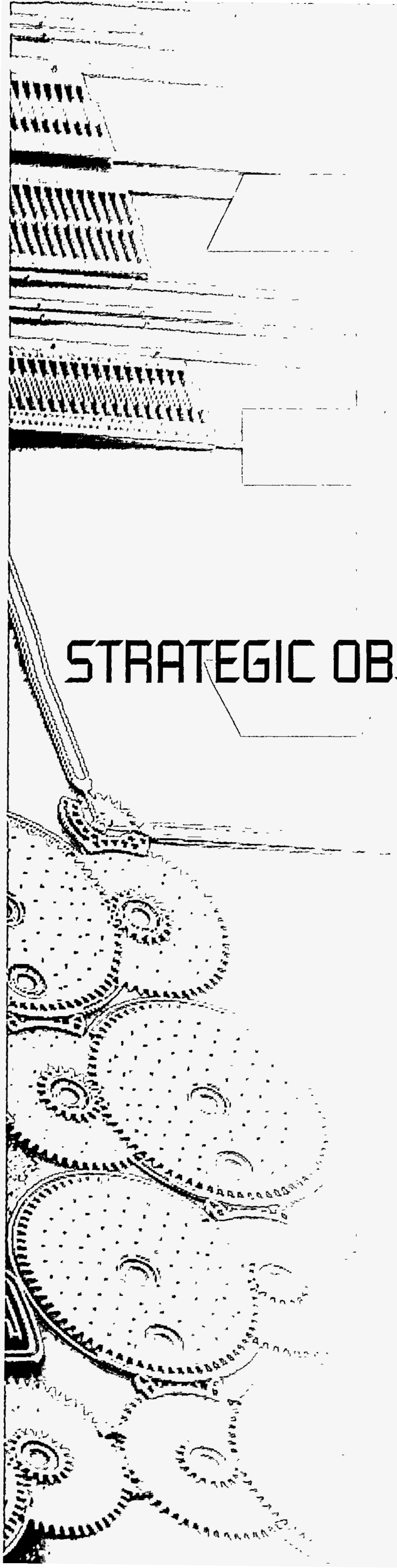
Sandia's engineering sciences support a core research activity that ensures the highest caliber of engineering simulation and analysis in support of our mission. Sandia provides national leadership in the engineering sciences research community, commensurate with our strong engineering identity. We foster mission-oriented research that includes experimental creativity, physical model development, and new computational capability in aerosciences, fluid mechanics, thermal sciences, reactive processes, solid mechanics, material mechanics, structural dynamics, computational technologies, uncertainty quantification, and electrical engineering/electromagnetics. Sandia's engineering sciences work closely with the combustion research program, which combines computational and experimental work that integrates numerous disciplines and component technologies; the energy and environment program, which drives innovative technology; and the geosciences research program, which uses a combination of closely related experimental, analytic, and theoretic techniques.

2.5.5 Pulsed Power Sciences

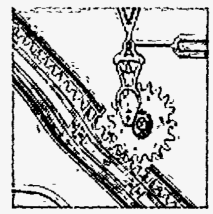
Sandia's research foundation in fast pulsed power technology applies innovative technological advances to problems of national importance in conjunction with other DOE laboratories, US industry, and universities. Sandia supports science-based stockpile stewardship by providing radiation environments to certify survivability of strategic systems in the stockpile and support DOE initiatives such as the Stockpile Life Extension Program. The large-volume, high-temperature, high-energy-density environments uniquely generated with pulsed power are key contributors to weapon physics research and experimentation. These capabilities are especially critical in the absence of underground nuclear testing for certification of weapon survivability and performance. The inertial confinement fusion objectives of evaluating high-energy-density environments and developing high-yield fusion laboratory capabilities for DOE Defense Programs will be advanced by using pulsed power to drive z-pinch sources.

During the past year, Sandia's Z Accelerator (formerly the modified Particle Beam Fusion Accelerator) has used our z-pinch technology to make history by producing world-record x-ray outputs. These z-pinch high-energy-density environments can now be cost-effectively applied to stockpile surety concerns ranging from the simulation of weapons effects to the assessment of weapon physics calculations, including the exploration of nuclear fusion reactions. The advanced hydrodynamic radiography objectives of generating a high-brightness, compact x-ray source for DOE Defense Programs will be advanced using pulsed power to drive a magnetically immersed bremsstrahlung source.

We apply efficient, high-average-power sources of x-ray, electron, and ion beams to defense-related missions of materials hardening, environmental remediation, and materials welding and joining. In partnership with industry and universities, we will also apply these capabilities to materials surface modification, electronic pasteurization of food and pharmaceuticals, sterilization of medical instruments and medical wastes, and repetitive electromagnetic force. Pulsed power technology will remain a critical but specialized capability for DOE Defense Programs missions.



STRATEGIC OBJECTIVES



Sandia's annual planning process ensures integration and alignment of all our planning elements, including the strategic plan, strategic objectives, institutional plan, and operating plan. Sandia's Strategic Plan 1997[1] is aligned with the DOE Strategic Plan[2] and also aligns with other planning documents such as the DOE Albuquerque Operations Office Plan[3] and other relevant DOE program guidance and direction. Alignment with the DOE's strategies was confirmed at the DOE Onsite Review in August 1996 and again in October 1997. Because of the significant amount of work that Sandia conducts for agencies and organizations outside the DOE, the Sandia planning process also accounts for some non-DOE goals and objectives (consistent with Sandia's DOE mission assignments and technology base).

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[1] *Sandia Strategic Plan 1997.* SAND98-0500. Albuquerque, NM: Sandia National Laboratories.

[2] *U.S. Department of Energy Strategic Plan.* 1997. Electronic version available at http://www.doe.gov/doeplan.html

[3] *U.S. Department of Energy Albuquerque Operations Office Strategic Plan: Fiscal Year 1997 Update.* Copies on file at US DOE/AL, Albuquerque, NM.

During the 1998 annual planning process Sandia used a number of DOE documents as well as knowledge of current DOE program plans and directions. The "Green Book"[4] was an essential driver for the DOE Defense Programs sections of this plan. Over the past few years Sandia has also contributed to and reviewed the DOE Laboratory Operations Board Missions Plan.[5] Sandia has also reviewed and contributed to the DOE Strategic Plan, and our strategic objectives are consistent with this plan (see Table 3.1).

As a formally designated federally funded research and development center, Sandia provides engineering and science to ensure the security of our nation. Therefore, Sandia develops technology that responds to a wide range of national security threats.

We also apply Sandia's capabilities to specific needs of other federal agencies and private concerns. We remain alert to opportunities that could lead to technologies or new capabilities that meet our customers' needs and simultaneously enhance our ability to perform our national security mission.

In 1998 Sandia's executive management revamped Sandia's Strategic Plan by revising the specific implementing goals and strategies (for the three- to five-year time frame) that support the eight strategic objectives: four primary *whats* (see sections 3.1 through 3.4 below) and four supporting *hows* (see sections 3.5 through 3.8 below). Sandia's strategic objectives are the highest-level statement of the long-term objectives that will guide our future decisions. These objectives identify our areas of strategic focus but are not intended as an all-inclusive list of Sandia's programs. As in years past, these implementing goals are also supported by sets of specific operational goals and milestones for FY 1999 (see chapter 4). We also have developed a set of key business results that we use to measure our success in areas such as revenues, customer satisfaction, and cost reduction.

The first four strategic objectives below address *what* we will accomplish during the next ten years. These strategic objectives demonstrate the nature of our work and will guide our allocation of resources. At the end of sections 3.1 through 3.4, these first four strategic objectives are referenced to major programmatic activities, which continue to be organized by DOE Budget and Reporting Code. The references are given at a level commensurate with the chapter 6 program descriptions.

[4] *U.S. Department of Energy Stockpile Stewardship Plan: Second Annual Update (FY 1999)*. 1998.

[5] *Strategic Laboratory Missions Plan—Phase I: Volume I and Volume II (Mission Activity Profiles)*. Laboratory Operations Board, US DOE. 1996. Copies available from Office of Public Affairs, US DOE, 1000 Independence Avenue SW, Washington, DC (electronic version available at http://vm1.hqadmin.doe.gov:80/seab/aboutpln.html).

3.1 Nuclear Weapons: Our Primary Mission

Sandia's primary mission is to ensure that the nuclear weapons stockpile is safe, secure, reliable, and fully capable of supporting our nation's deterrence policy. Together with Los Alamos and Lawrence Livermore national laboratories, Sandia is accountable for two critical elements of nuclear deterrence: the nuclear weapons stockpile and the expertise that ensures the stockpile remains safe, secure, and reliable. We honor that accountability by

- providing leadership for the nation in setting and meeting the highest standards for surety (safety, security, and reliability) of the nuclear weapons stockpile;
- being the systems integrator for our DOE and DOD customers and our laboratory and production facility partners in planning and executing the work of sustaining the stockpile;
- maintaining the vitality and effectiveness of our scientific and engineering capability and the expertise we need to perform our nuclear weapons mission; and
- providing our customers with technical options to assess and respond to changes in the global nuclear threat.

For descriptions of programmatic work related to this objective, see the following sections of chapter 6:

6.1.1 Assistant Secretary for Defense Programs (DP)
6.1.1.1 Core Stockpile Stewardship Programs (DP0101)
6.1.1.2 Inertial Confinement Fusion (DP02)
6.1.1.3 Technology Transfer and Education (DP03)
6.1.1.4 Core Stockpile Management Programs (DP0401)
6.2 Work for Non-DOE Entities
6.3 Laboratory Directed Research and Development Program

3.2 Nonproliferation and Materials Control

We will reduce the vulnerability of our nation to threats of proliferation, use of weapons of mass destruction, nuclear incidents, and environmental damage. This objective is synergistic with our nuclear weapons mission. We will

- support national needs for treaty verification and nonproliferation with innovative and affordable technology and system solutions;

Table 3.1. Comparison of Sandia Strategic Objectives and DOE Business Lines

Sandia Strategic Objectives	DOE Headquarters Strategic Plan Business Lines
Nuclear Weapons Responsibilities Our primary mission is to ensure that the nuclear weapons stockpile is safe, secure, reliable, and fully capable of supporting our nation's deterrence policy. Nonproliferation and Materials Control We will provide national leadership and key technologies that reduce the vulnerability of the US to threats of proliferation, use of weapons of mass destruction, [and] nuclear incidents. Emerging National Security Threats We will develop high impact responses to emerging national security threats.	National Security "effectively support and maintain a safe, secure, and reliable enduring stockpile without nuclear testing, safely dismantle and dispose of excess nuclear weapons, and provide technical leadership for national and global nonproliferation and nuclear safety activities"
Energy and Critical Infrastructures We will enhance the surety (safety, security, and reliability) of energy and other critical infrastructures.	Energy Resources "assure adequate supplies of clean energy, reduce US vulnerability to supply disruptions, encourage efficiency and advance alternative and renewable energy technologies, and increase energy choices for all consumers." National Security Initiate "correction of DOE infrastructure vulnerabilities identified by the President's Commission on Critical Infrastructure Protection." 
Science and Technology We will pursue "science with the mission in mind" and apply the new knowledge to solve our customers' technical problems.	Science and Technology "use the unique resources of the Department's laboratories and the country's universities to maintain leadership in basic research and technology development in support of the Department's other business lines, contribute to the nation's science and mathematics education, and deliver relevant scientific and technology information."
Partnerships To succeed in our increasingly complex and highly dynamic missions and produce the most for the taxpayers' dollars, we will maximize our beneficial use of strategic partnerships.	Energy Resources "Cooperate with foreign governments and international institutions" National Security "Establish strategic alliances and collaborations" Science and Technology "Pursue technology research partnerships with industry, academia and other government agencies"
Nonproliferation and Materials Control We will provide national leadership and key technologies that reduce the vulnerability of the US to threats of ... environmental damage.	Environmental Quality "reduce the environmental, safety, and health risks and threats from DOE facilities and materials, safely and permanently dispose of civilian spent nuclear fuel and defense-related radioactive waste, and develop the technologies and institutions required for solving domestic and international environmental problems."
People We will apply excellence as our standard for attracting people to join and remain at Sandia and for measuring the performance of teams and individuals. Infrastructure We will create an infrastructure that operates as a system and is a differentiating advantage for our strategic objectives. Business Results We will achieve mission success and provide exceptional service in the national interest. One measure of this will be to successfully attain critical business results.	Corporate Management Human Resources Communication and Trust Environment Safety and Health Management Practices

Sandia provides advanced technologies and systems solutions to support DOD missions.

- use technology and analysis in pursuit of stable international nuclear relationships to secure special nuclear materials, especially in the former Soviet Union; develop means to monitor nuclear weapons activities effectively and affordably; and support regional security initiatives;
- extend and apply our technology and analysis to threats involving chemical and biological weapons;
- advance realistic solutions to our nation's legacy of nuclear weapons waste and related environmental problems and work to apply this research and technology globally; and
- be a significant provider of science and technology solutions to assess evolving national threats.

For descriptions of programmatic work related to this objective, see the following sections of chapter 6:

6.1.2 Office of Fissile Materials Disposition (GA)

6.1.3 Office of Nonproliferation and National Security (NN)

6.1.3.1 Nonproliferation and Verification Research and Development (GC)

6.1.3.2 Nuclear Safeguards and Security (GD)

6.1.3.3 Arms Control and Nonproliferation (GJ)

6.1.3.4 Material Protection, Control, and Accounting (GJ)

6.1.3.5 Initiatives for Proliferation Prevention (GJ)

6.1.3.6 Intelligence (NT)

6.1.4 Assistant Secretary for Environmental Management (EM)

6.1.6 Office of Civilian Radioactive Waste Management

6.3 Laboratory Directed Research and Development Program

3.3 Energy and Critical Infrastructures

We will enhance the surety (safety, security, and reliability) of energy and other critical infrastructures. We will "wage peace" by identifying threats, developing technologies to mitigate them, proposing alternative solutions, and supporting the DOE and other agencies in responding to these threats. We will develop surety system solutions that protect the nation's critical infrastructure and enhance our national security. These solutions will address the increasing interdependency among the domestic and global infrastructure elements, and our dependence on information systems and energy availability. These solutions will also address the reliability of the supply, distribution, and end use of energy and other critical commodities and services, and their related environmental quality issues such as air and water pollution.

We will develop and apply system solutions for the nation in order to provide

- energy surety by revitalizing energy science and technology in the fossil, renewable, and nuclear energy areas (spanning energy supply, distribution, and end use) and by synergy with the nation's energy efficiency, environmental, and global climate change policies;
- transportation surety by increasing the safety and security of high-consequence mass transportation systems such as aviation and high-speed rail;
- civilian physical surety in the areas of high-consequence events (such as loss of life, loss of water supplies, and disruption of essential services) through coordinated federal, state, local, and private efforts;
- information surety, emphasizing energy, telecommunications, banking and finance, vital human services, and continuity of government; and
- surety of complex systems by identifying critical nodes of interdependencies, defining threats and vulnerabilities, and developing solutions that provide a timely response to attack or system failure.

We will also

- become a sought-after national resource in energy and critical infrastructures public policy development by contributing to the national debate on energy and critical infrastructures surety, thus helping shape national priorities and developing a constituency for Sandia surety; and
- enhance the role of science and technology in energy and critical infrastructures by developing capabilities in the areas of first-principle theoretic understanding, simulation science, and science-based validation methods for development of new surety technologies.

For descriptions of programmatic work related to this objective, see the following sections of chapter 6:

6.1.4 Assistant Secretary for Environmental Management (EM)

6.1.5 Assistant Secretary for Energy Efficiency and Renewable Energy (EE)

6.1.7 Office of Nuclear Energy

6.1.8 Assistant Secretary for Fossil Energy

6.1.9 Office of Energy Research Science and Technology Programs

6.2.3 Department of Transportation

6.2.6 Environmental Protection Agency

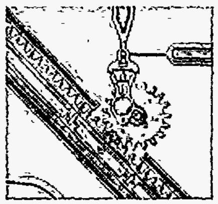
6.2.7 Other Federal Agencies

6.3 Laboratory Directed Research and Development Program

3.4 Emerging National Security Threats

We will develop high-impact responses to emerging national security threats. We will apply our differentiating scientific and technological strengths to provide our nation with advanced technologies and systems solutions. We will

- develop technologies and systems to combat terrorism at each stage of the threat;
- support counterproliferation by developing systems solutions to locate, deter, and defeat the production, storage, and delivery of weapons of mass destruction (this includes activities related to hardened, deeply buried structures and time-critical, movable targets);
- provide systems for the DOE and other agencies to deter the use and mitigate the effects of chemical and biological weapons;



- provide technology to help the DOD achieve superiority in information operations, including distributed command and control systems for battlefield awareness;
- provide superior warfare technologies via advanced sensor systems that collect, process, and disseminate precise battlefield information;
- develop systems to mitigate the war-fighting capability and the deadly legacies of leftover ordnance of all types (such as mines and residual biological and chemical warfare agents); and
- develop technologies to support distributed, collectively intelligent systems for application to distributed in situ monitoring, distributed deterrents for fixed and mobile site security, sensor arrays to detect mobile weapons of mass destruction, intelligence gathering, distributed battlefield command and control, battlefield sensor arrays, chemical/biological sensors, mine removal operations, and multiple unmanned aerial and space vehicles.

We will also contribute to technologically superior military systems solutions for the DOD. We will apply our scientific and technological capabilities to create system-level innovations that provide advantages over adversaries in critical areas such as advanced sensor systems, advanced conventional weapons, military space and ballistic missile defense, and the use of intelligent and robotic systems for military operations.

For descriptions of programmatic work related to this objective, see the following sections of chapter 6:

6.2 Work for Non-DOE Entities

6.2.1 Department of Defense

6.2.2 Nuclear Regulatory Commission

6.2.3 Department of Transportation

6.2.4 National Aeronautics and Space Administration

6.2.5 Department of State

6.2.6 Environmental Protection Agency

6.2.7 Other Federal Agencies

6.2.8 All Other Reimbursables

6.3 Laboratory Directed Research and Development Program

To achieve the above four strategic objectives, Sandia will use the following four "how we will do it" strategic objectives that highlight our businesslike approaches. We will focus on improving internally and integrating our internal support with our technical efforts to meet our customers' needs.

3.5 People

We will hire the very best people and provide them with opportunities to contribute to their greatest potential. We will apply excellence as our standard for attracting people to join and remain at Sandia and for measuring the performance of teams and individuals. We will

- provide challenging work in an environment that is safe and fair and embodies our corporate values;
- hold ourselves accountable for performing our work to the best of our abilities and encouraging ideas that improve work content, work processes, and the workplace itself;
- obtain the new skills that we will need by hiring new employees and retraining current employees and by selecting and teaming these employees to foster rapid progress;
- challenge our employees to improve their knowledge and skills and their ability to meet changing priorities; and
- encourage innovation and creativity to fulfill our customers' requirements.

3.6 Science and Technology

We will pursue "science with the mission in mind" and apply the new knowledge to solve our customers' technical problems. We will

- be the best of the best in key science and technology areas needed to ensure mission success;
- enhance and integrate our theoretic simulation and validation capabilities to lead a revolution in engineering design and manufacturing;
- discover, develop, and validate new techniques to assure predictable performance of complex systems in normal and abnormal environments; and
- develop integrated microsystems to provide safe, secure, reliable, and affordable components to enhance national security.

3.7 Sandia Infrastructure

We will create an infrastructure that operates as a system and is a differentiating advantage for our strategic missions. The infrastructure system will

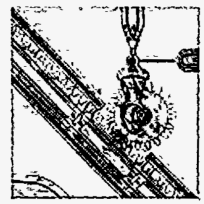
- increase resources available for business-unit work by reducing cycle time for product and service delivery and by improving the overall cost effectiveness of mission work;
- create an environment that attracts and retains a work force suitable for world-class missions;
- enhance Sandia's reputation as a national security laboratory; and
- support Sandia's present missions and prepare for our future missions.

3.8 Partnerships

To succeed in our increasingly complex and dynamic missions and produce the most for the taxpayers' dollars, we will maximize our beneficial use of strategic partnerships by

- pursuing long-term strategic partnerships in industry segments that engage in similar technological developments, partnering through consortia whenever feasible;
- creating strategic relationships with universities to further our research programs, help us recruit the very best technical talent, support science and engineering education, and help undergird our nation's science and engineering infrastructure;
- collaborating with other government laboratories to apply the world's best technical talent to solve major challenges to our nation;
- developing strategic international collaborations that strengthen our mission-related science and technology;
- increasing our visibility as a national laboratory with our industrial, academic, and political constituencies; and
- leading the development of a science and technology park near us to improve our opportunities for local, national, and international partnering.

LABORATORY GOALS AND MILESTONES FOR FISCAL YEAR 1999



4.1 Goals and Milestones for FY 1999

Sandia's FY 1999 goals and milestones have been developed based on linkage with the eight strategic objectives (see chapter 3) and on input received from customers and stakeholders. This section includes DOE Appraisal Agreement goals, where applicable.

4.1.1 Nuclear Weapons

We will meet all negotiated stockpile and production commitments by

- certifying the MC4380 neutron generator design,
- completing the first production unit for the W87 Life Extension Program,
- completing revalidation of the W76 weapon,
- conducting approximately 110 surveillance tests, and
- publishing the President's Annual Certification Report.

We will sustain a strong science and technology base, maximizing its impact on improving the stockpile and modernizing the nuclear weapons complex by establishing a distance-computing connection to Lawrence Livermore National Laboratory's initial implementation of the Accelerated Strategic Computing Initiative and defining computational grid architecture for the nuclear weapons complex.

We will create a revolution in engineering and manufacturing by developing and applying processes for integrating Accelerated Strategic Computing Initiative, Advanced Design and Production Technologies Initiative, and advanced manufacturing technology advances into specific stockpile support projects.

We will implement a predictive approach to stockpile surveillance that will use our research and development strengths to selectively assess stockpile surety and drive the Stockpile Life Extension Program. Sandia will coordinate and complete an integrated ten-year plan for development and implementation of instrumented flight vehicles and enhanced-fidelity joint test assemblies in partnership with the DOE and Lawrence Livermore and Los Alamos national laboratories.

We will apply the Z Accelerator to nuclear weapons program research in partnership with Los Alamos and Lawrence Livermore national laboratories while continuing to pursue high fusion yield. After receipt of Critical Decision One, we will initiate conceptual design of the X-1 Advanced Radiation Source.

We will develop and evaluate technology options for transparency, accounting, and protection of nuclear warheads declared excess to US and foreign nuclear stockpiles.

The DOE will review a subset of Sandia's nuclear weapons programs during FY 1999. Areas scheduled for review include the Stockpile Stewardship Program, the Reconfiguration Program, and the Stockpile Life Extension Program Weapon Retrofit. Criteria for the DOE review will be the quality of science, technology, and

Reentry trails from a W87/Mark 21 joint test assembly exercise.

engineering; programmatic performance, management, and planning; relevance to national needs and agency missions; and performance in the operation and construction (if applicable) of major research facilities.

4.1.2 Nonproliferation and Materials Control

This Sandia objective will reduce the vulnerability of the United States to threats of proliferation and use of weapons of mass destruction, nuclear incidents, and environmental damage.

4.1.2.1 Treaty Verification and Nonproliferation Technology

We will expand the national capability for early detection and characterization of proliferation activities through innovative application of satellite, aircraft, and ground-based multispectral light detecting and ranging (lidar) and microsensor technologies. Specifically, we will complete multithermal imager satellite payload-to-bus integration.

4.1.2.2 Materials Management and International Cooperative Measures

We will use Sandia's physical security and system experience to deploy materials protection, control, and accounting systems worldwide. Specifically, we will develop joint demonstrations of materials security systems with Russia by

- completing a magazine-to-magazine demonstration,
- completing a joint evaluation of a US/Russia demonstration, and
- reaching an initial agreement for a weapons transparency monitoring demonstration.

We will develop international partnerships for in-depth collaboration and cooperative monitoring demonstrations, with emphasis on regions of high proliferation. Specifically, we will

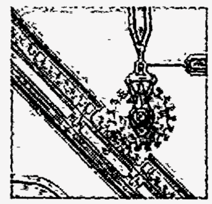
- complete agreement on an initial demonstration with Japan and South Korea, and extend collaboration with China via an agreement for a joint technical project with a Chinese institute; and
- complete a cooperative monitoring center plan with the Defense Threat Reduction Agency for joint work on regional security issues.

4.1.2.3 Chemical and Biological Nonproliferation

We will assume the lead for at least one (and possibly two) of the four domestic demonstration and application programs planned in the current growth proposal for chemical and biological nonproliferation by solidifying the systems integration lead role for the Infrastructure Protection and the Domestic Demonstration Application programs.

4.1.2.4 Waste Legacy

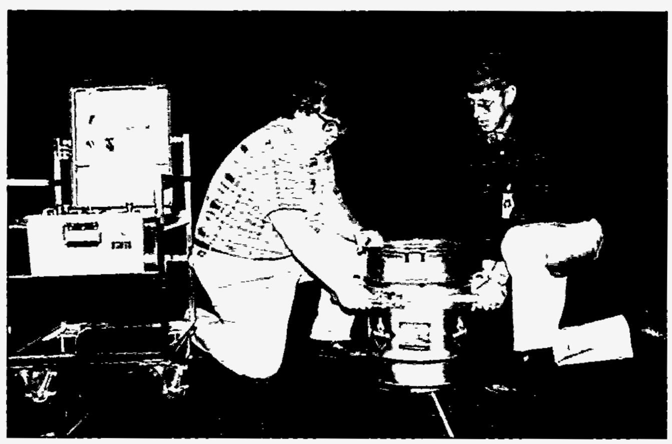
We will finish our physical cleanup by FY 2001 by completing Phase II construction of the Corrective Action Management Unit as a critical indicator of our progress. We will release the last site for mission use in FY 2002.



4.1.2.5 Physical Security

We will develop physical security projects with the DOE to protect nuclear and other vital assets. Specifically, we will provide security assistance to at least four DOE sites in the areas of strategic planning, security technology, and implementation.

The DOE will review a subset of Sandia's nonproliferation and materials control programs during FY 1999. Criteria for the DOE review will be the quality of science, technology, and engineering; programmatic performance, management, and planning; relevance to national needs and agency missions; and performance in the operation and construction (if applicable) of major research facilities.



Sandians John Brozek and Don Dietz check a tritium reservoir shipping container, a physical security device developed at Sandia.

4.1.3 Energy and Critical Infrastructures

This Sandia objective will enhance the surety (safety, security, and reliability) of energy and other critical infrastructures.

4.1.3.1 System Expertise

We will become a recognized center of excellence for infrastructure surety system solutions by increasing Energy and Critical Infrastructures revenues and receiving funding from at least five new customers.

4.1.3.2 National Public Policy Resource

We will become a national resource in the public policy development process by establishing the Institute for Surety Science and Engineering.

4.1.3.3 Science and Technology

We will become the provider of choice of science and technology (information sciences and experimentally validated simulation) that underpins the surety of energy and other targeted infrastructures and anticipates future infrastructure problems that could compromise our nation's security. Specifically, we will

- secure a leadership role and a new initiative in the DOE Strategic Simulation Initiative, uniting various national laboratories and DOE offices; and
- complete facility modifications, obtain Food and Drug Administration approval for producing molybdenum 99, and complete production readiness.

The DOE will review a subset of Sandia's energy programs during FY 1999. The Medical Isotopes and Photovoltaics programs are scheduled for review. Criteria for the DOE review will be the quality of science, technology, and engineering; programmatic performance, management, and planning; relevance to national needs and agency missions; and performance in the operation and construction (if applicable) of major research facilities.

4.1.4 Emerging National Security Threats

This Sandia objective will develop high-impact responses to emerging national security threats by applying Sandia's differentiating scientific and technological strengths to provide our nation with advanced technologies and systems solutions.

4.1.4.1 Strategic Business Area Growth

We will increase funding by developing roadmaps for program area technology needs and communicating them to Sandia technology development sponsors.

4.1.4.2 Combating Terrorism

We will become the supplier of choice for customers looking for high-technology solutions for countering terrorism. Specifically, we will

- secure a leadership role for Sandia in the DOE Domestic Demonstration Application Program in conjunction with the chemical and biological defense program area, and
- extend our alliance with the Federal Bureau of Investigation to include forensic sciences.

4.1.4.3 Superior Technical Accomplishments

We will develop superior technical solutions to meet the needs of our DOD customers by

- successfully deploying target objects for the Integrated Flight Test series sponsored by the National Missile Defense Program Office in the Ballistic Missile Defense Organization; and
- successfully demonstrating the performance of an interferometric terrain-aided guidance system.

4.1.5 People

We will establish partnerships with universities and education entities that enable Sandia to attract and retain people and provide science and technology capabilities attractive to our customers. We will do this by implementing a five-year management plan that identifies strategies for attracting, retaining, and inspiring our future work force.

We will support organizational structures built around work that fulfills customer requirements. We will design human resources business rules and streamlined, agile systems that support rapid deployment of people to meet shifting internal and external requirements by implementing the reengineered human resources portion of the PeopleSoft/Oracle enterprise.

We will ensure that Sandia managers model attributes for engendering trust and commitment, and that will help create a work environment inspiring excellence and innovation. Specifically, we will

- implement a cost-effective employee opinion survey to assess our work environment and productivity; and
- analyze results, establish baseline measures, and make recommendations that support a trusting work environment.

4.1.6 Science and Technology

We will sustain a creative research environment generating breakthroughs that greatly enhance opportunities for Sandia to serve the nation. Specifically, we will

- complete validation plans for the major Accelerated Strategic Computing Initiative code groups (mechanics, electromagnetic radiation transport, and shock physics) that provide the basis for all submodel physics experimental validation activities;
- establish and maintain national leadership in high-end computing using distributed computing systems;
- advance the science of double quantum well tunneling for microelectronics applications and demonstrate a room-temperature quantum transistor; and
- demonstrate predictive reliability through creation of scientific models for materials interface performance (polymer/solid and metallization/ceramic adhesion).

We will also build the first three-axis accelerometer prototypes in direct support of the Micronavigator Program.

The DOE will review a subset of Sandia's science and technology programs and capabilities during FY 1999. Scheduled for review are the Microelectronics and Photonics, Material and Process Sciences, Engineering Science, and Combustion Research programs.

Criteria for the DOE review will be the quality of science, technology, and engineering; programmatic performance, management, and planning; relevance to national needs and agency missions; and performance in the operation and construction (if applicable) of major research facilities.

4.1.7 Sandia Infrastructure

4.1.7.1 Integrated Risk Management

We will know our work, understand the risks associated with our work, and effectively manage those risks by

- completing the first full cycle of our Integrated Safety Management System, including feedback and improvement for each activity and facility covered by a primary hazard screen; and
- ensuring that the CY 1999 days-away case rate is at least 10 percent less than that for CY 1998.

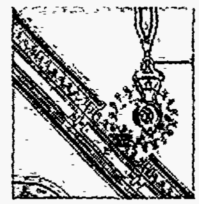
4.1.7.2 Information

We will develop and sustain an advanced integrated information and distributed information system that enables twenty-first century engineering and dramatically reduces the time and cost of management and administrative tasks. Specifically, we will implement the Oracle data base business systems conversion within budget and on schedule. In addition, we will implement year 2000 (Y2K) computer solutions for all critical Sandia information systems.

4.1.7.3 Space

We will plan for, acquire, configure, utilize, maintain, renovate/modify, and dispose of buildings, utilities, and facilities in accordance with Sandia's strategic business needs. Specifically, we will

- move sixty people and their associated laboratories and auxiliary functions out of temporary and substandard space in support of corporate mission requirements (Joint Computational Engineering Laboratory) and the demolition program;



- move one hundred people and auxiliary functions to support the Model Validation and System Certification Test Center; and
- reduce the facilities operations and maintenance restoration backlog from approximately $14 million to approximately $8 million by completing $6 million of critical/important facilities equipment/systems restoration projects.

The DOE will review Sandia operations support in the areas of environment, safety and health; environmental restoration and waste management; and safeguards and security operations.

Review criteria will be based on high-level objectives and measures that make evident our ability to protect people, protect the environment, protect information and special nuclear materials, meet all regulatory compliance requirements, and demonstrate sound management practices.

4.1.8 Partnerships

We will pursue long-term strategic partnerships with industries that engage in similar technological developments, partnering through consortia whenever feasible. Specifically, we will

- assist strategic business unit owners in achieving a total of $70 million in nonfederal entity funds-in—with at least $7 million from major aerospace/defense companies ($5 million from Lockheed Martin Corporation companies and $2 million from others) and at least $17 million from companies that license Sandia technology (including $2 million of license/royalty funds);

- develop (in cooperation with all the strategic business units and strategic management units) a strategic business planning standard and prototype a marketing plan (including intellectual property deployment strategies) for at least one technical area in each strategic business unit and strategic management unit; and
- cooperate with Technology Ventures Corporation to form at least ten new New Mexico ventures and two hundred new technical assistance projects with small businesses.

We will collaborate with other government laboratories to apply the world's best technical talent to solve major challenges to our nation. Specifically, we will develop cooperative mechanisms for partnerships among industry, the DOE, other DOE laboratories, other government agencies, and the international scientific community to solve selected critical infrastructure issues.

We will increase our visibility as a national laboratory with our industrial, academic, and political constituencies by developing and executing a minimum of two technology expositions that target our industrial, government agency, or political constituencies.

We will lead the development of a science and technology park near Sandia/New Mexico to improve our opportunities for local and national partnering. Specifically, we will get at least five key companies committed to locate at the Sandia Science and Technology Park for the purpose of increased interaction with us.

The DOE will review Sandia's Technology Commercialization Program and Work for Others Management Program during FY 1999. Criteria for the DOE review will be the quality of science, technology, and engineering; programmatic performance, management, and planning; relevance to national needs and agency missions; and performance in the operation and construction (if applicable) of major research facilities.

4.2 Metrics

We will achieve external customer satisfaction ratings of 9.0 or greater in the key customer and program/project customer categories.

We will continue to improve internal customer satisfaction relative to FY 1998 levels of internal customer satisfaction ratings.

We will continue to achieve a score of "outstanding" on the DOE multiprogram quarterly review.

We will increase total revenue at a growth rate equal to or greater than inflation (3 percent) in accordance with revenue targets and accountability negotiated with each strategic business unit and strategic management unit. We will meet or exceed our fee and earnings before income tax.

We will generate nonfederal entity revenue of $70M in FY 1999.

We will set annual indirect targets (center support, general and administrative, and site support cost pools) to achieve a goal less than or equal to 25 percent of total operating costs. Specifically, we will target center support costs at $117 million and general and administrative/site support costs at $256 million for total indirect costs of $373 million in FY 1999.

We will expand community outreach programs that enhance recognition of Sandia's efforts by increasing participation in volunteer programs and increasing our media exposure.

The DOE will review high-level corporate management areas that demonstrate Sandia's ability to develop, deploy, and manage corporate-wide leadership, planning, and relationships with customers and the community while making effective use of corporate-level data and information to support decision making. Two new areas will be included in this high-level review for FY 1999: Effective Resource Management and the Supplier Partnerships Program.

SANDIA ACCOMPLISHMENTS FOR FISCAL YEAR 1998

The accomplishments described in this chapter were considered completed during the 1998 fiscal year.

5.1 Nuclear Weapons

Sandia's nuclear weapons program ensures that the nuclear weapons stockpile is safe, secure, reliable, and fully capable of supporting our nation's deterrence policy.

5.1.1 Schedules and Milestones

We met all our negotiated commitments to provide technical support for DOE-directed weapon modification, alteration, and limited-life component exchange programs. We have also met all the required DOE shipment schedules.

The DOE conducted quarterly reviews of the weapon retrofit functional area. Our rating was "outstanding."

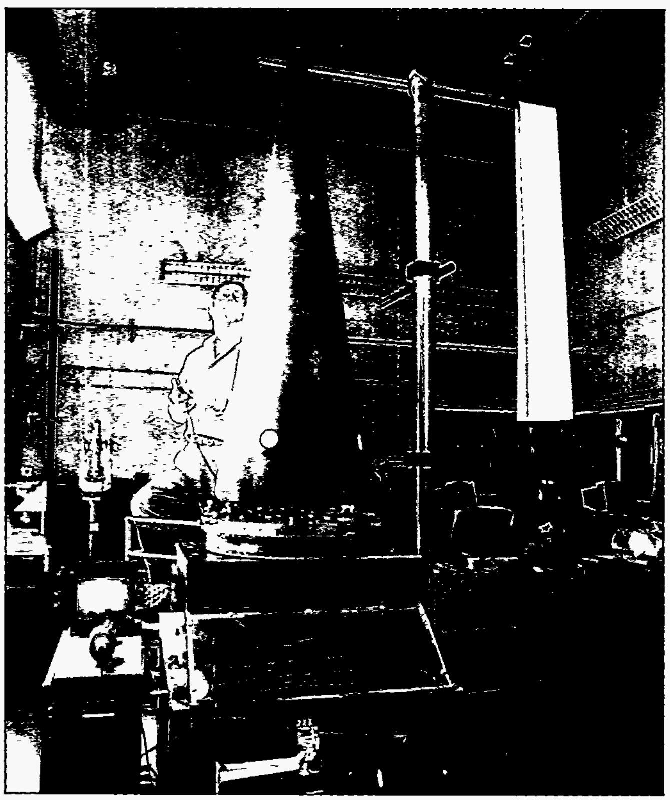
We also met the FY 1998 goal for the Advanced Design and Production Technologies Initiative by directly fabricating an electronic circuit and a molding die using the Laser Engineering Net Shape process.

5.1.2 Stockpile Life Extension Program

As system integrator, Sandia was instrumental in completing the first round of Stockpile Life Extension Program planning. This resulted in planning guidance that levels both costs and workload requirements for nuclear weapons stockpile maintenance and refurbishment, using Strategic Arms Reduction Treaty I, II, and III scenarios.

5.1.3 Reentry Vehicle's Stockpile Life Extension

Sandia participated in a joint DOD/DOE study to identify options for extending the life of the Minuteman III's W62/Mark12 reentry vehicle and for upgrading the weapon to meet modern safety standards. In concert with Lawrence Livermore National Laboratory and the DOD, Sandia provided design options ranging from minimal modifications of components to an extensive redesign of the warhead's electrical system. The DOE's Albuquerque Operations Office published a portion of the study in May 1997. Sandia provided detailed design information and helped coordinate the report for the rest of the study, which was completed in December 1997.



Sandian Woody Green performs flight trajectory measurements on a W87/Mark 21 reentry body.

5.1.4 Retrofits for Stockpile Life Extension

We completed a retrofit of the existing B83-0 strategic bomb to address aging issues and enhance nuclear surety. We also completed designs for replacement of key limited-life components (neutron generators and gas transfer systems) in the W76 (sea-launched Trident warhead) as part of the W76 stockpile life-extension program.

The W76 neutron generator and the burst disk supporting Los Alamos National Laboratory's W76 design responsibility are significant and technically demanding. To meet sunset technology replacement needs, Sandia applied science-based stockpile stewardship methodologies to the design, development, and certification of these limited-life components.

During FY 1998 we redeveloped gas transfer system designs for the W62, B83, and W87 weapons, including the associated qualification and tritium compatibility certification of hardware made from new forging suppliers (the DOE's Oxnard forging facility has been closed).

We completed advanced development of the B61-7 stockpile life-extension program in preparation for full-scale engineering development in FY 1999. We also successfully flight tested the first enhanced fidelity instrumentation on the W87 (intercontinental ballistic missile warhead) as part of our stockpile surveillance program.

Additionally, we completed safety upgrades ALT 335 (trajectory sensing signal generators) and ALT 339 (encrypted recode capability) in all B61-3, B61-4, and B61-10 active stockpile weapons.

5.1.5 Computer Simulation of Hostile X-Ray Sources

Sandia's new Monte Carlo computer code that predicts the transport of electrons and photon radiation was used for the first time to efficiently assess the radiation vulnerability of weapon systems exposed to hostile x-ray sources. This code is being used on the world's fastest computers to predict the dose of radiation to the vulnerable regions of particular weapon components. The worst-case angle of attack is identified and used in a subsequent analysis to predict mechanical (shock and thermal) effects. The new code is being used to help certify the radiation hardness of the MC4380 neutron generator within the W76 system.

5.1.6 Neutron Generator Production

Neutron generator production completed the Qualification Evaluation Lot 1 for neutron tubes and began the Qualification Evaluation Lot 1 for completed generators. The Neutron Generator Recertification Program completed thirty-two consecutive lot submittal quality assurance inspection procedures without a failure.

Developing processes for neutron generator production involves Sandia production, design, and research organizations. Modeling, testing, and verification experiments are used to qualify many processes in the production program. Encapsulation modeling in the Model Accreditation Via Experimental Sciences for Nuclear Weapons (MAVEN) project reduced encapsulant cure time by 60 percent. Accelerated Strategic Computing Initiative efforts in braze furnace modeling and simulation increased process-step yields by an estimated 20 percent. A chemical preparation process yielded a new method for developing high-purity lead zirconate titanate materials.

The thermal battery backup production program has completed demonstration of war reserve capability, producing one lot of batteries. The capability is being mothballed for future use if the need arises.

5.1.7 Linked Computer Codes for Predicting Behavior of a Fire-Engulfed Missile

A multidisciplinary Sandia team performed the first complete, coupled safety assessment of a W80 air-launch cruise missile engulfed in a fuel fire. One assessment used Sandia computer codes to calculate how the weapon would be affected by a fire originating from a ruptured airplane wing. This assessment 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). The assessment demonstrated the feasibility of coupling these codes using the Accelerated Strategic Computing Initiative's multiple parallel processing computer platform.

5.1.8 Virtual-Reality-Based B61 Training Software

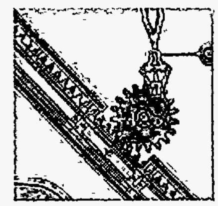
Sandia developed and delivered to Pantex a virtual-reality-based training software prototype that could provide a cost-effective supplement to current physical trainers. Virtual reality training allows participants to acquire experience with unusual circumstances or conditions that cannot be simulated on a physical model. Persons using the software are immersed in a virtual Pantex assembly bay complete with a B61 tail section and the tools and parts required by the procedure to remove the parachute.

5.1.9 Advanced Risk and Reliability Model Integrated Software

Sandia has developed a variety of probabilistic risk assessment tools for modeling nuclear weapons, telecommunications systems, aircraft, and robotic manufacturing systems. Sandia has now updated, refined, and integrated these previously separate tools into the advanced risk and reliability model integrated software. For example, a risk analyst can now combine computer models of the events surrounding a weapons transportation accident with a detailed model of the weapon's internal safety systems. The resultant 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.

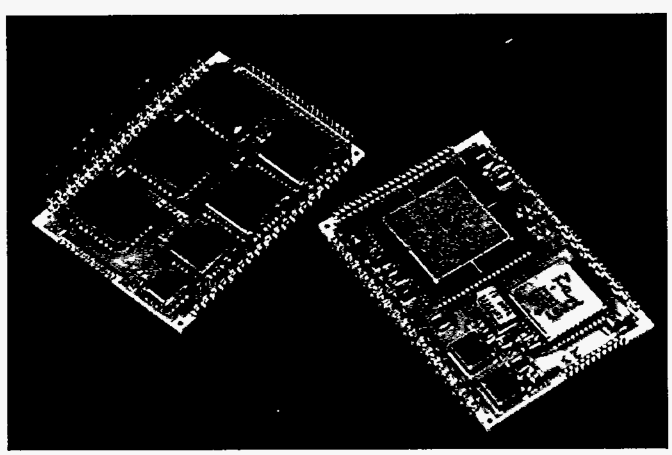
5.1.10 Permissive Action Link Upgrade

Sandia developed the T1565A headquarters code processor to extend the capability of the US European Command Management Permissive Action Link Control Team to perform peacetime code management for nuclear weapons in Europe beyond the year 2000. 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, replacing an antiquated system.



After the T1565A upgrade, a common architecture was created for permissive action link support equipment for continental United States and Pantex applications.

The MC4519 encryption translator assembly (part of the weapon permissive action link system) ensures that a weapon can be armed by authorized users only. The encryption translator assembly device is a cost-effective way to upgrade use-control weapons systems with cryptographic recode capability without exposing code information. The device is being produced for B61-3, B61-4, and B61-10 weapons, previously equipped with a use-control system that did not have encryption capabilities.



Sandia develops encryption translators for weapon permissive action link systems.

5.1.11 Screening Technique for Stockpile Security Soft Spots

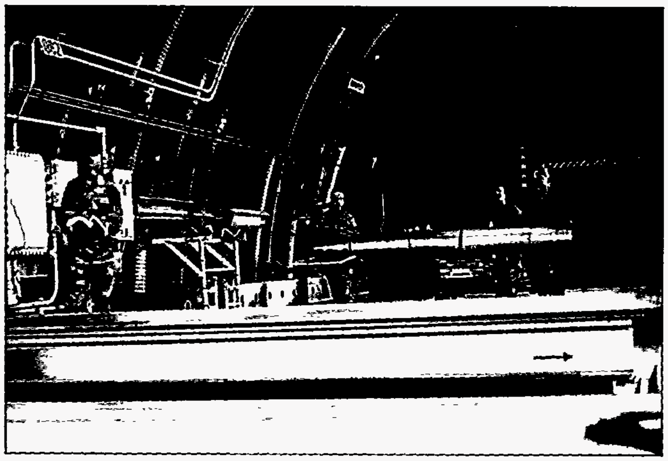
Sandia developed a screening technique to determine the extent of security and use-control soft spots across the entire nuclear stockpile in the various environments where weapons are stored. This screening technique identifies common problems or weaknesses and focuses on areas of highest concern, enabling managers to improve overall stockpile security.

5.1.12 Laboratory Simulation of Reentry Vehicle Radiation and Shock

The W76/Mark 4 reentry vehicle must survive the first intense x-ray impulses from a nuclear detonation and the subsequent shock wave. Sandia has developed new laboratory techniques to simulate this extremely harsh environment and validate computer models for the W76/Mark 4. A steel bar instrumented with a strain gauge and attached to a pendulum strikes the reentry vehicle, exciting the components to nearly the shock level of a hostile environment. Different areas of the reentry vehicle are point loaded, and the steel bar strikes the reentry vehicle at various force levels to help predict how components will respond to nuclear shock. The data gathered are used in finite-element models to characterize the reentry vehicle's mass, stiffness, and damping capabilities.

5.1.13 Radiation-Hardened Integrated Circuits

Sandia's Microelectronics Development Laboratory met a milestone in the development of radiation-hardened integrated circuits



Sandia has developed screening techniques that improve stockpile security.

by fabricating a high-density (0.5-micron complementary-metal-oxide-semiconductor technology) integrated circuit memory that functioned at dose levels in excess of 7 millirads. The integrated circuit was manufactured using a recently developed shallow trench isolation technology, rather than the more common local oxide technique.

5.1.14 Laboratory Duplication of Violent Forces on Reentry Vehicles

Reentry vehicles entering the Earth's atmosphere must survive a turbulent boundary layer. Sandia has designed an experimental technique to better simulate this environment by combining multiple shaker mechanisms with reverberant sound energy to 10 kilohertz. We also simulated the ejection shock environment (the significant kickoff shock the reentry vehicle experiences as it is forced from its payload platform) by impacting a tuned mechanical resonator attached to the reentry vehicle with an air-driven projectile.

5.1.15 Sensor-Based Robotic System

The weigh and leak check system is a sensor-based robotic system that remotely and automatically handles stockpile pits at the Pantex plant in Amarillo, Texas. The weigh and leak check system unpacks pits from containers, delivers the pits to testing stations, weighs and leak checks the pits, and repacks them. The system reduces operator exposure to radiation, eliminates heavy lifting, and minimizes human mishandling. In 1997 Sandia completed development, testing, shipment, and installation. Integrated testing was completed in early 1998.

5.1.16 Robot-Controlled Gas Generator Disassembly

Sandia's automated gas generator disassembly system uses a robot to disassemble gas generators designed to eject parachutes from nuclear weapons. Because the aging generators are unsafe, the operators run the system from a remote location. The automated disassembly system takes apart the gas generators, pours out the propellant, and cleans the scrap metal—yielding better-separated waste than the alternative burning process and enhancing recycling efforts. The system had dismantled 980 MC1362 explosive gas generators by February 1998.

5.1.17 Vertical-Cavity Surface-Emitting Laser-Based Stronglink Monitor

Sandia has developed a new vertical-cavity surface-emitting laser (VCSEL)-based stronglink monitor. VCSELs are "grown" on a semiconductor substrate and have a multilayered bottom region of material that acts as a high-performance mirror, a middle region that emits light when electrically charged, and a top region of mirrorlike material. The VCSEL-based stronglink monitor has been assembled into a working prototype of the collocated detonator stronglink. Collocating two stronglinks at the detonator allows a more compact design with fewer parts.

The VCSELs and microlenses for this device were fabricated in Sandia's Compound Semiconductor Research Laboratory and mounted to a Sandia-designed ceramic substrate.

5.1.18 Milliengine with Applications as Actuator Stronglink

Sandia designed, fabricated, and operated a new magnetic actuator called the milliengine. The milliengine's size fits between motors built in conventional machine shops and the nearly invisible silicon micromotors built at Sandia. The milliengine is fabricated using an x-ray lithography process that can produce both plastic and metal parts with tolerances ten times smaller than those possible with conventional precision miniature machining. The milliengine may eventually be used as an actuator for nuclear weapon stronglink mechanisms.

5.1.19 Miniature Enhanced Fidelity Instrumentation System Telemeter

The enhanced fidelity instrumentation system, a miniature telemetry system that we are developing, is a component in the W87 Flight Test Unit-12, a simulated warhead that was flight tested in May 1998. This type of minimally intrusive flight test instrumentation gathers and processes sensor data while its reentry vehicle is in flight and transmits the data to ground-based receivers. The telemeter and its weapon reentry vehicle will ultimately be used in DOE weapons testing activity managed by Sandia in coordination with the US military.

5.1.20 Advanced Security Attack Tools

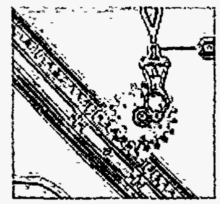
Sandia completed a series of tests of advanced security attack tools for the DOE Office of Safeguards and Security. We evaluated the performance of explosive standoff weapons and demolition munitions that could be used to breach security. Members of a special military entry team completed more than thirty explosive attacks designed 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.

5.2 Nonproliferation and Materials Control

Sandia is reducing US vulnerability to threats from proliferation, weapons of mass destruction, nuclear incidents, and environmental damage. Our strategy uses innovative analytic, scientific, and technological techniques to find practical applications.

5.2.1 Schedules and Milestones

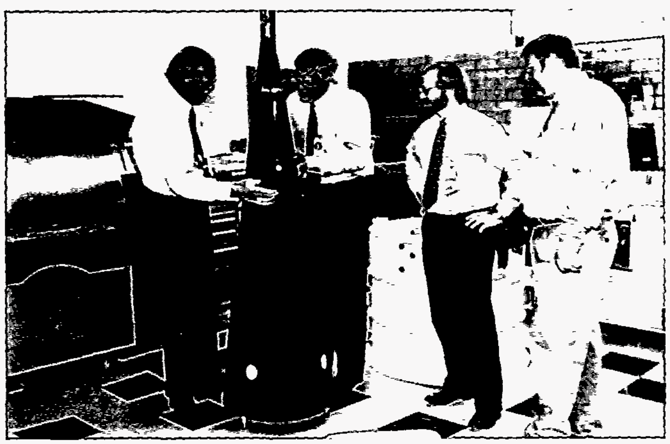
The DOE conducted quarterly reviews of the nonproliferation and materials control functional area. Our rating to date is "outstanding." We expect that the remaining functional areas being reviewed by the DOE in FY 1998 will meet expectations. Final results will be reported in the FY 1998 Appraisal Self-Assessment Report.



5.2.2 Treaty Verification

Sandia helps maintain confidence in global treaty verification, including Comprehensive Test Ban Treaty compliance. This includes our innovative application of satellite, aircraft, and ground-based multispectral light detecting and ranging (lidar) and microsensor technologies.

The multispectral thermal imager, a small satellite, demonstrates the utility of visible to long-wavelength infrared images and radiometry for a number of DOE and DOD missions. All sensor payload subsystems have been prototyped and integrated, and flight hardware has been fabricated. The satellite payload was integrated in FY 1998, which will lead to integrated system testing and a future launch.



Sandians Conrad Stayner and Brien Bopp conduct a W87 briefing for Los Alamos National Laboratory staff.

5.2.3 Comprehensive Test Ban Treaty Support

Sandia supported the Comprehensive Test Ban Treaty by developing sensor and data processing technologies to monitor treaty compliance and by providing technical experts to the Treaty Preparatory Commission. We also completed the Integrated Verification System Evaluation Model, which estimates the ability of US and international monitoring networks to detect nuclear explosions. During preparation for the ratification hearings, the Integrated Verification System Evaluation Model was used to brief former Energy Secretary Peña and Senator Domenici's staff on treaty verifiability.

5.2.4 Software for Improving Verification of Comprehensive Test Ban Treaty

Sandia developed the MatSeis software to help verify the Comprehensive Test Ban Treaty. MatSeis allows in-depth research in specialized seismic signal processing to detect small events such as nuclear tests that might indicate a treaty violation. MatSeis provides a user-friendly graphic interface, direct access to treaty monitoring data bases, and a simple, cost-effective way for researchers to incorporate their seismic algorithms. MatSeis may be downloaded from the treaty web site.

5.2.5 United Nations' Comprehensive Test Ban Treaty Organization

The United Nations' newly formed Comprehensive Test Ban Treaty Organization located in Vienna, Austria, began using Sandia-developed software as part of its web site. Sandia developed the software for the DOE to assist in project management. The software can automatically generate contact lists, group email lists, searchable document libraries, and document review and comment pages to facilitate communication and cooperation among geographically dispersed parties.

5.2.6 Materials Control and International Regional Cooperative Measures

The partnership for nuclear material security is a DOE multilaboratory effort to prevent the misuse of nuclear materials in the newly independent states of the former Soviet Union. Sandia has responsibility for upgrading the physical security at various nuclear sites in these newly independent states. Sandia met all milestones identified for this program in FY 1998. The following sites were commissioned during FY 1998 and include nine in Russia and one in Romania:

- the Beloyarsk Nuclear Power Plant;
- the Research and Development Institute of Power Engineering, Sverdlovsk Branch;
- the Moscow State Engineering Physics Institute;
- the Research and Development Institute of Power Engineering;
- the Tomsk Polytechnic University;
- the Institute of Theoretical and Experimental Physics;
- the Joint Institute of Nuclear Research;
- the Karpov Institute of Physical Chemistry;
- the Khlopin Radium Institute (two sites);
- the Petersburg Nuclear Physics Institute; and
- the Institute for Nuclear Research in Pitesti, Romania.

Cooperative efforts continue with Russia, the International Atomic Energy Agency, and other countries and organizations. Efforts include programs with the Russian weapons laboratories, regional cooperative workshops and demonstrations through the Cooperative Monitoring Center, and bilateral agreements with Japan, Argentina, and Finland related to international safeguards and nonproliferation. Remote monitoring systems have been installed in Finland and Argentina in cooperation with the International Atomic Energy Agency.

5.2.7 Device for Monitoring Stored Nuclear Materials

Sandia has expanded US remote monitoring of nuclear materials in storage containers by integrating six sensors into an 8-cubic-inch cylindrical package. The sensors in this electronic device detect radiation dose, dose rate, pressure, humidity, hydrogen, and temperature. The device, which can perform about 250,000 data acquisition and transmission cycles using an AA battery, is part of Sandia's Integrated Nuclear Materials Monitoring Project.

5.2.8 Physical Protection of Nuclear Materials

Sandia's national security experts worked with their colleagues from the former Soviet Union to improve transportation security and enhance the physical protection of nuclear materials at forty-four selected sites. We helped design and install a physical security system to protect weapon-grade nuclear materials in storage at the Kiev Institute of Nuclear Research in Ukraine. The institute will be a model to teach physical protection concepts in Ukraine. At the Institute of Theoretical and Experimental Physics in Moscow, newly upgraded equipment helps protect, control, and account for significant quantities of weapon-grade nuclear materials. A National Security Committee delegation headed by US Congressman Thornberry visited the site and was 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.

5.2.9 Sandia Nuclear Blast Sensors in Orbit

Two satellites carrying Sandia monitoring instrumentation were launched. The Defense Support Program satellite maintains a stationary orbit 22,700 nautical miles above Earth. The second satellite became part of the Global Positioning System. All system satellites carry Sandia instruments for detecting nuclear detonations to verify compliance with the Limited Test Ban Treaty. Sandia also delivered six new satellite payloads that will be launched over the next several years to replenish the system.

5.2.10 FORTÉ Satellite to Spot Secret Testing

Sandia and Los Alamos national laboratories are analyzing data from the 7-foot-high Fast On-Orbit Recording of Transient Events (FORTÉ) satellite, orbiting 500 miles above Earth. Although Sandia has developed and monitored satellites in the past, this is the first time we have actually controlled a satellite's operations. FORTÉ (launched in August 1997) was developed jointly by Sandia and Los Alamos national laboratories and sponsored by DOE's Office of Nonproliferation and National Security to test new ways to spot secret nuclear weapons tests.

5.2.11 Center for National Security and Arms Control

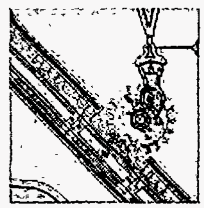
Sandia is addressing the threat posed by weapons of mass destruction through our Center for National Security and Arms Control, a state-of-the-art facility.

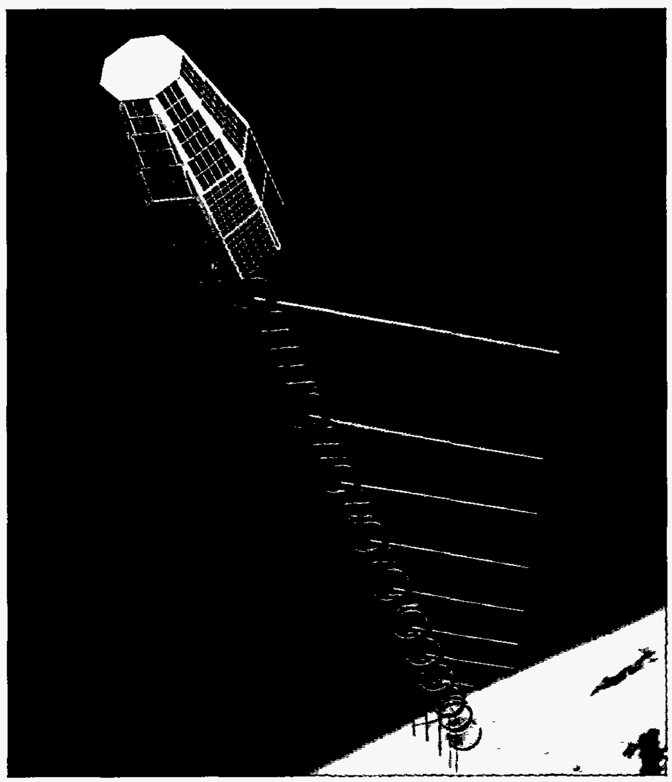
We continue working with other countries to contribute to International Atomic Energy Agency acceptance of remote monitoring for safeguards. Remote monitoring systems were delivered on schedule in Finland and Australia, and the Finland system was successfully demonstrated to the International Atomic Energy Agency in Vienna in March.

Also, Sandia developed agreements with Russian laboratories about requirements for intelligent containers, and we deployed a systems-level field trial of storage monitoring technologies in the United States and in Russia.

5.2.12 United States and Russian Nuclear Warhead Dismantlement

Sandia developed a comprehensive US/Russian program to study nuclear weapons dismantlement. This program engages the Russian nuclear weapons institutes in intellectual studies of issues associated with Russian nuclear weapons dismantlement. Participating Russian laboratories include Chelyabinsk-70, Arzamas-16, and the Institute of Automatics. Sandia contract requirements 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.





The FORTÉ satellite was developed jointly by Sandia and Los Alamos national laboratories.

5.2.13 Airborne Multisensor Pod System for the Kazakhstani Government

Sandians and other members of a multilaboratory team conducted a seventeen-day remote sensing mission in the Republic of Kazakhstan. The airborne multisensor pod system team collected extensive data on a former nuclear weapons test area and other locations in eastern Kazakhstan. The primary objective of the program is to help the United States and its allies verify that nations involved in arms control treaties are complying with those treaties.

5.2.14 Cooperative Monitoring Center International Workshops

Sandia's Cooperative Monitoring Center promotes communication among political and technical experts from around the world and is a resource for the US government and the international arms control and nonproliferation community. The Cooperative Monitoring Center 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.

5.2.15 Chemical and Biological Nonproliferation Domestic Applications

Sandia is a major contributor to the DOE's Chemical and Biological Nonproliferation Program. We are developing a combined chemical/biological detector for domestic applications based on our microchemlab technology, and we conducted several laboratory proof-of-concept tests in 1998.

Members of the San Jose, California Fire Department conduct training with a chemical/biological warfare sensor developed by Sandia.

We are also developing decontamination foams for large area recovery and restoration. These foams have performed successfully on chemical/biological simulants. Live agent testing is planned for CY 1998.

5.2.16 Smallest Gas Separation Column

A Sandia device demonstrated the separation and detection of toluene from a nerve agent simulant in less than one minute. The gas separation column on a 1-square-centimeter silicon chip is the smallest demonstrated to date. The column, which would measure 80 centimeters if straightened, is produced by etching a winding channel onto a silicon chip substrate and then covering the channel with Pyrex. Substances are separated and identified by the rate at which they travel down the column. By sending the column's output to a surface acoustic wave sensor, we can measure minute quantities (less than 1 picogram) of chemical species as they collect on the device. The acoustic wave sensor can detect chemical agents relevant to nonproliferation.

5.2.17 Ion-Beam Technology for Nondestructive Identification of Trace Elements

Sandia and Lawrence Livermore national laboratories have 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. The new ion-beam imaging and analysis system is an extremely sensitive probe for trace element analysis—approximately one hundred times more sensitive than the electron microprobe. The primary customers for this technology include national security agencies responsible for detecting nuclear smuggling and verifying compliance with arms control and nonproliferation treaties.

5.2.18 Nuclear Waste Legacy

As part of the DOE viability assessment of the Yucca Mountain repository, we completed a total-system performance assessment. This work estimated the behavior of the repository for a million years after closure. The congressionally mandated assessment will help the DOE determine whether to continue developing this repository.

Sandia has conducted detailed analyses of the Waste Isolation Pilot Plant site. Based on Sandia geotechnical analyses and performance assessment models that predicted the behavior of the repository, the Environmental Protection Agency has certified the Waste Isolation Pilot Plant for disposal of radioactive waste.

5.2.19 SEAtrace™ Assessment of Barriers for Underground Leaks

Sandia and Science and Engineering Associates (SEA), Inc. developed the SEAtrace assessment system to determine the magnitude and location of leaks in subsurface barriers used to prevent migration of hazardous wastes. SEAtrace injects a benign gas into the ground, the gas moves through any leaks in the underground barrier, and a computer code provides real-time data analysis. The system detected and measured the size of leaks sooner, faster, and better than other technologies.

5.3 Energy and Critical Infrastructures

5.3.1 Schedules and Milestones

The DOE is conducting quarterly reviews of selected energy and critical infrastructures functional areas. We project that the functional areas being reviewed by the DOE in FY 1998 will meet expectations. Final results will be reported in the FY 1998 Appraisal Self-Assessment Report.

5.3.2 Medical Isotopes

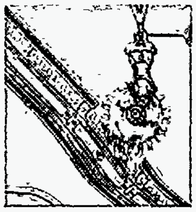
Innovative teaming approaches were developed to meet all major milestones for the medical isotopes effort. These milestones included 80 percent completion of Hot Cell Facility construction (decontamination, demolition, and construction), restart of the Annular Core Research Reactor, and evaluation of Food and Drug Administration requirements to qualify as a supplier of medical isotopes.

5.3.3 New Imaging Techniques for Size and Growth of Gas Well Fractures

Sandia performed six hydraulic fracturing experiments at a research site in Colorado, concluding four years of gas-production optimization testing, which was funded by the DOE and the Gas Research Institute. Investigators created hydraulic fractures at depths of 4,000 to 5,000 feet. A highly sensitive receiver using advanced accelerometer technology detected the seismic signals and imaged the size of each fracture and the direction in which it propagated. Long fractures are desirable, but expenses increase when the fractures propagate outside the reservoir and enter shales. The experiments demonstrated the feasibility of real-time fracture mapping for gas-production stimulation.

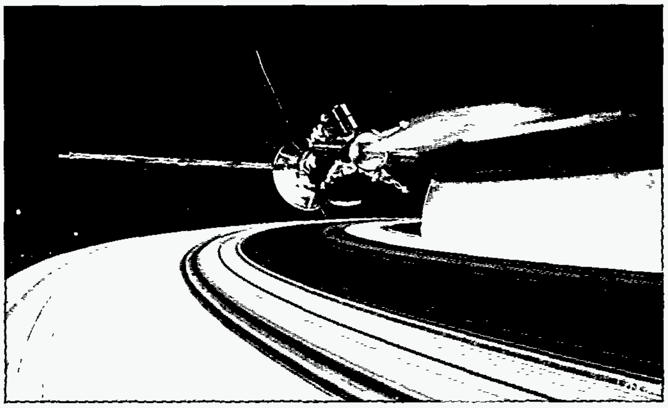
5.3.4 Brine Injection System for Recovery of Oil from a Leaking Mine

Sandia's brine injection system helped the DOE and site-operations contractor DynMcDermott remove nearly all the 72 million barrels of oil stored in a leaking underground Strategic Petroleum Reserve mine at Weeks Island, Louisiana. Many holes were drilled into the sediments above the mine to identify and flood the area with a saturated salt solution that delayed additional leaks. The salt solution pooled beneath the oil, and the remaining oil floated to the brine surface, where it is being skimmed.



5.3.5 Risk Analysis of Cassini Spacecraft

The Cassini spacecraft launched in October 1997 generates electricity for the mission via radioisotope thermoelectric generators fueled by plutonium 238. Prior to the launch, 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 probability of a radiation release during a launch or reentry accident. Sandia 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 analyzed accident scenarios for the Cassini spacecraft.

5.3.6 Risk Analysis for Maritime Shipment of Nuclear Materials

The DOE SeaRAM program has evaluated risks associated with transporting nuclear materials by ship. Sandia provided a technical basis for answering questions about the risks. Finite-element calculations showed that even if the containment cask (stronger than almost all ship hulls) was contacted in a collision, it would be pushed through the hull and into the sea. 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 reach the hold are unlikely to burn long enough or at a temperature high enough to damage the cask. Sandia studies confirmed that the risks associated with maritime shipment of radioactive materials are extremely small.

5.3.7 High-Consequence Engineering Conference Series

High-consequence incidents involve loss of life, severe financial loss, danger to the environment, or compromises to national security. Because most of Sandia's work is high-consequence, we have developed expertise in high-consequence engineering. Sandia has hosted six high-consequence engineering conferences. The seminars in this series focused on understanding, predicting, and preventing failures in a variety of critical applications.

5.3.8 Explosives-Detection Portal

Sandia's explosives-detection portal, sponsored by the Federal Aviation Administration, may help prevent airliner hijackings and bombings. The portal can identify persons who have recently worked with or have been exposed to any of a wide variety of explosives. The portal passes a puff of air over a person and then collects and analyzes the air sample. The detector determines both the type and quantity of even small quantities of explosives and displays this information on a computer screen. The same technology can be adapted to detect narcotics and chemical agents or can be used for environmental monitoring.

5.3.9 Disablement of Unabomber's Last Bomb

Sandia explosives experts disabled the Unabomber's last bomb, which had been wrapped and was ready to send. Over a three-day period, Sandians worked to defuse the bomb, to ensure that all the evidence was preserved, and to understand the bomb's working mechanisms. During an Albuquerque visit in February 1998, President Clinton praised the effort.

5.3.10 Modeling of TWA Flight 800 Fuel Tank Explosion

Sandia supported the National Transportation Safety Board in characterizing the center fuel tank explosion of TWA Flight 800. We developed flame-front propagation models of the fuel/air ignition and subsequent explosion. These simulations showed that a fire could have produced enough pressure in the fuel tank to cause the explosion and that the configuration of the tank may have increased the rate of pressure rise in the tank during the burn. The National Transportation Safety Board also asked Sandia to perform sensitivity calculations to locate the ignition source.

5.4 Emerging National Security Threats

Sandia's emerging national security threats area provides advanced technology solutions for the DOD and other entities to defend the nation against weapons of mass destruction, defeat hardened deeply buried targets, combat terrorism, and support related missions. We are also members of numerous committees and commissions that support the DOD and related national security entities.

5.4.1 Ground Sensors

Sandia ground sensors designed to detect and identify mobile missile launchers became operational in FY 1998. Sandia also tested candidate incendiary warheads for use against hardened structures as part of the Defense Special Weapons Agency Dipole Hail Program and also fielded various characterization sensors for underground structures as part of a Defense Special Weapons Agency/Defense Intelligence Agency program.

5.4.2 Bomb Disablement System

A cost-effective Sandia disablement system was commercialized and is in use by bomb squads throughout the United States. In FY 1998 Sandia conducted a national bomb disablement training workshop in conjunction with the Albuquerque Police Department and the Federal Bureau of Investigation. Sandia also demonstrated technology to disable large vehicle bombs.

5.4.3 Surety

In FY 1998 the Authentication Center of Excellence was established at Sandia to provide surety assessments for government "smart card" applications. The US Navy was the center's first customer. Sandia's provision of information system red teams was expanded to other customers, including the Defense Advanced

Research Projects Agency. High-power microwave technologies and automated methods for performing surety assessments were also expanded.

Sandia's surety assessment organizations developed a new system model for airline safety with wide applications (including the weapons program). The model helps assess the relative safety of various situations and establishes pointers to the most important sources of problems and the most effective protective measures.

5.4.4 Intelligent Bandwidth Compression Software for Real-Time Target Information

Sandia has developed software that enhances the effectiveness of synthetic aperture radar. This radar equipment on an aircraft emits and receives signals (even at night or through clouds) to produce high-resolution, two-dimensional images of the terrain. However, the images are too large to transmit in real time over readily available communication links. Therefore, Sandia developed intelligent bandwidth compression software communication devices that can move large amounts of information in real time. Intelligent bandwidth compression software includes advanced detection and compression algorithms to accomplish the necessary bandwidth reduction. The software examines each synthetic aperture radar image for targets of interest and then divides each image into target areas that will be saved and target-free background areas that will be compressed. A ground-based computer reconstructs the compressed image for analysis in real time with virtually no loss of critical target information.

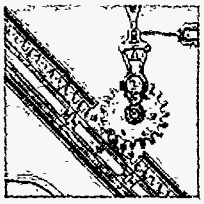
5.4.5 Inertial Terrain-Aided Guidance System for Delivering Weapons to Preprogrammed Targets

The inertial terrain-aided guidance system is an advanced, all-weather, day-and-night, radar-guidance system being implemented as a nose-kit mounted on the front of conventional penetrator weapons. Sandia is developing the system for the Defense Special Weapons Agency as part of the DOD-funded Counterproliferation Technology Demonstration Program, which examines all aspects of countering weapons of mass destruction. The system uses a traditional inertial measurement unit in conjunction with a high-altitude, Doppler-sharpened radar altimeter to autonomously guide weapons to a preprogrammed target. A weapon guided by the system can be delivered through fog, clouds, smoke, rain, or snow.

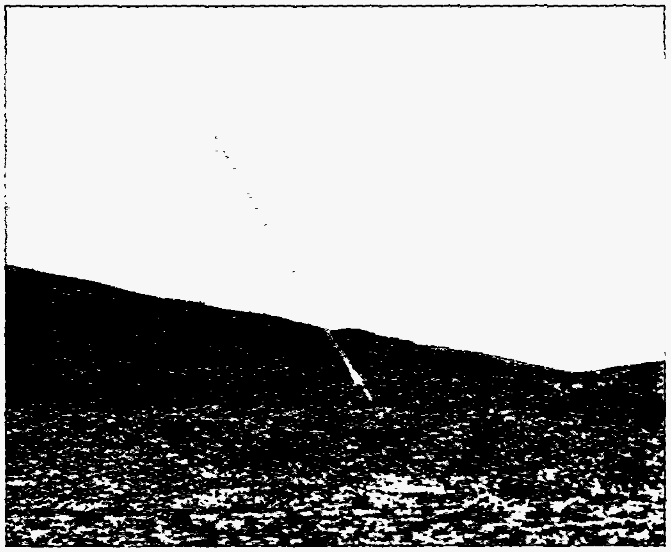
5.4.6 Concrete Cratering Model

A Sandia-developed computational model for determining the dynamic response of brittle materials won a DOD-sponsored computer code benchmarking competition. Participants predicted the exact geometry of the crater formed in a reinforced concrete slab by 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. 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 used to characterize situations such as rapid entry into concrete structures to rescue hostages or disable threats.

5.4.7 Sensors on Interceptor Missiles for Differentiating Reentry Vehicles from Decoys



To test how well an interceptor missile can differentiate between a reentry vehicle and a decoy in space, the first two interceptor tests in a series of National Missile Defense Integrated Flight Tests were performed. 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 lightweight decoy



Sandia is developing and testing advanced guidance systems for conventional penetrator weapons.

targets. The reentry vehicle and targets were deployed in midflight to test how well optical sensors on board an interceptor could differentiate between the reentry vehicle and the decoys. The tests were successful in gathering data for intercept algorithms. For upcoming missions, the interceptor missile will be required to strike the primary target.

5.5 People

Sandia strives to continue hiring the "best of the best." We have a flexible organization that includes a system for developing leaders and managers and an environment that supports daily and long-term operations, creative work, high-performance teams, customer focus, and quality work. In a work environment where trust prevails, employees have been inspired to give their best performance at work and within the community.

5.5.1 Improved Work Environment

The integrated job structure was implemented. This competency-based, market-oriented structure contains common concepts and philosophies to guide all levels of work. The integrated job structure provides clear alternative career paths, simplifies classification processes, and uses occupation descriptions to facilitate market matching.

The human resources portion of the PeopleSoft system was implemented and helped transform Sandia's business practices to match those used by commercial enterprises. This self-service web page allows employees to view both corporate-specific and employee-specific benefits information. The PeopleSoft technology simplifies post-and-bid and internal movement, supplying "one-stop shopping" for staffing needs.

Employee business rules were revised and converted to a web-based format to improve accessibility for employees.

The new Vacation Donation Plan enables Sandians to help colleagues during family emergencies. This plan allows employees with unused vacation to donate time to other employees who have an emergency requiring time away from work.

5.5.2 Education Programs

Our Knowledge Management Program Plan was published and distributed. The plan presents a one-year program to develop weapon-design skills for newly hired designers and emphasizes access to past, present, and future nuclear weapons data and information. The first functional panel on weapons expertise radar was conducted and documented. A knowledge management home page was placed on our internal web.

Our Corporate Training, Development, and Education organization and the Energy, Information, and Infrastructure Technology Division collaborated with the New Mexico Institute of Mining and Technology to develop a computer science master's degree program. This program gives employees the opportunity to obtain a master's degree while making a career change and enables new hires to complete their master's degree in computer science.

A one-year certificate program in computational simulation was established at the University of New Mexico to develop Sandia's capabilities in this important field.

5.5.3 Awards and Community Service Activities

The New Mexico chapter of the Public Relations Society of America received four awards on behalf of Sandia. First place in public affairs (government) was awarded to the Robotics and Intelligent Machines Exposition held in Washington. First place in internal newsletters (government) went to the *Sandia Daily News*. Second place went to the *Sandia Lab News*. Sandia's "Shoes for Kids" public service campaign received honorable mention.

Sandia and Lockheed Martin Corporation received the National Society of Fundraising Executives' 1997 Outstanding Business in Philanthropy Award in recognition of our participation in community outreach programs.

Sandia's Laboratory Management Performance groups received an "outstanding" rating in the DOE's annual appraisal. Each group established annual goals, completed a self-assessment, and received the DOE assessment. Annual goals were line ownership of diversity, cost savings and cycle-time improvement in staff augmentation, implementation of the integrated job structure, demonstration of line of sight via completion of performance management forms, successful union negotiations, and utilization of feedback to improve customer satisfaction.

During FY 1998 Sandians contributed more to the Employee Contribution Plan/United Way Campaign than ever before, exceeding $1 million.

More than 1,700 Sandians donated approximately 50,000 hours of service to their local communities in the Sandia Volunteers Program.

Sandia provided a mentorship/volunteer fair model for a city-wide mentorship fair sponsored by Leadership Albuquerque and the city of Albuquerque.

Sandia earned the DOE's Roadrunner Award for progress in diversity, and our SALUD Health Promotion Program received Sandia's Turquoise President's Quality Award.

5.6 Science and Technology

Sandia leads the nation in the technology areas of integrated microsystems, integrated model-based engineering and manufacturing, and surety science and technology. These areas draw on our research foundations science base in the areas of materials and process science, computational and information sciences, microelectronics and photonics sciences, engineering sciences, and pulsed power sciences.

5.6.1 Materials and Process Science

5.6.1.1 Breakthrough Process for Versatile Super-Porous Films

New thin films developed at Sandia consist of precisely arranged pores that could become effective gas and liquid separators, 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, which occurs when detergent-like organic molecules chemically interact with silica-based inorganic components. The organic and inorganic components spontaneously organize into uniform cell-like structures, each cell coating surrounding an organic core. The next part of the process (an oxidative heat treatment) removes all the organic material and leaves a three-dimensional silica network of precisely defined pores.

5.6.1.2 Biological Microcavity Laser for Blood Sample Analysis in Minutes

Sandia and the National Institutes of Health patented a hand-held device that analyzes blood samples in minutes rather than in the current time of hours to weeks. The biological microcavity laser can immediately detect sickle-cell anemia and other blood anemias, and it may be able to detect tiny changes in cell structure such as those caused by the AIDS virus. The laser can distinguish between cancerous and noncancerous cells and should allow observers to monitor cancer cell growth and death. The device, based on Sandia's vertical-cavity surface-emitting laser (VCSEL), generates laser light using individual blood cells from a drop of blood in the VCSEL microcavity. The blood cell becomes a light guide that 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 traditional need to kill or stain blood cells for better visibility. The biological microcavity laser may influence health care by combining the low cost and small size of semiconductors with the high speed and sensitivity of laser microtechnology.

5.6.1.3 Aircraft Repair with Bonded Composite Doubler

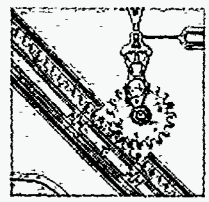
Sandia repaired the door corner of a Delta aircraft using a bonded composite doubler in lieu of a conventional riveted metal patch. This new technique eliminates rivet holes that can initiate new cracks. The composite also provides a high strength-to-weight ratio, corrosion resistance, improved aerodynamics, and shorter installation time.

5.6.1.4 New Class of Room-Temperature Gamma-Ray Detectors

Cadmium zinc telluride crystals are being used in a new class of room-temperature gamma-ray detectors. Sandia produced the first detailed characterizations of the properties and performance of these crystals, leading to an explanation of their behavior. Previous radiation detectors could be used only after being cooled to liquid nitrogen temperatures. The new detectors are smaller and can be left unattended for much longer periods.

Sandia's understanding of cadmium zinc telluride crystals could impact the way nuclear materials are monitored and could accelerate an emerging $1 billion per year medical imaging business. *Discover* magazine recognized the Sandia team leader as Innovator of the Year in the Sight category.

5.6.2 Computational and Information Sciences



5.6.2.1 Teraflops Supercomputer

Teraflops supercomputer simulations use massively parallel computing, an approach pioneered by Sandia. Thousands of discrete computing tasks are assigned to several hundred separate computing processors; the computing tasks are accomplished simultaneously and their results reassembled. All of today's high-performance supercomputing employs this massively parallel approach.

The teraflops supercomputer was developed jointly by the DOE, Sandia, and Intel. The supercomputer represents the initial goal of the DOE's Accelerated Strategic Computing Initiative, a fifteen-year program designed to move nuclear weapons design and maintenance from a test-based to a simulation-based approach.

5.6.2.2 Asteroid Strike Model Using the Teraflops Supercomputer

Using virtual reality techniques, decades of experience in shock physics, advanced computer programs, and the world's fastest computer, we recently modeled the impact of a 1.4-kilometer asteroid striking the Atlantic Ocean twenty-five miles south of Brooklyn, NY. Sandia's teraflops supercomputer, which performs more than one trillion mathematical operations per second, calculated a three-dimensional moving picture of the collision.

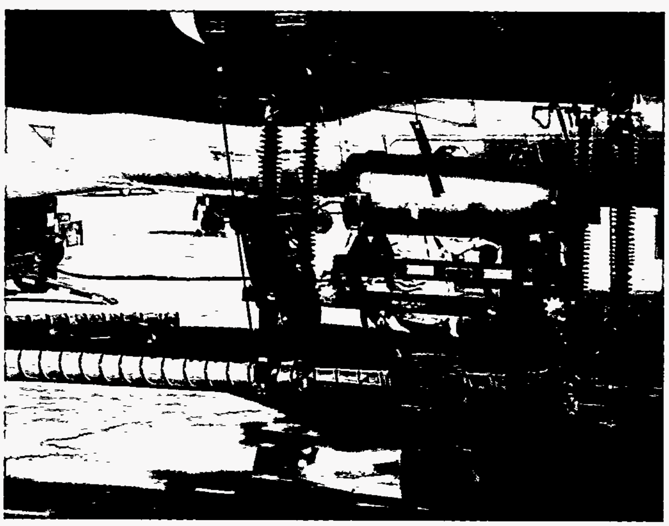
The work supports Sandia's DOE mission to develop computer codes that can one day model the extremely complex physics processes that occur during a nuclear weapon blast. In the absence of actual nuclear testing, the DOE and the weapons laboratories are developing increasingly powerful supercomputers and computer codes to simulate the complex three-dimensional physics involved in nuclear-weapon performance and to accurately predict the degradation of nuclear weapon components as they age in the stockpile.

5.6.2.3 Teraflops Supercomputing and the Revolution in Engineering

The teraflops supercomputer is fostering a revolution in engineering that allows scientists to perform calculations never before possible. The supercomputer is a critical component of the DOE's Science-Based Stockpile Stewardship Program to ensure the safety, security, and reliability of the nation's nuclear stockpile without nuclear testing. 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 meeting in Washington, DC, for the news media, industry, academe, and congressional representatives.

5.6.2.4 Modeling the Effects of Foam Decomposition in the W80 Fireset

Under the Accelerated Strategic Computing Initiative (ASCI) in support of Sandia's surety mission, we modeled the W80 fireset thermal response to a fire. We included the effects of the fireset foam, which provides structural and thermal protection for the weapon safety systems embedded in it. In a fire, the foam can thermally decompose and transform from a solid to a gas, exposing the stronglink and weaklink safety systems. Using 256 processors on the ASCI Janus teraflops computer, Sandia completed an unprecedented number of computations to simulate the fireset's response. During a 600-second simulation, half a trillion radiation calculations were needed to compute the amount of energy transferred along surface areas of the foam enclosure—areas increasingly exposed as the foam transforms from a solid to a gas. Previously, such simulations were not feasible because of prohibitively large requirements for computer time and memory. This simulation demonstrated that computational models can resolve accident problems previously impossible to predict and prohibitively expensive to measure. We will next evaluate how the W80 fireset would respond to other accidents during handling, transport, deployment, and storage.



The W80, here being loaded into the payload bay of an air launch cruise missile, is being evaluated by Sandia.

5.6.2.5 Prototype Next-Generation Parallel Computing System

As part of a research and development project, Sandia assembled a prototype parallel computing system capable of 1 trillion floating point operations per second. A team of Sandia researchers 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 ninety-six nodes in New Mexico and thirty-two nodes in California.

5.6.2.6 SecureNet Links Design Laboratories 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 that interconnected the networks. The wide-area network, a critical element in the DOE's plan for science-based stockpile stewardship, is called SecureNet and is part of the Accelerated Strategic Computing Initiative to support remote access to teraflops computing resources. In connection with the Advanced Design and Production Technologies Initiative, SecureNet has been enlarged to include the Y-12, AlliedSignal, Pantex, and Savannah River production plants. SecureNet has already enhanced the flow of classified design and production information between the laboratories and plants.

5.6.2.7 Manufacturing Development Engineering Extranet Links Sandia and Suppliers

Sandia has developed a web-based encrypted system called the Manufacturing Development Engineering Extranet to provide a timely, accurate, and unified approach to the secure sharing of information between Sandia and its external weapon components suppliers. The system replaces paper procedures for test and inspection data, drawings, annotations, and signoffs, and also provides the basis for future enhanced capabilities. The capability was extended to five suppliers in less than six months.

5.6.2.8 Product Realization Environment and Product Realization Information Management Environment Manufacturing Systems

Sandia has developed two new manufacturing information systems. The product realization environment (PRE) is based on common object request broker architecture, 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.

The product realization information management environment (PRIME) is a data management tool that enables personnel to easily manage, archive, and retrieve product-related information using a standard browser interface. Unlike traditional data base tracking systems, which are upset when changes are made to some (but not all) manufacturing records, PRIME enables efficient tracking of changing engineering and manufacturing processes. PRIME uses the Sandia intranet for email and for access to financial and human resource data. Both PRE and PRIME are being used by key cooperative research and development agreement partners (e.g., the diesel combustion partnership of Sandia's Combustion Research Facility and other national laboratories, DOE offices, universities, and manufacturing plants).

5.6.2.9 Sandia and Oak Ridge Distributed Computing

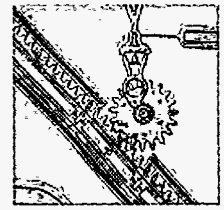
Computer scientists at Sandia and Oak Ridge national laboratories demonstrated the power of distributed computing when they linked two supercomputers to solve a combustion problem. The simulation was performed by linking particle dynamics software developed at Sandia to model chemically reacting turbulent flow problems with a computational steering package developed at Oak Ridge to visualize simulation performance, determine necessary changes, and vary the direction of simulations in real time. 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.

5.6.2.10 Classified Network Able to Tap Unclassified Network Using FTP Guard

Sandia developed the FTP Guard to connect Sandia's classified Internal Secure Network with our unclassified Internal Restricted Network, allowing classified users access to unclassified files. Previously, data could be moved from the unclassified network to the classified network only on disks and tapes. The multilevel gateway (a Pentium-based workstation running Sandia-developed software) is the first of its kind to receive DOE accreditation. The gateway accepts requests from the classified environment, ensures their validity, and retrieves the requested information from the unclassified environment.

5.6.3 Microelectronics and Photonics Sciences

5.6.3.1 Hardened High-Density Integrated Circuit



A high-density integrated circuit memory was demonstrated to function at dose levels in excess of 7 millirads. The 0.5-micrometer technology used to fabricate this memory employed recently developed hardened shallow trench isolation rather than the more common local oxide technique. Consequently, this Sandia technology is directly scalable for fabrication of the next-generation integrated circuit.

5.6.3.2 Microelectronic Integrated Circuit

Sandia's microelectronics infrastructure, which is associated with integrated circuit design, fabrication, packaging, testing, and certification, advanced to the point that four custom integrated circuit types were delivered to customers. These integrated circuits are initial deliveries that support stockpile evaluation, stockpile lifetime extension, and satellite programs. Twenty-nine more integrated circuit types will be delivered this year. The integrated circuits include digital, analog, nonvolatile memories and integrated micromachines that range in quality from engineering prototypes to weapon-ready devices.

5.6.3.3 Integrated Circuit Failure Analysis Techniques

Research and development projects have yielded powerful new failure analysis techniques that will be used to support Microelectronics Development Laboratory product delivery commitments and additional external partnerships. A new technique to enable faster, more sensitive measurement of integrated circuit quiescent currents has been developed; it allows early detection of potential integrated circuit reliability problems, further extending the existing technique. A scanning fluorescent microthermal imaging technique was developed and patented. This technique enables the rapid detection of defects associated with integrated circuit failures. These techniques will allow us to more rapidly identify and correct integrated circuit yield and reliability issues.

5.6.3.4 Microelectromechanical Systems

Microsystems have the potential to miniaturize weapon functions such as navigation, trajectory sensing, safing, and fusing while increasing reliability and robustness. A Sandia microelectromechanical-based 24-bit countermeshing gear discriminator has been built in the Microelectronics Development Laboratory. Prototype discriminators have been coupled with custom processing and optical devices from the Compound Semiconductor Research Laboratory to demonstrate optical shuttering and beam steering.

Sandia's technology for integration of microelectromechanical systems and microelectronics has been licensed for commercial production. This technology transfer is important to establishing a commercial source for future integrated microelectromechanical systems applications in navigation, trajectory sensing, and fusing.

5.6.3.5 Tool to Improve Microchip Production

Sandia patented a device called an electrostatic chuck, which electrostatically clamps onto a silicon wafer, allowing the temperature to be regulated with confined helium gas. Because the chuck face is made of the same materials as computer chips and is fabricated with well-understood silicon chip technology, manufacturing costs should be far lower and batch contaminations far fewer than those for conventional sprayed-on overcoats. Prototypes were fabricated at our Microelectronics Development Laboratory.

5.6.3.6 Heat Pipe Substrate to Cool Microelectronic Devices

Sandia developed a high-performance metal heat pipe substrate (approximately 2 inches square) for microelectronic cooling applications. The design uses embedded microheat pipes to cool components such as microprocessors by transferring large amounts of heat without active fans or pumps. We 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 is considering other applications for the new technology, such as cooling the components of computers, cellular phones, and radar systems.

5.6.4 Engineering Sciences

5.6.4.1 Engineering Sciences Research Foundation External Advisory Panel Review

An external advisory panel review was held for the Engineering Sciences Research Foundation. The review panel reemphasized that foundation research is exceptional.

5.6.4.2 Invisible Gases Made Visible with Infrared Laser Imaging

Sandia's backscatter imaging of leaks shines an infrared laser on areas to be probed. Part of the 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 television-like screen. During the past year, Sandia has increased both the range of such measurements and the number of gases that can be detected. The ultimate 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. Laser-based sensing may also be used to characterize emissions from destroyed explosives and detect weapons of mass destruction.

5.6.4.3 Bonded Enzymes and Transistors to Detect Chemical Warfare Agents

Biological enzymes combined with field-effect transistors produce a simple but sensitive detector for chemical warfare agents. The detector is less than a square inch and relies on enzymes developed to digest chemical agents. A drop of solution is placed on the detector; if a chemical agent is present, the enzymes begin digesting it. During digestion, 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—indicators that chemical agents are present.

5.6.4.4 Direct Numerical Simulations of Combustion

This numerical simulation analyzed eighteen chemical species and sixty-eight 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. Pocket formation is affected by the diffusion into the reaction zone of light hydrogen molecules, 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.

5.6.4.5 Replicated Dinosaur Sounds

Sandia and the New Mexico Museum of Natural History and Science collaborated to recreate the sound made by the Parasaurolophus dinosaur 75 million years ago. The dinosaur's bony tubular crest that extended back from the top of its head contained a labyrinth of air cavities that might have been used to produce sounds. The three-dimensional computer-modeling techniques used to create the dinosaur sound were the same techniques used to analyze 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.

5.6.4.6 Refrozen Food Detector

Frozen food that thaws in transit can now be identified by an inexpensive detector placed in the package. Sandia's patented detector changes color when the frozen food temperature rises above freezing.

5.6.4.7 Wear-Resistant Diamond Coating

Sandia has developed a simple and inexpensive way to relieve internal stresses of noncrystalline diamond films, a significant advance to produce wear-resistant coatings. Crystalline diamond coatings require high temperatures to deposit properly, and they have very rough surfaces. Stress-free coatings are deposited at room temperature and are extremely smooth, which will improve protection and extend lifetimes of tools, auto parts, and plastics (such as those used in biomedical devices). Sandia has applied for a patent.

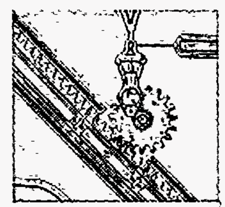
5.6.5 Pulsed Power Sciences

The traditional application of the Sandia Pulsed Power Program is radiation-effects science. The intense radiation environments achieved on the Saturn and High-Energy Radiation Megavolt Electron Source III (HERMES III) accelerators are critical for x-ray and gamma-ray certification of new hardware for stockpile weapon systems.

5.6.5.1 Z Accelerator Advances

The Z Accelerator reached a record output of cold x- rays (160 kilojoules of greater than 4.5 kiloelectronvolts). These x-rays are critical for evaluating the material response of components to hostile radiation environments that previously were available only in underground nuclear testing. This intense environment was put to use in supporting the radiation hardness certification of the MC4380 neutron generator. Another recent advance in z-pinch technology doubled the amount of x-ray energy produced by the Saturn x-ray source in aluminum and tungsten wire arrays. This technique will be applied to the Z Accelerator to improve the source for weapon-effects testing.

5.6.5.2 X-1 Advanced Radiation Source



Sandia's pulsed power science and technology program continued to break world records in both x-ray energy (2.0 megajoules) and x-ray power output (290 terawatts) using the Z Accelerator and z-pinch loads. Static and dynamic hohlraum temperatures of 150 electronvolts and 155 electronvolts, respectively, have been achieved. The Z Accelerator provides an important testbed for weapons science issues such as weapon effects, radiation transport, material properties and instabilities, experimental validation of computer codes, and development of a conceptual design for the proposed X-1 Advanced Radiation Source Facility. Sandia president Paul Robinson has asked the DOE to establish a date for a Critical Decision One review of the X-1 proposal.

Sandian Don Cook shows Albuquerque mayor Jim Baca a model of the Z Accelerator's wire array.

5.6.5.3 High-Yield Designs

Sandia has demonstrated the technical ability to develop the pulsed power driver that is theoretically required to achieve high yield. Currently, three potential target/capsule designs could achieve high yield. During 1998 additional analyses, two- and three-dimensional calculations and experimentation validated the three designs.

5.6.5.4 Advanced Hydrodynamic Radiography Program

A major advance in pulsed power technology was made for the DOE-sponsored national Advanced Hydrodynamic Radiography Program, which supports the proposed Advanced Hydrotest Facility. A critical requirement is an intense radiographic source to experimentally diagnose the complex implosions in the primary of a nuclear weapon. Sandia's application of a magnetically immersed electron beam diode has produced the extreme brightness required for advanced hydrodynamic radiography in the Sandia Accelerator and Beam Research Experiment Facility. Experiments scaled this technology toward full advanced hydrodynamic radiography intensities on the High-Energy Radiation Megavolt Electron Source III (HERMES III) accelerator.

5.7 Sandia Infrastructure

We continued realigning and refocusing Sandia's human, physical, and process infrastructure. We are establishing specific measurable goals, adopting proven and effective approaches derived from best-in-class models, insisting on accountability, tracking progress, and eliminating requirements that do not add value.

We also began aligning Sandia's and Lockheed Martin's strategic plan, strategic objectives, and operational plans with the goals and objectives of the DOE's strategic plans. To the extent possible, we incorporated this alignment into Sandia's performance measures for the annual DOE appraisal process.

5.7.1 Tiger Team Findings

In 1989, independent task groups referred to as "Tiger Teams" began conducting comprehensive environment, safety, and health compliance audits at DOE facilities.

Sandia closed out and received completion certificates from the DOE Albuquerque Operations Office for 563 findings included in the Tiger Team audits at Sandia/California in August 1990 and at Sandia/New Mexico in May 1991. The last finding was closed out on 29 July 1998, far ahead of the original schedule of May 2003.

5.7.2 Integrated Safety Management System

Sandia's Integrated Safety Management System was implemented to assure that all work is performed safely and efficiently. The system provides a framework for line ownership of safe work practices and applies basic management concepts and principles to all activities under the purview of environment, safety, and health.

5.7.3 Environment, Safety, and Health Services

Sandia improved environment, safety, and health services by establishing multidisciplinary teams to support Sandia line organizations. Members of line support teams are often located at their customers' facilities to provide dedicated, real-time, support. Team members strive to provide risk-based options on how work can be done safely, comply with requirements, and cost less. Line management determines the acceptable level of risk based on consequence and cost of controls.

5.7.4 Infrastructure for a Revolution in Engineering and Manufacturing

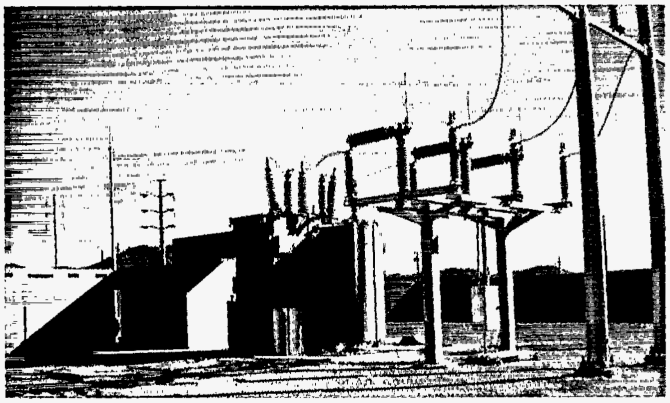
We began to align the information infrastructure with the emerging revolution in engineering and manufacturing. We improved the usefulness of the classified Internal Secure Network for the nuclear weapons design community. We piloted an integrated information system for firing set electromechanical components that provided nuclear weapons engineers desktop access to product realization information. A companion pilot project provided the W76 redevelopment effort with seamless project management tools.

5.7.5 Oracle System

We converted from a number of internally developed systems to a single, commercial Oracle system for our manufacturing and financial systems. The manufacturing portion of Oracle was implemented on time and within budget. Other commercial systems implemented were the PeopleSoft system for payroll and human resources, Business Objects for financial reporting, and WebER for online expense reporting.

5.7.6 Facilities

The Power Systems Modernization Project is under way. This project is correcting all safety concerns, converting all primary overhead transmission lines to 115 kilovolts, and providing a second power source.



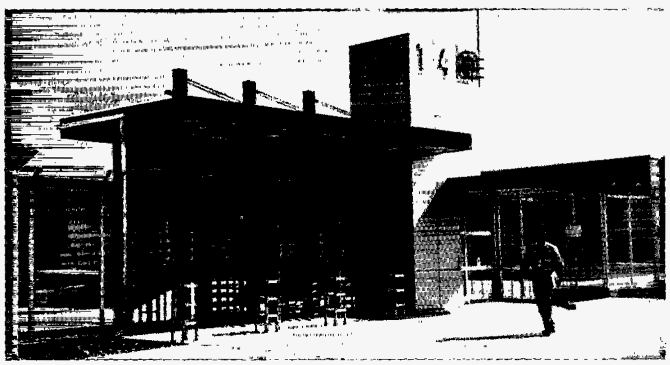
The Power Systems Modernization Project is under way at Sandia/ New Mexico.

5.7.7 Space Consolidation

More than three hundred personnel were moved into space better suited to their needs. Half of these were moved from a remote location to Technical Area I, where there is better access to resources and equipment.

5.7.8 Automated Doors and Gates

Almost all entrances in Technical Areas I and IV are now completely automated, with thirty-three automated turnstiles, thirty-one automated doors, and one automated vehicle gate providing limited access to areas and buildings. More than 200,000 gate entries are made each month. Two DOE security appraisals resulted in no automated access deficiencies, and user surveys show an 80 percent satisfaction rating.



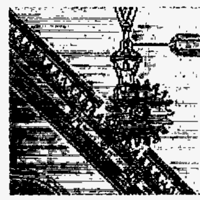
Automated gates have replaced guards at many secured entrances.

5.7.9 Surplus Nuclear Material

Nearly fifteen metric tons of radioactive materials were eliminated from Sandia's inventory, resulting in a significant reduction of overhead costs.

5.7.10 Conversion to Property Protection Area

In March, ahead of schedule and under budget, Sandia/ California completed conversion of the south two-thirds of the site to a property-protection area with classified islands. This four-month project involved successful teamwork among the Safeguards and Security, Facilities, and Maintenance organizations. Benefits include increased mobility for uncleared personnel, a related drop in escort costs, enhanced ease of interaction with present and potential business partners, and removal of extensive and unsightly fence work.



5.7.11 Procurement

We implemented an online procurement guide for Sandians and suppliers, reduced cycle time and complexity by consolidating contracts for staff augmentation and communications products, piloted an electronic purchase request system, moved toward commercial best practices in source selection, and piloted a new supplier evaluation process.

Sandia's efforts in providing contracts to small businesses were honored on 3 June 1998, when Sandia was named the DOE's FY 1997 Management and Operating Contractor of the Year for Small Business Program Policies.

5.7.12 Customer Satisfaction

A second external customer satisfaction survey showed overall improvement from the prior year in levels of satisfaction. Four new corporate-level actions were identified and assigned as part of our continuous improvement. Results and actions were presented to Sandia executive and middle management, the DOE, and Lockheed

Martin. An FY 1997 and FY 1998 statistical impact analysis of internal customer satisfaction with support services identified high-impact opportunities, and more than seventy improvement actions were completed.

In February 1998 the Area Manager of the DOE Kirtland Area Office formally transmitted the DOE's performance appraisal of Sandia for FY 1997. The appraisal (which always lags the current fiscal year) gave us an overall rating of "outstanding" for meeting DOE mission priorities.

5.7.13 Area III Remediation

We received a permit from the Environmental Protection Agency and completed the first phase of construction of the Corrective Action Management Unit, which included bulk waste storage areas. This Corrective Action Management Unit is located in Technical Area III and is designed primarily for remediation of the Chemical Waste Landfill. This is the first such unit approved in the DOE complex.

5.7.14 Sandia Overhead Reduction

We reduced our total general and administrative, site support, and center support costs. Redesigning business processes to make them more efficient and cost effective adds value to the line operating environment and helps Sandia accomplish our strategic and operational objectives.

5.7.15 Technical Library Center of Excellence

Our technical library implemented an imaging center of excellence, a service intended to help researchers better manage their document collections. The library digitizes program documents to make them more useful, manageable, sharable, and retrievable.

5.7.16 World Wide Web Site Award

The Web Marketing Association gave Sandia's web site a "best of industry" award in the government agency category. More than two hundred sites were judged on the bases of design, innovation, content, interactivity, ease of use, and use of technology.

5.7.17 Information System Pilots

We piloted an integrated design and information system for firing-set electromechanical components. This prototype system allows users at desktop computers immediate and complete access to major component designs via a high-resolution image management system with connectivity to an internal secure network.

A second information system pilot seamlessly integrated project management tools with infrastructure information. The pilot system involved the customer in a detailed design review and established user screen designs, case statements, and an extranet web site.

5.7.18 Reduction in Days-Away Case Rate

Sandia successfully reversed an adverse trend in the days-away case rate, the safety metric that indicates the most serious work-related injuries and illnesses. At the end of FY 1997 the corporate days-away case rate was 0.53 (53 cases per 10,000 people), an increase from Sandia's past performance and above the corporate goal. At the end of FY 1998, the days-away case rate had dropped to a lower number because of implementation of safe work practices through the Integrated Safety Management System and specific corrective actions in high-injury types of work.

5.8 Partnerships

This year Sandia obtained more than $50 million from strategic partnerships with industry and an additional $1.75 million from licensing our software and technology. We established executive points of contact with more than twenty strategically important companies, including three major aerospace/defense contractors. We developed a preferred technology partner status with Boeing regarding advanced modeling and simulation; executed agreements with Lockheed Martin Corporation for revenues exceeding $2 million; began developing a strategic modeling and simulation partnership with Lockheed Martin Corporation for teraflop computer applications; and developed collaborative efforts with Raytheon (Hughes). We also developed strategic relationships with six critical suppliers, and we are involving partners in our strategic grand challenges such as the chemistry laboratory on a microchip (chemlab). Similarly, our extreme ultraviolet lithography partnership with the consortium and other laboratories completed agreements with several critical suppliers. These suppliers are providing hardware for critical system components—including the laser plasma source, the engineering test stand, optics, and steppers.

5.8.1 University Campus Executives

The campus executives appointed last year for seventeen universities interacted with their campuses this year, met regularly with their campus recruiting teams, and led the development of data books for their recruiting team. Contracts for strategic research partnerships were placed at five key universities.

5.8.2 International Programs Working Group

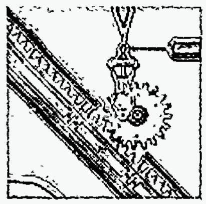
The International Programs Working Group was established to provide a forum for communication among groups involved in international program development and for sharing issues and lessons learned. An international partnering site, established on Sandia's internal web, includes a downloadable copy of the international partnering guidelines. International collaborations include a Russian fuel cell consortium and an environmental hardware initiative.

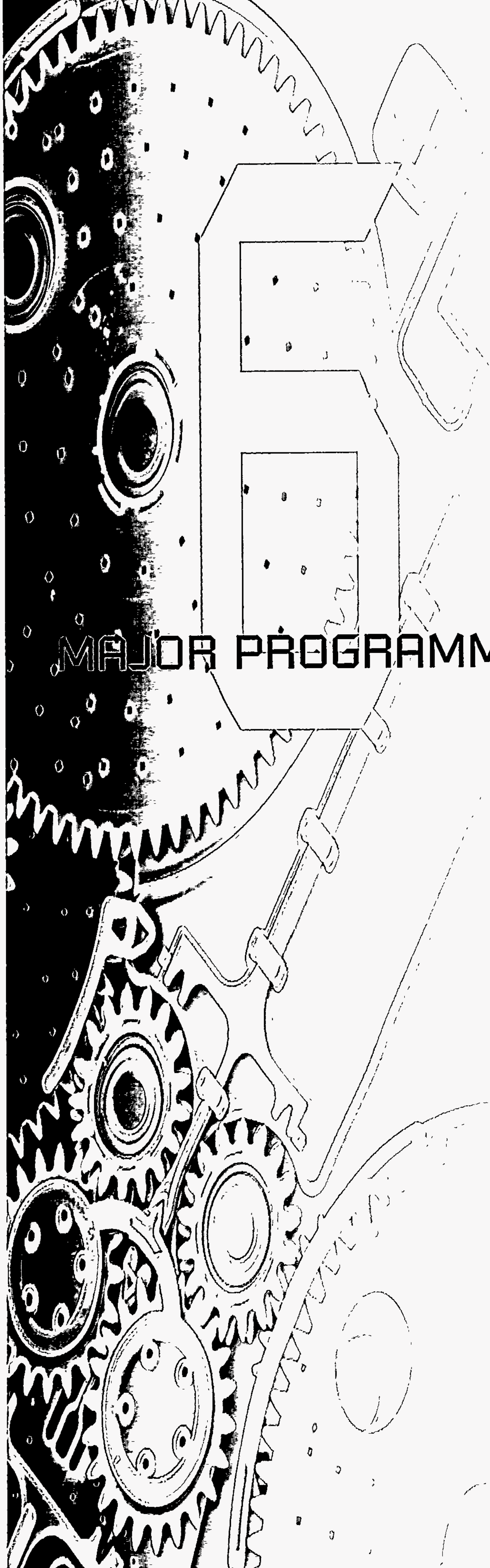
5.8.3 Cooperative Research and Development Agreement for GOMA Code

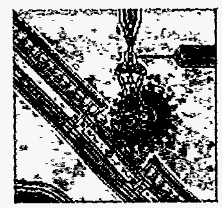
Sandia and the Coating and Related Manufacturing Processes Consortium signed a $2.5 million cooperative research and development agreement to advance GOMA, Sandia's finite-element code that analyzes fluid-dominated manufacturing processes critical to DOE Defense Programs. One manufacturing process applies 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.

5.8.4 United States and Russia Nuclear Weapons Surety

The presidents of Sandia and the Russian nuclear research center signed a memorandum of understanding that encourages collaboration in applying Sandia- and Russian-developed nuclear weapons surety principles to all US and Russian critical infrastructures. The agreement resulted from discussions among scientists at both institutions and will lead to the improved safety, security, and reliability of infrastructure components such as gas pipelines.







MAJOR PROGRAMMATIC ACTIVITIES

6.1 Programs for the Department of Energy

6.1.1 Assistant Secretary for Defense Programs

President Clinton recently reconfirmed the necessary role that nuclear weapons continue to play in our national defense policy and our national security framework:

> Even with the Cold War over, our nation must maintain military forces that are sufficient to deter diverse threats.... We will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership with access to strategic nuclear forces from acting against our vital interests and to convince it that seeking a nuclear advantage would be futile. Therefore, we will continue to maintain nuclear forces of sufficient size and capability to hold at risk a broad range of assets valued by such political and military leaders....[1]

[1] President Clinton's Nuclear Posture Review of the US Strategic Command (July 1997).

In the first months of 1998, amid continuing speculation about the military capabilities of North Korea and Iran, it was revealed that China had developed a capability for accurate intercontinental delivery of nuclear weapons. In May 1998 India suddenly resumed nuclear testing with the detonation of five devices over a period of only a few days. Following the apparent success of this testing campaign, Indian Defense Minister George Fernandes announced that India would follow a policy of no first use of nuclear weapons but would "inevitably" arm a portion of its missile arsenal with nuclear warheads. Fernandes said that being a nuclear weapons state does not make any sense without such weaponization. Later in May, Pakistan (which continues to clash with India over control of the border region of Kashmir) responded with multiple nuclear tests and announced the deployment of its own nuclear arsenal, issuing an official statement indicating that the long-range Pakistani Ghauri missile was being capped with nuclear warheads to respond to India. By the middle of June, both India and Pakistan had clarified their position several times; however, international concern remained high.

Although these events may not be an immediate threat to US vital interests, it is clear that even in the wake of the Cold War the United States must be prepared to cope with a dynamic global security environment characterized by the rapid evolution and spread of military technologies, including weapons of mass destruction and systems capable of delivering them. In this environment, the US nuclear weapons stockpile continues to be a necessary element of our national defense.

The three DOE Defense Programs national laboratories are responsible for the design, production, and maintenance of the US nuclear weapons stockpile. Both Los Alamos and Lawrence Livermore national laboratories design nuclear explosive packages around which the weapons of the stockpile are constructed, while Sandia has sole responsibility for integrating such nuclear explosive subsystems with the myriad nonnuclear components and subsystems necessary for safe, survivable, reliable, and deployable nuclear weapons. In this critical systems integration and ordnance engineering role, Sandia is the central interface with the DOD for weapons requirements, system design, logistics, surveillance, maintenance, training, and dismantlement.

Sandia's responsibilities include the design, development, testing, certification, production, maintenance, and retirement of the principal subsystems for safing, arming, fusing, and firing; external neutron initiation; gas transfer; use control; aerodynamic and structural components; delivery system interfaces; and the associated hardware and instrumentation needed to test these systems. We must also certify that these components are hardened to function properly after exposure to radiation. These responsibilities involve more than 90 percent of the individual parts of a typical nuclear weapon, which often contains more than six thousand parts representing at least one hundred classes of component types and two hundred process streams for manufacture and assembly. Limited-life components have service lives based on the constant, relatively rapid, and precisely predictable degradation of their particular constituent materials. Such components must routinely be replaced before these constituent materials degrade sufficiently to compromise their ability to function properly. Sandia also has critical responsibilities for production of many of these components.

Sandia provides field engineering support to the military throughout the service life of every nuclear weapon in the areas of use control, handling, shipping, storage, and maintenance. These responsibilities include support for the periodic replacement of limited-life components, a process known as limited-life component exchange. We develop and maintain capabilities for the safe and secure transportation and storage of nuclear weapons, design the ancillary equipment that enables military personnel to handle and maintain nuclear weapons safely and securely, and support the dismantlement of weapons retired from the stockpile. Sandia also conducts the stockpile sampling and surveillance program for the DOE as well as specific surveillance activities associated with Sandia components and subsystems. We support retrofits that improve the safety or use control of stockpiled weapons or correct defects discovered through stockpile surveillance.

Our primary mission is to ensure that the stockpile remains constantly safe, secure, reliable, and fully capable of supporting the nation's deterrence policy. Our most important responsibilities are nuclear weapons reliability and surety; we ensure the continuous safety, security, use control, and overall reliability of every nuclear weapon. Nuclear weapons with the advanced safety, security, use control, and performance characteristics of the US nuclear weapons stockpile represent an extraordinary technical achievement, and maintaining these weapons is a complex and demanding task. Sandia's "cradle-to-grave" responsibilities demand an enduring knowledge base, a science-based engineering approach, and a fundamental understanding of both existing and future technologies. Thus, we must address two stewardship issues. First, we must ensure the reliability and credibility of the stockpile. Stockpile surety is a very clearly defined responsibility, which is annually assessed, certified, and reported to the President. Second, we must sustain the capabilities and expertise (the nuclear weapons competency) needed to assure the viability of the stockpile in the future. Maintaining these capabilities is a more subtle and complex task but is equally critical to the long-term credibility of the deterrent.

We remain committed to sustaining the core intellectual, technological, and physical infrastructure necessary to support our mission. Our commitment to this mission reflects the continuing need to preserve the credibility of the nuclear deterrent through this challenging period of our history. However, our ability to sustain this national investment has eroded during the past several years. We are increasingly forced to operate in a risk-mitigation mode, balancing immediate stockpile obligations against the need to assure a viable future stockpile and to preserve the people, facilities, and capabilities required to provide that assurance. Although guided by the DOE's long-term comprehensive planning and management effort (the Stockpile Stewardship and Management Program), we continue to face critical challenges exacerbated by a gradual decline in real funding, as anticipated budgets remain insufficient to fully support stockpile obligations and implement projects that are both needed and already planned.

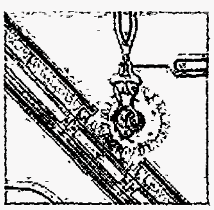
The fact that no new full weapon designs have been developed or produced for many years poses several challenges. The weapons remaining in the US nuclear weapons stockpile are rapidly aging past their original design lives, we have little experience with age-related deterioration in materials or components under these circumstances, and the credibility of the deterrent rests on a shrinking stockpile of these aging weapons. Stockpile reductions have diminished the number of weapons in the stockpile and have also retired many of the older weapon types, reducing the number of different weapon designs in the arsenal. The stockpile is now more uniform than at any time since the 1950s, increasing the risk that a single repeated flaw, known as a common mode failure, could compromise the remaining weapons. This risk is exacerbated by the fact that today's consolidated, streamlined, and smaller production complex has less capacity to rapidly respond to a large unanticipated problem.

The absence of new weapons development programs has also affected our human resources. We met the challenge of the Cold War by building and sustaining our human sources of innovation, by applying the resulting technological leverage, and by maintaining constant vigilance against technological surprise. The true foundation of the deterrent has always been the intellectual, scientific, and technological capabilities of our staff and their ability to apply technological leverage toward national security objectives. However, over time and in the absence of new weapons development, we are losing personnel who have direct experience with the weapon development process. With declining budgets, the number of weapons scientists and engineers at Sandia is now lower than at any time in nearly fifty years. Our critical base of experience in system and subsystem design and integration is eroding, and the next generation of weapons probably will be developed by individuals having no previous experience with the complexities of a complete weapon design and integration effort.

The challenges that we face are chronic and acute. For example, the need to maintain reliable sources of radiation-hardened microelectronics and associated technologies is a continuing concern. Because radiation-hardened microelectronics are not reliably available from alternative sources, additional resources are needed to ensure a capability to fabricate these essential weapons components. A comparable area of acute concern is the need to preserve and properly utilize our tremendous national capabilities in pulsed power technology. Pulsed power is currently the only method available to certify the survivability of subsystems and systems in hostile environments and to validate the computer codes being developed, making our pulsed power research and capabilities vital to properly mitigating the risks associated with the cessation of underground nuclear testing.

The activities of the nuclear weapons complex are defined and guided by the two fundamental elements of the Stockpile Stewardship and Management Program. The first element is stockpile stewardship, which encompasses activities that preserve and exercise the fundamental scientific and technological capabilities required for the necessary long-term support of the stockpile. The second element is stockpile management, which entails the engineering, production, surveillance, and maintenance activities that support specific weapon, component, or stockpile needs. However, nuclear weapons are an extremely complex technical achievement. Therefore, the long-term credibility of the deterrent can be ensured only through a coordinated effort that is seamlessly implemented from initial design, through production and field deployment and maintenance, to final retirement and dismantlement. At Sandia, we approach our responsibilities in this coordinated manner.

For example, we have organized a major portion of our work on computational modeling and simulation and on advanced design and manufacturing technologies into a set of programs that will collectively focus on the Revolution in Engineering and Manufacturing Initiative. This initiative is being developed to gain maximum benefit from available resources, to focus advanced development in computational modeling and simulation and in advanced design and manufacturing technologies, and to provide improved opportunities for application of the tools developed in these programs to ongoing stockpile support projects. The objective of this initiative is to significantly reduce cycle times, costs, and defects—thereby providing a more affordable and maintainable nuclear weapons stockpile.



The Revolution in Engineering and Manufacturing Initiative includes four program areas. The first program is high-end, nonlinear computing, which sustains and modernizes our strategic computing capabilities through development of enabling technologies for the computational speed and efficiency required to tackle modeling, simulating, and prototyping complex systems. This first program also includes the development of fundamental algorithms, software, and methods that enable the use of massively parallel computing systems and that guide the development toward applications directly relevant to modeling and simulating complex nuclear weapon components and systems. These activities are all part of the Accelerated Strategic Computing Initiative (ASCI).

The second program area is information integration and virtual prototyping. This area includes endeavors that are part of the Advanced Design and Production Technologies (ADaPT) Initiative, as well as several ASCI components. This program area also includes several ongoing stockpile support projects. These weapons projects will define processes for integrating ASCI, ADaPT, and advanced manufacturing capabilities into standard stockpile support endeavors. They will also provide a focus for much of the advanced development in these technology areas.

The third program area is engineering business practices and information systems. The primary objective is to create a seamless, compatible, and accessible software interface between an engineer's workstation and available high-performance computing, modeling, simulation, and virtual prototyping capabilities. As this program is developed, it will offer engineering personnel the opportunity for complete vertical integration, from computer-aided design tools and drafting files, production drawings, and field maintenance and stockpile surveillance reports to interactive high-performance modeling and simulation applications. These advances are enabling the use of highly automated, digital, paperless engineering, testing, and production techniques. The completed portions of this program give engineers access to a standardized, integrated, digitized engineering information infrastructure that provides immediate access to the information and design and analysis tools they need for model and simulation-based life-cycle engineering processes. The result is that engineers are beginning to use this computational environment as their first line of approach to the stockpile management process, thus reducing the need for physical prototyping, bypassing unnecessary tests, eliminating negative environmental impacts, and lowering the time and costs involved in the work. Engineers are learning to accurately model nuclear weapons needs for use in simulating, planning, and evaluating innovative technology approaches, predicting production capacities and inherent limitations, interpreting the impact of changing stockpile requirements, and assessing weapons system management strategies before making investment decisions.

The fourth program area entails the participation of Sandia's Chief Information Officer, who provides the infrastructure for all information management at Sandia and works to assure compatibility among the other initiatives, facility capabilities, and capacity.

6.1.1.1 Core Stockpile Stewardship Programs (DP0101)

The United States faces two critical issues that are the focus of Sandia's efforts in nuclear weapons stockpile stewardship. We must maintain confidence in a continuously aging stockpile, and we must reduce and manage the vulnerability of a smaller stockpile to common mode failures. Moreover, we must resolve both issues without underground nuclear testing.

With no new weapons being developed or produced, the age, size, and structure of the stockpile will continue to change into the next century, with important implications for maintaining the credibility of the deterrent. The stockpile will soon be the oldest ever deployed by the United States, and we have little precedent to guide us in predicting nuclear systems deterioration under these conditions. In the past, the stockpile consisted of more weapons and more types of weapons, providing both a substantial base from which to gather reliable stockpile surveillance data and a substantial inventory of deterrent options in the event of a problem with any particular weapon type. Today, however, reductions in stockpile size and the number of different weapon types in the stockpile have reduced the diversity of the stockpile and raised the possibility that a common mode failure could compromise a significant portion of the remaining deterrent. In addition, stockpile size reductions have also increased the relative importance of each aging weapon as part of this smaller available deterrent. These factors narrow the margin of error that can be tolerated in the remaining weapons and drive the need for better stockpile surveillance to ensure the continuing credibility of the deterrent.

Unfortunately, these same stockpile reductions and aging processes have also eroded the primary traditional mechanism for conducting surveillance. We traditionally monitored the condition of the stockpile by randomly selecting and inspecting weapons for extensive and often destructive testing. As problems in weapons components, systems, or subsystems were discovered, Sandia investigated the cause and potential impact on the stockpile and then developed options for correction. This ongoing sampling process consumed a number of weapons and components over the service life of a particular weapon type. In the past, greater production capacity and shorter weapons service lives allowed the prebuilding of sufficient replacement parts to establish a "protected period" for each weapon type. During this protected period, a desirable rate of stockpile sampling could be maintained without reducing weapon numbers below intended stockpile levels. Today, however, we face reduced stockpile numbers, sharply constrained production capabilities, and far longer service lives. Most weapons now in the stockpile have already served beyond their intended service lives, and all weapons in the stockpile will reach the end of their design lifetimes during the next two decades. Given these conditions, the weapons remaining in the enduring stockpile will outlive their protected periods, thus reducing opportunities for stockpile sampling, eroding stockpile numbers, or both. These issues are driving the development of a new science-based approach to stockpile stewardship, an approach that is shifting away from our past reliance on physical prototyping and empirical testing and toward the greater use of computational modeling and simulation to support maintenance.

6.1.1.1.1 Direct Stockpile Activities (DP010101)

Sandia's direct stockpile activities include work in replacement component development, stockpile readiness, stockpile improvement, enhanced surety, future technologies, and stockpile reduction. With no new weapons being developed or produced, these efforts are generally constrained to studies, technology demonstrations, stockpile surveillance, dismantlement, or the development of specific "piece parts" required to repair deterioration or defects in existing weapons components or to make limited modifications essential to maintaining deterrent credibility as the stockpile continues to shrink and age.

Today, the US nuclear weapons stockpile is safe, secure, and reliable; however, ensuring the continued reliability and safety of these aging weapons is already a significant engineering challenge. Most weapons components suffer from normal aging, have physical limits on their service lives, and must eventually be refurbished or replaced. Limited-life components, which have service lives based on the predictable degradation of specific constituent materials, must be routinely replaced before the materials degrade sufficiently to compromise their reliability. To address these challenges, the Stockpile Stewardship and Management Program includes a systematic component replacement program known as the Stockpile Life Extension Program (SLEP).

Although the SLEP focuses heavily on meeting scheduled limited-life component exchange needs, Sandia's critical responsibilities in nuclear weapons surety, particularly in the area of weapons safety, also drive many of the component upgrades. Sandia plays a crucial role in maintaining confidence in stockpile safety and reliability, a role that requires us to ensure the continuous security, safety, and use control of all nuclear weapons. Safety remains paramount in stockpile stewardship, and Sandia strives to ensure that all safety and security components inculcate the most advanced and reliable approaches. As a result, the SLEP also uses limited-life component exchange to both renew crucial components and approach limited-life component exchange and related modernization systematically and efficiently in blocks of related components.

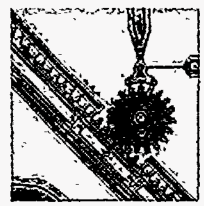
In spite of these efforts, the context for stockpile surveillance has changed in the current environment, where development activities are tightly limited. In the past, the safety, security, and reliability of the entire stockpile was pulled forward by the technological and engineering advances and the constant research, testing, review, and assessment associated with each new weapon developed. Thus, the entire stockpile benefited from a continuous process of material and design review and modernization. Today, with no new weapons being developed, the synergistic link between the maintenance of the stockpile and the ongoing weapons development and replacement process has been broken, drastically changing and intensifying our stockpile surveillance responsibilities.

Sandia is addressing these intensified responsibilities through a variety of programs, including the Enhanced Surveillance Program. Because of today's extremely long weapon service lives, much of our work is aimed at monitoring and addressing the impact of aging in weapons, weapons components, and weapons materials. We are expanding our knowledge of aging in modern industrial materials and advancing our knowledge of the effects of such aging in complex weapons components and subsystems. We are also expanding the use of advanced sensor technology to help reduce the cost of such heightened surveillance while obtaining the additional monitoring needed to detect failure processes before they can impact the deterrent.

Sandia supports weapons retirement schedules. Dismantlement continues to be a major effort to which Sandia provides support in transportation, storage, and disassembly. We support the safe and secure disposition of materials from dismantled weapons and also use the dismantlement process to gather information on the aging processes and their effects on weapons materials and components. To facilitate inspections, Sandia has developed expertise in special nuclear materials containers that periodically can be opened and resealed with induction brazing. This development arose from other research on joining metals, and we now are able to achieve multiple braze cycles, allowing repeated access and inspection without excessive embrittlement or erosion of the container alloy. Under other funding areas, our work on containers has also supported international disarmament efforts through the development of fissile material containers to assist weapon dismantlement in Russia.

6.1.1.1.2 Experimental Activities (DP010102)

Sandia is responsible for certifying that weapons systems and components are hardened to function properly when exposed to hostile radiation, whether encountered by satellites and reentry vehicles in space or by the environments created during nuclear detonations. Sandia integrates experimentation and computational simulation in support of radiation-effects testing, radiation transport, diagnostics, and analyses to certify that electronic components will operate in such hostile radiation environments. This role has made Sandia an internationally acknowledged center of excellence for the development and application of fast pulsed power technology, in collaboration with other national laboratories, domestic industry, and universities. The large-volume, high-temperature, high-energy-density environments uniquely generated with pulsed power are key contributors to weapon physics research and experimentation. These capabilities are especially critical in the absence of underground nuclear testing for certification of weapon survivability and performance. The inertial confinement fusion objectives of evaluating high-energy-density environments and developing high-yield fusion laboratory capabilities for DOE Defense Programs are also advanced by using pulsed power to drive z-pinch sources. These efficient, high-average-power sources of x-ray, electron, and ion beams are applied to a wide range of defense missions, including materials hardening, environmental remediation, and materials welding and joining. In partnership with industry and universities, we have also applied these capabilities to the exploration of materials surface modification, electronic pasteurization of food and pharmaceuticals, sterilization of medical instruments and medical wastes, and repetitive electromagnetic force.



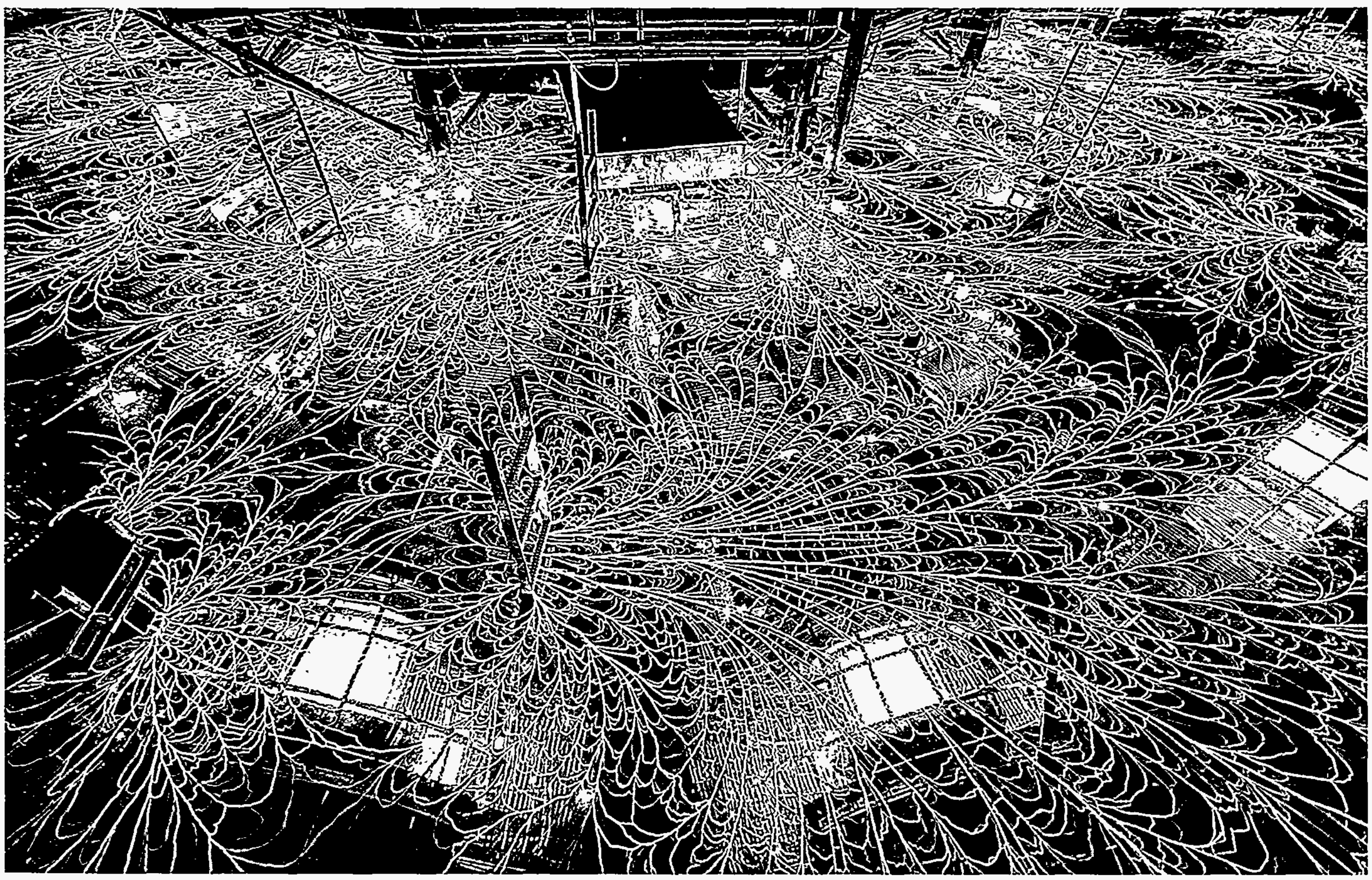
In accordance with a presidential directive, Sandia helps maintain the core capabilities that would be needed to resume underground nuclear testing at the Nevada Test Site. Our experimental activities fall into the three broad categories of archiving, nuclear component assessment, and nonnuclear component assessment.

Archiving creates and supplies a nuclear weapons effects and weapons developmental testing library containing all Sandia effects test information that has been deemed a national resource. Various types of information are involved; however, preserving information related to past activities at the Nevada Test Site is a critical priority.

In the area of nuclear component assessment, Sandia maintains underground test capabilities. Sandia's principal core capability supporting the Nevada Test Site is the provision of arming and firing systems used in underground testing. Sandia also provides and fields the arming and firing systems for effects and reliability testing, including integration with closure systems and experimenter timing requirements.

In the area of nonnuclear component assessment, Sandia is charged with certifying that weapons components and subsystems will survive and function reliably in hostile radiation environments. In the past, we relied heavily on underground nuclear testing of iterative prototypes to validate and certify the safety and reliability of the stockpile. However, with the cessation of underground nuclear and radiation-effects testing, we shifted to alternative methods that can reduce our reliance on large-scale empirical testing. Such alternative methods involve greater use of computational modeling and predictive analyses; they also include aboveground simulation for radiation-effects testing and computer code validation. To fully accomplish this shift, we must improve our understanding of complex systems and our ability to computationally model and simulate these systems. Thus, we need enhanced simulation capabilities, improved materials data, and advanced computational technologies. We are focusing our developmental work on aboveground experimentation, high-performance computing, and computational simulation.

In the aboveground experimental facilities for predicting the effects of radiation on electronics and materials, we are progressing toward a high-yield laboratory microfusion capability that can support the weapon physics and weapon effects concerns associated with the stockpile; this capability might also provide an option for fusion energy production. A principal focus of our pulsed power research program is to extend the ability to generate high-energy-density plasmas and to enable experimentation in regimes suitable for studies of radiation flow, radiation opacities, temperature scaling, warm x-ray weapon effects, and fusion capsule physics. Sandia's Z Accelerator continues to produce world record x-ray outputs that can be cost-effectively applied to stockpile surety concerns ranging from the simulation of weapons effects to the assessment of weapon physics calculations and designs. The unprecedented success of these efforts has prompted a proposal to construct the X-1 Advanced Radiation Source, which would be the next-generation accelerator. The X-1 would generate x-ray outputs far beyond those that can be generated on the Z Accelerator, enabling a comprehensive range of weapons and energy research activities at a comparatively low cost.



Sandia's Z Accelerator continues to achieve new breakthroughs in x-ray power output.

6.1.1.1.3 Accelerated Strategic Computing Initiative (DP010103)

In the past, we relied heavily on large-scale empirical testing of iterative prototypes, not only to certify that components could withstand hostile radiation environments but also to validate and certify the safety and reliability of the whole stockpile. In response to continuing budget constraints, a smaller stockpile that offers reduced opportunities for stockpile sampling, and increasing constraints on all forms of empirical testing, we must now shift to alternative and less expensive methods. The success of such methods generally will depend on innovative testing approaches. Rudimentary versions of virtual testing and prototyping are in use today; however, to meet our stockpile stewardship needs, virtual applications must achieve high-resolution, full-system capabilities. To accommodate simulations with the required complexity and detail, we must increase current computational speeds tremendously, and the objective of the Accelerated Strategic Computing Initiative (ASCI) is to accelerate these necessary advances in computational science and technology to hasten the shift from test-based methods to computation-based methods.

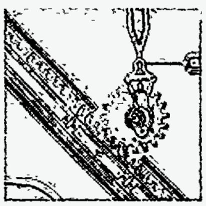
At Sandia, the ASCI consists of work in applications, problem solving environments, maintenance of sufficient onsite computational networking and communication capabilities, and alliances. The applications effort is presently developing high-performance, full-system, full-physics predictive codes to support weapons performance assessments, renewal process analyses, accident analyses, and certification. Our work on problem solving environments is designed to create a computational infrastructure and an operating environment that will ensure ASCI computational capabilities are always easily accessible and usable. Our onsite computational networking and communication capabilities embody the use of innovative approaches to develop and maintain the capabilities and connectivity required to properly fulfill our nuclear weapons responsibilities Our alliances coordinate the application of academic research to ASCI goals.

Sandia designers depend increasingly on virtual modeling and simulation, spending more time computing and less time and fewer resources on physical prototyping and expensive performance testing. Our needs range from integrating, accessing, and preserving existing information to creating, disseminating, and assessing new information—including predictions of age-related material degradation and complex accident scenario assessments. The technologies required to meet these needs range from desktop to high-end computers; they also involve networks for distributed computing, including security, system software, middleware, and associated tools and applications.

In the software domain, we are working on new mathematical methods, algorithms, and software for the solution of large-scale problems on massively parallel, often distributed systems. Areas of importance include shock physics, chemically reacting flows, electromagnetics, and the computational analysis and design of materials, all with application to accident scenarios, weapons performance and safety, materials aging, manufacturing, and infrastructure surety. As these techniques are developed, they are incorporated directly into codes and applications relevant to nuclear weapons system design and certification, weapons system response prediction, weapons systems and subsystems life spans, and virtual prototyping for the requalification and replacement of components and subsystems.

6.1.1.1.4 Special Projects (DP010104)

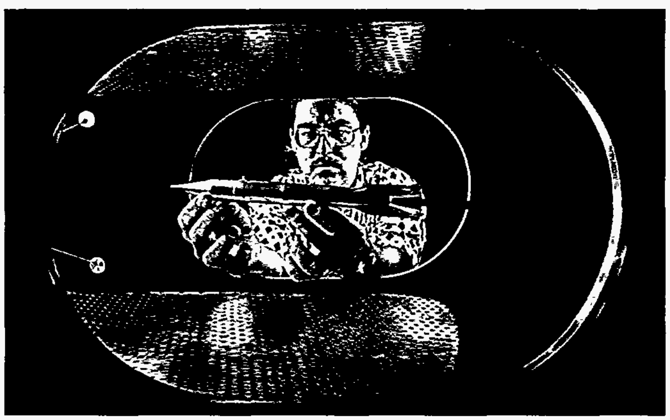
Sandia also undertakes unique special projects that are either mandatory for ongoing mission activities or particularly suited to our resident capabilities. For example, Sandia plays a distinct role in ensuring the security of nuclear weapons and weapons materials. As one of these special projects, we developed the SafeGuards Transporter, the next-generation vehicle for the safe and secure transport of high-value and high-risk materials within the continental United States. This vehicle drastically reduces the need to transport weapons by air, thus eliminating a potential safety concern. The SafeGuards Transporter has potential uses in the safe and secure transport of a wide variety of other hazardous cargoes for final disposition. Sandia also implements the Memorandum of Understanding on Munitions between the DOE and the DOD. This program is a cooperative, jointly funded research and development effort of the DOE and DOD to exploit the technology base resident at the DOE national laboratories to develop capable, cost-effective, nonnuclear munitions. We support activities in technology areas of mutual interest to the two agencies, and major research thrusts include reducing the operational hazards associated with energetic materials, advanced initiation and fuse development, munitions life-cycle engineering, hard target penetration, and computer simulation. Sandia also assists in efforts aimed at the efficient decontamination and decommissioning of buildings and the remediation of contaminated sites with the goal of reclaiming and properly reapplying defense site assets.



6.1.1.1.5 Performance Assessment Science and Technology (DP010201)

The technologies associated with performance assessment science and technology fall into the three focal areas of performance assessment, materials science and performance, and physics. Our work in performance assessment focuses on the integration of knowledge from advanced experimentation, the development of advanced computational algorithms directly derived from fundamental physical phenomena, and the subsequent evolution of advanced computational models and simulations of these complex phenomena. The modeling and simulation work in performance assessment provides a basis for model- and simulation-based life-cycle engineering for weapons applications, particularly the characterization of normal and abnormal environments and quantification of the response of weapons components and weapons systems to these environments. These goals drive a new role for our testing capability, specifically the experimental validation and certification of analytic models to establish unprecedented confidence in the use of computational simulations for nuclear weapons surveillance and maintenance. The Model Accreditation Via Experimental Sciences for Nuclear Weapons Program supports this validation and certification of computational models. Because predictive modeling is only as good as the physics that underlie it, the Experimental and Systems Certification Capabilities Program establishes integrated and efficient system certification capabilities to support the nuclear weapons program, including subelements addressing technology development, knowledge preservation, and modernization. The needs of these two groundbreaking programs are also driving the development of a new technology base that can provide the unique diagnostics and experimental techniques and the micro/nanoscale sensor and device technologies needed for full-field characterization and high temporal and spatial resolution. These capabilities are essential for phenomenology definition and subsequent model development.

Our work in materials science and performance spans the synthesis, characterization, and processing of metallic, ceramic, organic, and composite materials and is intended to provide a fundamental understanding of materials, materials processing, and the performance of devices on the atomic and molecular scale. One of our distinguishing strengths is the development of advanced materials and processes tailored to meet the needs of a specific application. These competencies form the technical basis for meeting mission needs for new and replacement materials for refurbished weapons components, enhanced surety subsystems, and advanced energy storage devices. New methods of processing materials are explored with the goal of creating manufacturing processes that will fabricate components more quickly and inexpensively, while longer term studies of changes in materials over time produce models of aging for reliability predictions. Physical processes at the nanoscale level are measured and modeled to support work in miniaturized components, with one area of development being the integration of statistical techniques with advanced analytic techniques to enhance information extraction in near-real-time and near-atomic scale scenarios. Areas of emphasis include semiconductor physics, electronic materials, nanostructures, surface physics and chemistry, ion/solid interactions and defects physics, materials sciences, and shock wave physics. For example, our efforts in nanostructures, advanced materials, and ion beam science involve a number of related areas. First, we are conducting experimental studies to complete algorithms required for first principle simulations of materials performance and aging, from which we are evolving computational models of the shock-induced electrical and mechanical performance of new ferroelectric ceramics for incorporation into weapons component surveillance and maintenance codes. Second, we are developing validated models to forecast and optimize the design of next-generation, radiation-hardened integrated circuits. Finally, we are developing a modeling capability of the shock wave response of "small" smart materials and structures for surety microdevices.



Sandian Ken Chavez adjusts a scale model of the B61-11 for a wind tunnel test.

Our work in physics supports applied physics research for nonnuclear component assessment as well as source development experiments and studies using Sandia's pulsed power facilities to better understand the transport of radiation through matter, the deposition of radiation in materials, the mechanisms leading to damage and failure in components and integrated circuits as they age past their expected lifetimes, and the mitigation of these and other radiation-related damage mechanisms. We are also optimizing and applying the uniquely efficient radiation environments created by z-pinches. Areas of major interest include x-ray effects in materials and electronics, z-pinch source development, radiation transport applications, and advanced pulsed power development.

6.1.1.1.6 System Components Science and Technology (DP010202)

This technology category is subdivided into the three focal areas of systems engineering, advanced manufacturing technology, and component science.

Sandia's capabilities in systems engineering are our defining strength. We are charged with the proper integration of nuclear explosive subsystems with the myriad nonnuclear components and subsystems necessary for safe, reliable, and readily deployable nuclear weapons. Thus, we have "cradle-to-grave" stewardship of all principal nonnuclear subsystems, including aerodynamic and structural components, delivery system interfaces, and the associated hardware and instrumentation needed to handle and test these systems. Sandia also coordinates, engineers, and certifies the complex interfaces and interactions among these materials, components, and subsystems. Sandia's most important responsibilities are to ensure the safety, security, and reliability ("surety") and the use control of the US nuclear weapons stockpile. From a functional standpoint, these responsibilities cannot be subdivided or addressed piecemeal but must be met through a comprehensive, coordinated, continuous, and fully integrated involvement with every aspect of nuclear weapons design, development, testing, certification, production, maintenance, and dismantlement. These critical engineering and integration responsibilities define Sandia as an institution with unique systems engineering capabilities.

Sandia's stewardship encompasses every phase in the life span of every weapon in the stockpile from design to dismantlement; it also includes scientific and technological integration across the entire spectrum of functions within that stockpile. From use control strategies and components to limited-life component exchange procedures, Sandia has responsibility for coordinating, integrating, and ultimately transforming DOE's requests into a credible nuclear shield.

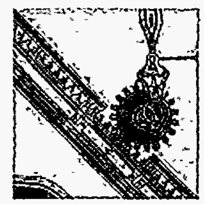
Sandia's capabilities in systems engineering were demonstrated by the rapid development of the B61-11, a mechanical field modification that converted the B61-7 into an earth-penetrating gravity bomb as a replacement for the aging B53. This extensive retrofit repackaged the B61-7 into a new one-piece, earth-penetrating steel case and certified that all materials, components, and subsystems of the repackaged weapon would work properly in their new configuration. This effort involved all aspects of systems engineering, ensuring the proper physical and functional interactions between components and subsystems, certifying the long-term mechanical and chemical compatibility among diverse materials, and ensuring the maintainability of all such materials, components, and subsystems.

To create the B61-11, we used massively parallel computer simulations of earth penetration and thermal and mechanical shock to evaluate timing, shocks, stresses, and standoff requirements; employed our competencies in materials, computation, and engineering science to model and design a new steel weapon case to withstand extreme stresses; used our competencies in microelectronics and the engineering sciences to ensure safety, security, reliability, and use control under new handling requirements and delivery system interfaces; and used our competencies in microelectronics, computation, and pulsed power technology to certify an appropriate level of radiation hardness. We delivered the B61-11 to the Air Force two weeks ahead of schedule.

Sandia's expertise in advanced manufacturing technology is also critical. With the passage of time, materials and methods originally used to produce the weapons remaining in the enduring stockpile are no longer available. In some cases, materials and methods have become commercially obsolete, replaced by more modern alternatives. For example, most radiation-hardened microelectronics are no longer produced or the technology is no longer supported by former suppliers. A problem in one of these components could result in the need for an immediate redesign and refabrication of a crucial weapon subsystem. In other cases, modern safety or environmental concerns have halted the use of older materials and methods. We cannot rely on the ability to produce replica components from original and now outdated designs. Maintaining the ability to design, develop, certify, and either produce or procure updated materials and components is vital to ensuring the long-term reliability of the stockpile.

To meet these challenges, we are pioneering a new revolution in engineering and manufacturing that builds on our established strengths in concurrent engineering, advanced processes and materials, and "agile" manufacturing methods. Also, our direct production responsibilities for neutron generators provide an opportunity to pilot, prototype, and demonstrate revolutionary new approaches.

In the past, we followed the standard industrial practices of the time. We defined an initial design, built prototypes, tested and evaluated these prototypes to determine design performance, refined our designs, and then adjusted the resulting designs for manufacturability. Although appropriate at the time, this linear and iterative use of physical prototypes and empirical testing was expensive, time consuming, and inefficient. Production support for a smaller stockpile in today's tight fiscal environment demands a more agile production complex in which manufacturing facilities and processes are flexible and responsive and the same production infrastructure can be used for fabricating a wide variety of products.



Concurrent engineering techniques have proven valuable for maintaining a proper relationship between product designs and manufacturing processes. Thus, we are using computational modeling and simulation technologies to develop modular design tools that enable the concurrent optimization of designs for performance, manufacturability, inspection, environment, procurement, and cost. We are creating linked virtual prototyping environments in which a product and its manufacturing processes are designed concurrently. Evolving computational technologies enable a better focus on the entire life cycle of a weapon,

A Sandia-developed planning and visualization software was used to design assembly sequences for the B61-11. Sandian Terri Calton is shown with the B61-11 tail assembly and the computational model.

with particular emphasis on new, more efficient, and better integrated approaches to design, testing, and production. These techniques reduce time and labor during the design phase, contribute to improved product performance, lower manufacturing risk, shorten the product realization cycle, and cut costs.

These advanced capabilities were demonstrated when the prototype for a replacement nose tip was taken from concept to an accepted flight component through a completely paperless process. This polycarbonate nose tip is a very complex shape requiring five-axis machining, yet drawings were neither created nor needed. Solid models of the part were developed as computer files using design/engineering software. These files were directly compatible with the software packages used for finite-element analysis, numerically controlled machining, and inspection. The process proved to be so flexible and efficient that refinements to the part were allowed even as it was being machined, with no significant downtime.

We are also applying these new computational tools to the development of advanced materials and processes for sensors, optoelectronics, and radiation-hardened electronics, as well as fabrication techniques for advanced submicron semiconductor circuits. In response to environmental concerns, we have developed environmentally benign materials such as solders with a lower lead content, polymer curing agents that are not carcinogenic, and nontoxic solvents that do not impact atmospheric ozone.

An agile manufacturing operation benefits from the use of advanced materials and techniques and allows flexible manufacturing processes to be readily established and easily modified, upgraded, or replaced. Sandia is already applying such agile manufacturing concepts to the fabrication of replacement components.

Ultimately, the safety and reliability of every nuclear weapon in the stockpile directly reflect the level of perfection with which we discharge our component engineering responsibilities. Sandia is building integrated capabilities on the strong foundation of our basic competencies. We are drawing on our competency in materials science to expand our knowledge of aging in modern industrial materials and the effects of such aging in complex weapon component and subsystem environments. We draw on our computational sciences to model and predict the progress of this aging without destructive testing of samples from an increasingly limited stockpile base. We use our competencies in engineering, microelectronics, and photonics to expand the use of advanced sensor technology to help us monitor and detect failure processes before they can impact the deterrent. For example, to predict long-term storage degradation in thermal batteries, we analyzed the key chemical reactions that occur within these batteries as they age so that we can now confidently predict the storage and service life. To minimize the harmful long-term effects of moisture on delicate electronic components, we used our expertise in engineering, materials science, and computational modeling to advance the state of the art in molded desiccant technologies.

Electronic components largely determine the reliability of a weapons system, the precision of weapon delivery to the target, and the operability of the weapon in the potentially severe environments encountered during delivery. Satellites that monitor compliance with international arms control agreements also require specialized microelectronic device performance. Many of the requirements for these devices cannot be met by commercial electronic products. Sandia's competencies in microelectronics and photonics support the development, fabrication, and production of unique and advanced microelectronic and photonic devices and circuits, microsensors, and intelligent microelectromechanical systems that are not obtainable from commercial sources. Distinguishing strengths of this competency include materials growth and development, digital and radio frequency device design, fabrication technologies for silicon and compound semiconductor devices, radiation-hardened microelectronics, advanced packaging technologies, and the design of processes and equipment for the manufacture of integrated circuits. These capabilities provide the underlying state-of-the-art science and technology required to meet mission needs for electronics systems, ranging from fundamental solid-state physics to the design and fabrication of radiation-hardened integrated circuits.

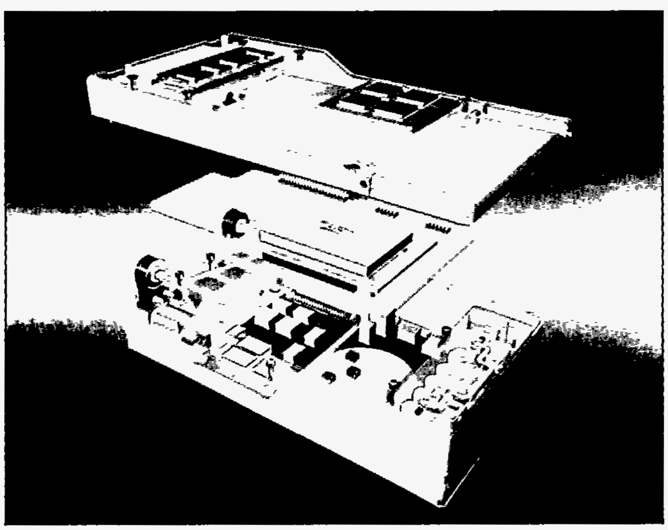
Sandia is also directing its integrated capabilities in component science toward pioneering developments in advanced miniaturization technologies. A differentiating capability is our expertise in the small, highly integrated, low-power, high-functionality devices known as integrated microsystems. Created through integrated circuit fabrication technology, these devices combine diverse functions, potentially ranging from processing electronics and microelectromechanical systems to fabricating sensors and communication devices on a single substrate or in very small multichip modules. Miniature machining, photolithographic semiconductor processes, and silicon micromachining are being employed to fabricate research prototypes of these advanced components.

These new systems will ultimately contain sensing, data processing and storage, mechanical actuation and manipulation, and communications to the external world in a single integrated package. Because of their low cost and high functionality, integrated microsystems will enable entirely new systems and applications and will change the way systems are created and used, leading to a corresponding change in the way electronics products are designed and manufactured.

For example, enhanced surety and surveillance for future weapons systems will be provided by the use of integrated microsystems for arming, fusing, and firing assemblies and for embedded state-of-health monitoring systems. As aging components are gradually exchanged, they can be replaced by modular components compatible with many delivery platforms and distinguished by their smaller size, fewer discrete parts, and higher level of integration and reliability. Miniaturization and integration will eventually enable virtually all weapon types in the stockpile to be retrofitted with the same standardized, modular components that provide additional and enhanced nuclear safety, use control, surveillance, and guidance and control features at reduced cost.

A very complex example of an intelligent, integrated microsystem is the "chemlab on a chip," which requires the integration of microelectromechanical system actuation devices for pumping microfluids and sensing chemicals, integrated complementary metal-oxide semiconductor electronics for interrogating and interpreting sensors, and communications using either radio frequency or photonic devices based on compound semiconductor technology.

Sandia is also supporting work in microelectronics production technologies, including the development of extreme ultraviolet lithography to provide early access to transistors and small-scale circuits for diagnosing radiation sensitivities of future technologies. Sandia is developing this technology to investigate the impact of fine geometries on the reliability of future circuits for stockpile applications, with particular attention to developing a predictive reliability of the interconnects used to wire the fine-geometry transistor into an integrated circuit. Our work in compound semiconductor materials and processes focuses on developing new materials systems and implementing production of these material systems through industrial vendors; this work supports radiation-hardened semiconductor lasers, optical waveguides, photodetectors, and radio frequency components. Strained-layer compound-semiconductor heteroepitaxy enables bandgap engineering of the electrical and optical properties of these artificially structured materials to maximize device performance for a given application through optimization of materials properties. In the area of integrated lasers, we are working to develop a theoretic and experimental understanding of nonlinear materials that would be suitable for direct processing using semiconductor manufacturing techniques and would also provide the basis for tuning the operating frequency of semiconductor lasers. In the simplest sense, these materials allow doubling of the laser frequency, thereby greatly expanding the operating space of the lasers for compact sensors and monitors.



An artist's conception of Sandia's "chemlab on a chip" shows (top) the push-button controls, (middle) the encasements for computation and power management, and (bottom) the analysis systems and batteries.

6.1.1.1.7 Chemistry and Materials Science and Technology (DP010203)

Meeting the demanding performance, safety, and physical security requirements associated with nuclear weapons requires a diverse range of materials expertise and capabilities, many unique to the nuclear weapons complex. With an aging stockpile, systematic predictive capability is needed to anticipate degradation over time in weapons storage environments. This predictive capability derives from science-based models of aging kinetics, new experimental methodologies to characterize the dominant aging mechanisms, atomic-scale analytic techniques to measure the early stages of aging, computational simulations of performance degradation in specific applications, and ultimately from integrated sensors built into weapons to constantly monitor the condition of the materials.

By accumulating data from both accelerated aging experiments and dismantled weapons, Sandia is improving the capability to detect, measure, and track the time-dependent properties and byproducts of aging in weapons materials and components. These properties and byproducts predict the progress of aging degradation in such materials and components through time. We are also integrating our empirical and theoretic work in materials science as a means of accelerating the development of computational models of the actual behavior of aging components and subsystems. Thus, we are advancing our ability to use the chemical signatures of age-related degradation in assessing and predicting such degradation, and in developing the computational capabilities needed to model and predict the effects of aging without destructive testing of samples drawn from an increasingly limited stockpile base.

In associated efforts, we are developing sensor technology that can be built into weapons to constantly monitor aging and degradation, and communications techniques that will allow us to contact and monitor such sensors without dismantling or otherwise disrupting a weapon.

In addition, replacement components for nuclear weapons must now be manufactured or remanufactured under conditions far different from those used for original fabrication. Some original materials and processes are no longer available because they are obsolete or constrained by more recent environmental, safety, or health regulations. Thus, new materials and processes must be found and certified.

Specific areas of interest continue to include polymer adhesion and interfacial failure mechanisms; thin-film nucleation, growth, and stress development studies; piezoelectric and ferroelectric integration with microcircuits and micromachines; bulk and interfacial materials aging mechanisms; model-based materials processing investigations and direct fabrication of structures from computer-aided designs; materials joining studies; microstructural and chemical analysis techniques; and nanoscale tribology phenomena.

6.1.1.1.8 Stockpile Computing (DP010205)

With the cessation of underground nuclear and radiation effects testing, increasing constraints on nonnuclear testing, continuing budget constraints, and a smaller stockpile that offers reduced opportunities for stockpile sampling, the nuclear weapons program must now shift toward new computational modeling, simulation, predictive analyses and even virtual testing approaches. Therefore, we must advance our understanding of complex systems and phenomena and our ability to computationally model such systems and simulate their behavior.

Sandia's traditional integrated capability in modeling, simulation, and testing is now playing a crucial role in meeting this challenge, which has intensified the need for improved materials response data, enhanced simulation capabilities, and advanced computational technologies. Optimizing computational tools to model and simulate complex physical phenomena requires advanced codes based on enhanced and more complete models, specifically including the best possible engineering descriptions of the physics and phenomenology important to weapon applications. Thus, we are using our competencies in empirical testing and materials science to expand our knowledge of materials and their behavior in components and systems under severe and dynamic mechanical, thermal, shock, and operational loading and under relevant environmental conditions. We are using our competency in computational sciences to mathematically model such materials and accurately simulate their behavior and interaction in complex systems. We are using our competencies in engineering and the computational sciences to develop an ability to predict the performance of complex systems. To continue meeting our responsibility to certify the survivability of weapon systems in nuclear environments, we are also drawing on our competencies in materials science, pulsed power sciences, computation, and microelectronics (augmented by aboveground experimentation) to expand our knowledge of materials and their behavior in nuclear environments and to develop the means to computationally model and predict the effects of radiation on electronics and materials and their performance.

Sandia's technology base for the full spectrum of modeling and simulation capabilities is rooted in stockpile computing, including the development of fundamental capabilities required to exploit a wide range of new computational engines. Activities range from fundamental, broadly applicable efforts to those of a developmental nature, all of which support both the Accelerated Strategic Computing Initiative and specific stockpile systems simulations.

Our work in stockpile computing is composed of computer science research, computational solid dynamics, computational mechanics, radiation transport, network research, and strategic computing operations. Computer science research addresses computational methods and technologies such as numerical methods for the design and processing of new stockpile materials, new massively parallel numerical algorithms, and new strategies for code reusability, portability, and debugging. Computer science research also explores new and innovative computational plant technologies. Computational solid dynamics develops codes for high-rate large-strain phenomena such as the simulation of shock, high-velocity impact, penetration, or blast. Computational mechanics addresses phenomenological model development such as analytic or computational methods that can represent fundamental phenomena and processes and then provide predictive solutions. Radiation transport addresses three-dimensional radiation deposition for thermostructural response and thermomechanical shock of systems in hostile environments. Network research investigates high-speed networks such as traffic flow control for asynchronous transfer mode networks and model simplification to enable scientific model development on parallel and clustered computing platforms. Strategic computing operations personnel maintain and operate leading-edge ultracomputing capabilities and facilities, including data storage and visualization for the Accelerated Strategic Computing Initiative.

6.1.1.1.9 Institutional and Infrastructure Requirements (DP0105)

Sandia's facilities infrastructure was built during five decades of great national investment to address formidable strategic responsibilities demanding sustained technical excellence. Although the specialized training and expertise of our personnel are our most important assets, the technological demands of the modern nuclear stockpile compel us to maintain appropriate equipment, facilities, and infrastructure. The pace of technological evolution and the normal effects of aging and deterioration require that we continually refurbish and update our capital assets. However, steadily eroding funding levels are having a significant effect on the maintenance of the national investment at Sandia. For example, computational modeling studies project that continuation of currently forecast reinvestment will significantly reduce our fit-for-use space over the next ten years.

Equipment is particularly sensitive to technological change. Some research and engineering equipment becomes obsolete and must be replaced within a few years. However, because of increasing programmatic challenges and continually declining budgets, our expenditures for weapons-related capital equipment in 1996 were less than half the equivalent expenditures in 1992. In fact, by 1996 Sandia's total annual capital reinvestment budget had eroded to less than 60 percent of 1988 levels. The 1998 budget is projected to drop to a small fraction of 1988 totals.

In response to budget constraints, staffing reductions, and the aging of much of our site infrastructure, available funds for general plant projects are being used primarily to support infrastructure rehabilitation efforts that add no space to current facilities. The single exception is a small facility needed to support our production responsibilities. Five of the most critical construction projects are described below. See section 8.3.5 (Sandia Facilities Investment Strategy) for additional information.

6.1.1.1.9.1 Process and Environmental Technologies Laboratory

The Process and Environmental Technologies Laboratory will be a new facility to house research and development, materials science, process technology development, and production support activities needed to address environmental, safety, and health issues related to the minimization and management of hazardous materials associated with the maintenance of the stockpile. This laboratory will contain roughly 140,000 gross square feet and is scheduled for completion in FY 2000.

6.1.1.1.9.2 Model Validation and System Certification Test Center

This facility will expedite the shift from heavy reliance on empirical testing to greater reliance on computational modeling and simulation for future stockpile stewardship efforts. The test center will consolidate and eliminate a number of older, obsolete, and redundant test command and control centers and replace them with a single modern facility interconnected with remote test sites through a state-of-the-art communications system. The new arrangement will allow us to replace obsolete data collection capabilities with new capabilities that will promptly and cost-effectively validate our modeling and simulation capabilities. Work is scheduled to start in FY 1999. The Model Validation and System Certification Test Center may be either a new facility or simply a renovation of an existing facility. In either case, completion of the project will eliminate substandard floor space.

6.1.1.1.9.3 Joint Computational Engineering Laboratory

The Joint Computational Engineering Laboratory is vital to Sandia's mission responsibilities in the areas of defense high-performance computing, communications, and computer-aided design and engineering. Funding is scheduled to begin in 1999. This facility will house equipment and support activities associated with Sandia's role in the Accelerated Strategic Computing Initiative. The mission requirements for the Joint Computational Engineering Laboratory will be met primarily through the renovation of existing facilities, with only a few specialized capabilities being added through new construction. Up to four existing facilities may be eliminated to allow this construction, resulting in a net reduction of substandard space.

6.1.1.1.9.4 Storm Drain, Sanitary Sewer, and Domestic Water System Modernization

This project will make essential improvements in several site utility systems. Funding began in FY 1998.

6.1.1.1.9.5 Distributed Information Systems Laboratory

The efficiency and cost effectiveness of the DOE's future product realization (advanced manufacturing technology), weapons surveillance, material disposition, and stockpile management efforts will increasingly depend on the ability to integrate modern information-based technologies and resources across the weapons complex through modern distributed information systems and high-speed secure networks that connect the various laboratories and facilities. The proposed Distributed Information Systems Laboratory will develop, implement, consolidate, and integrate the activities needed to incorporate such systems into a virtual enterprise for stockpile stewardship. The facility will consist of laboratories, workspace, and outreach areas to develop and validate process models and distributed information systems created from DOE technologies. In coordination with other facilities across the complex, the laboratory will be a key element of the Virtual Laboratory Testbed, an approved cooperative effort among the national laboratories. The testbed will serve as a national resource for domestic industrial efforts to develop technologies and products for distributed information systems. The conceptual design report and life-cycle cost analyses for the Distributed Information Systems Laboratory showed that new construction is preferable to renovation of existing facilities. The new facility will be built at Sandia/California, where existing substandard and excess facilities are being decommissioned and demolished to make room for the new construction. The result will be a net reduction of substandard space at the site. Funding is proposed to begin in FY 2000.

6.1.1.2 Inertial Confinement Fusion (DP02)

The DOE sponsors development of pulsed power technology as an x-ray source for nuclear weapons effects testing, weapon physics studies, and fusion power production. Pulsed power is a Sandia core competency, and the relatively lower cost and higher efficiency of pulsed power approaches have permitted unique megajoule-class facilities to be constructed. These are important national facilities for radiation-effects science, weapon physics research, radiation flow research, and survivability testing. The lower cost per unit of energy of pulsed power offers potential savings for future aboveground testing facilities. The fundamentally different x-ray production mechanism with z-pinches also provides a prudent risk-management alternative to laser approaches.

In 1998 the Inertial Confinement Fusion Program completed a major shift in research focus from developing light ion beams as a means of generating an intense x-ray source for indirect drive fusion to using z-pinches for that purpose. Our inertial confinement fusion work includes characterizing and demonstrating the utility of pulsed-power-generated soft x-ray sources for weapon physics and inertial confinement fusion experiments; diagnosing and modeling radiation flow, mix, and capsule implosions; developing and benchmarking simulation codes; designing and qualifying pulsed power components and target diagnostics for other ongoing initiatives; and operating, maintaining, and developing pulsed power facilities.

Sandia's Z Accelerator is the premier pulsed power source in the world to study inertial confinement fusion and weapon physics applications. After completing the modification to support the z-pinch drive in FY 1997, the Z Accelerator achieved a series of breakthroughs in pulsed power technology. In March 1997 a Sandia review panel commended the work completed and encouraged future work. In May 1998 another review panel reconfirmed the achievements at the Z Accelerator and the need for continuing research efforts in z-pinch physics and applications to the Inertial Confinement Fusion Program and high-yield fusion burn. The Z Accelerator exceeded the initial energy, power, and hohlraum temperature goals. Today, x-ray energy output is greater than 2.0 megajoules, a power of 290 terawatts has been achieved, and hohlraum temperatures have exceeded 150 electronvolts. A detailed Z-Pinch Science and Technology Plan was developed to establish the tasks that must be completed on the Z Accelerator to support high-yield fusion burn on the proposed X-1 Advanced Radiation Source accelerator. The X-1 would enable controlled high-yield fusion burn experiments. The Z Accelerator is being applied regularly to high-yield target physics, hohlraum physics, and z-pinch physics in order to support either X-1 requirements or weapon physics research.

Sandia also continues to collaborate with other national laboratories to develop the core science and technology required for ongoing initiatives. Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and the Atomic Weapons Establishment (England) are using the Z Accelerator in collaboration with Sandia to conduct weapon physics experiments that support certification of the stockpile. Additional applications with advanced

Sandia's z-pinch team is shown with the Z Accelerator, the world's premier pulsed power source.

experiments are being considered as other scientists become more familiar with experiments on the Z Accelerator. Sandia and Lawrence Livermore National Laboratory are teaming to build a kilojoule-class laser to be used as a point-projection or area x-ray backlighter on the Z Accelerator. This laser will be constructed from parts of the Nova and Beamlet laser facilities (being dismantled to make room for the National Ignition Facility). The backlighter diagnostic on the Z Accelerator will provide a capability needed for future weapon science and inertial confinement fusion experiments. Sandia also contributes pulsed power conditioning, target chamber design, development and integration of radiation-hardened target diagnostics, and work on internally pulse-shaped targets for ignition and high gain.

6.1.1.3 Technology Transfer and Education (DP03)

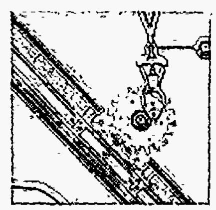
6.1.1.3.1 Technology Transfer

Technology partnerships remain a congressionally mandated mission of the DOE's national laboratories. These partnerships transfer technologies, skills, and knowledge between the DOE and the private sector. Today, the primary goal is to strengthen the core competencies of DOE Defense Programs and broaden the capabilities available for weapons applications by assembling embryonic concepts from the field of new technologies being explored by commercial industry. This goal is accomplished through collaborative partnerships with domestic private industries, collaborations which also enhance the international competitiveness of our strategic domestic industrial base. These partnerships support Sandia's participation in cooperative research and development agreements with individual companies, as well as other cost-shared collaborative projects involving industry consortia. Although the scale and mix of these efforts change from year to year, industry partnerships have generally fallen into the four major technology focus areas of advanced manufacturing and precision engineering, high-performance computing and applications, materials and processes for manufacturing, and microelectronics and photonics.

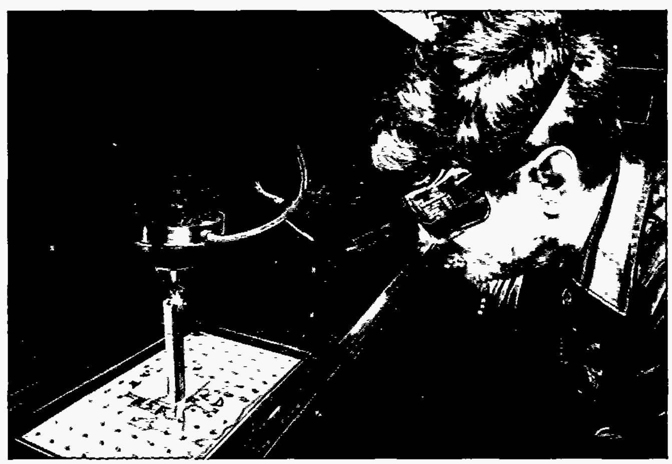
Our technology partnerships in advanced manufacturing and precision engineering are generally an outgrowth of the manufacturing capabilities that Sandia developed from decades of close work with DOE production plants. Sandia is charged during and after weapons development to ensure that designs are manufactured cost effectively and that products meet design intent. To meet these responsibilities, we have developed advanced manufacturing capabilities that can be used to respond to a variety of national needs. Cooperative research and development agreements in the area of advanced manufacturing and precision engineering focus on manufacturing systems design and development, manufacturing processes, computer-integrated manufacturing, machine tool design, precision measurements, precision engineering, instrumentation and sensing, and information technologies that enable agile manufacturing.

Our technology partnerships in high-performance computing and applications are built around Sandia's advanced capabilities in massively parallel computing methods and software infrastructure for parallel computing. Advanced computing technologies will play a critical role in the future of US national defense and economic security. Cooperative research and development agreements in this area pertain to high-performance computing and networking, simulation and modeling, pattern recognition and image analysis, and high-density data storage and transmission.

Our technology partnerships in materials and processes address the requirement for special materials and fabrication processes for nuclear weapons and the need for continuous advancement in this area. Cooperative research and development agreements focus on developing new materials and material processing techniques and on characterizing and certifying advanced materials.



In the area of microelectronics and photonics, the time required to translate research developments into manufacturing advantages is a major concern, and Sandia is involved in numerous cooperative research and development agreements with industry to speed this process. Our technology partnerships in microelectronics and photonics focus on advancing the fundamental electrical, mechanical, magnetic, and structural properties of electronic materials and on exploring new techniques for fabricating and selectively altering thin-film layers, surfaces, and surface regions. We also conduct research and development in compound semiconductors such as alloys of gallium arsenide and indium arsenide, materials that will play a greater role for improved safety and use control in future weapons systems.



Sandian Lane Harwell tests a laser-engineered shaping technique being developed at Sandia. Ten companies are teaming with Sandia via a cooperative research and development agreement to commercialize the technology.

In addition to cooperative research and development agreements involving individual companies, Sandia's technology partnerships also support cost-shared collaborations that involve large segments of specific industries or consortia, including the Specialty Metals Processing Consortium, the FASTCAST™ Program for rapid production of investment casting prototypes, and Sandia's Center for Microelectronics Technologies, which includes work conducted in collaboration with the US Semiconductor Manufacturing Technology (SEMATECH) consortium.

6.1.1.3.2 Education

DOE Defense Programs is a major contributor to Sandia's education outreach in areas that match our scientific strengths with local and national academic, government, and industry needs.

Sandia supports three postsecondary student programs focused on development of research and employment issues: the Student Internship Program, Scholars in Technology, and the University Research Semester.

In the broad area of institutional development, Sandia supports four major projects. The National Security Technologies Collaboration facilitates DOE Defense Programs-related research and development between Sandia and minority universities. After the Oklahoma City bombing, the Architectural Surety Education Collaboration was created to improve the surety of architecture in the event of future terrorist acts. The University Pre-Service Program was created at the University of New Mexico to improve the science and mathematics preparation of kindergarten through eighth-grade teachers. The Advanced Manufacturing for Education Program is a collaboration among Sandia, Albuquerque West Mesa High School and the Albuquerque Technical Vocational Institute to prepare qualified technicians for Sandia's advanced manufacturing programs.

Our education outreach programs have evolved greatly during the past five years. Reduced resources have resulted in focused initiatives, streamlined operations, and greater leveraging through partnerships. These outreach programs continue to apply our unique capabilities and resources to enhance Sandia's and the DOE's capabilities.

6.1.1.4 Core Stockpile Management Programs (DP0401)

Sandia has "cradle-to-grave" responsibilities for the nonnuclear components of every weapon in the US nuclear weapons stockpile. These responsibilities involve more than 90 percent of the individual parts of a typical nuclear weapon. Limited-life components have specifically limited service lives based on predictable degradation of their constituent materials. Such components must be replaced routinely before the constituent materials degrade sufficiently to compromise reliability, and Sandia has critical production responsibilities for many of these components.

Sandia provides field engineering support to the military throughout the service life of every nuclear weapon. Responsibilities include support for the periodic replacement of limited-life components. We develop and maintain capabilities for the safe transportation and storage of nuclear weapons, design the ancillary equipment that enables military personnel to handle and maintain nuclear weapons in a safe and secure manner, and support the dismantlement of weapons retired from the stockpile. Sandia conducts the DOE Stockpile Sampling and Surveillance Program and specific surveillance activities associated with Sandia components and subsystems. We support retrofits that improve safety or correct defects discovered through stockpile surveillance, and we play a critical role in ensuring the continuous safety, security, and use control, as well as the overall reliability, of every nuclear weapon.

Today, the US nuclear weapons stockpile is safe, secure, and reliable. However, the streamlining of the weapons production complex and the lack of new weapons designs entering production have already pushed most weapons in the stockpile past their originally envisioned service lives. All weapons now in the stockpile will reach the end of their design lifetimes during the next two decades, and little experience exists to guide us in predicting deterioration under these conditions. The credibility of the deterrent now depends on a shrinking pool of aging weapons. With reduced numbers and longer service lives, the weapons remaining in the stockpile may outlive their "protected periods," risking reduced opportunities for sampling and monitoring, an erosion of stockpile numbers, or both. All these factors narrow the margin of error in the remaining weapons and drive the need for tighter stockpile surveillance to ensure that the deterrent continues to be both trustworthy and credible.

The shrinking of the nuclear weapons production complex also places pressure on an increasingly limited infrastructure. Many materials and methods originally used to produce the weapons in the stockpile are no longer available. In some cases, materials and methods have become commercially obsolete, replaced by more modern alternatives. In other cases, modern safety or environmental concerns have halted the use of older materials and methods. In any case, we cannot rely on replica components from original and outdated designs. Maintaining the ability to design, develop, certify, and either produce or procure updated materials and components is vital to ensuring the long-term reliability of the stockpile. This problem is of particular concern for limited-life components. For these components, the ability to model the performance and aging of materials is increasingly important for predicting problems and providing the advanced warning needed to preemptively address stockpile concerns before they can significantly affect the deterrent. In these cases, Sandia has been forced to assume additional direct production responsibilities, further straining our resources. Supporting these needs in an era of continuously declining budgets has become a critical concern.

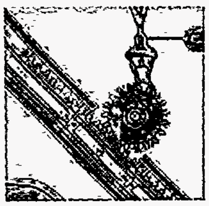
6.1.1.4.1 Weapons Program (DP0401011)

Most weapons components suffer from normal aging, have limited service lives, and must eventually be replaced. As these components age and our technological understanding and capabilities evolve, periodic repairs, modifications, and improvements are necessary. To address this challenge, the DOE has developed the Stockpile Life Extension Program to enable systematic limited-life component exchange and component upgrades in blocks of related subsystems. Driven primarily by the need for regular limited-life component exchange, the Stockpile Life Extension Program also works to renew the technological currency of these and other crucial components and to help maintain steadier, smoother production requirements, free from inefficient extremes in workload. Many of these activities are formally reviewed and approved on an individual basis by the DOE.

The first priority of the weapons program at Sandia is to ensure that all safety requirements are met in the design, development, production, and deployment of nuclear weapons. This requires continual monitoring and evaluation of the condition and quality of the stockpile. Nuclear weapons from the stockpile are sampled, returned to the DOE Pantex plant, denuclearized, instrumented, and tested. Some are subjected to environmental extremes in the Weapons Evaluation Test Facility at Pantex, while others are shipped to DOD sites, mated to their delivery systems, and used in test flights. If problems are detected or failures occur, a team is formed to find the cause and recommend a solution. A data base of all system tests and problems is maintained to provide reliability and safety data and serve as a record for use in future designs. Major changes to the stockpile evaluation program are being made to accommodate a smaller number of weapons and a declining budget. Handling, shipping, and disassembly costs are being reduced by coordinating the selection of weapons to be tested with routine weapons operations such as scheduled maintenance. Tests are being redesigned to assess aging effects caused by longer-than-expected service lives. Critical safety components are being held to higher standards, and researchers are working to develop more realistic test configurations that can improve our ability to detect subtle problems in high-reliability systems. We are now using commercially available hardware for test instrumentation to modernize and simplify weapon measurements.

Sandia also has responsibilities for the onsite production of some nonnuclear components and the characterization and qualification of weapons components procured from commercial vendors. These responsibilities include program and project planning, records maintenance and transfer, technological contingency strategy development, procurement activities, and infrastructure development and implementation. The most important part of this mission is related to limited-life component exchange requirements. A variety of essential weapon components have service lives that are defined by the constant, relatively rapid, and precisely predictable degradation of some of their constituent materials. Such limited-life components must be routinely replaced before these constituent materials degrade sufficiently to compromise their ability to function properly. A constant and reliable production and replacement supply of these vital components is essential to maintaining the credibility of the deterrent. Sandia has direct responsibilities for both the periodic field replacement of limited-life components (a process known as limited-life component exchange) and for the production of many of these components, most notably neutron generators. These responsibilities are complicated because design and production of these small but robust components is technologically complex. Production of these components involves integration of both nuclear and nonnuclear materials (which can be difficult and somewhat hazardous to handle and process), and the replacement component supply and the correct scale of the associated production operations are directly dependent on the size of the stockpile.

Sandia also supplies and tests containers used to transport and store nuclear components. Much of our work in this area has focused on the maintenance, support, and recertification of tritium containers and the design, development, and use of containers for transporting and storing nuclear components.



Finally, Sandia supports the dismantlement and disposal of nuclear weapons authorized for retirement from the stockpile. Under the terms of the Strategic Arms Reduction Treaty I (START I), the United States has dismantled thousands of nuclear weapons and will eventually dismantle more under START II. Our disassembly work has focused on process modeling and support, including the coordination and review of existing processes and procedures, the design of new processes and procedures, and efforts to use robotics to reduce human radiation exposure. Sandia works closely with the DOE Pantex plant to design safe and efficient processes for all phases of dismantlement and disposal. Automated processes using robotics and computer modeling offer improvements in safety and efficiency for scheduling the return and staging of retiring weapons, analyzing the processes for security and safeguards, prioritizing retirement and disassembly, and providing risk assessment management. For many operations, the development of new dismantlement processes has helped us meet immediate work schedules and support future operations. Concern for the environment has introduced new challenges to the disposal of materials, and limited records of the materials in some older components have necessitated work on a common materials data base to be used by all design and production agencies.

6.1.1.4.2 Production Support and Capability Assurance (DP0401011)

Sandia ensures that the production capabilities of the nuclear weapons complex are properly configured in response to changing national strategic needs. We support the actual production of weapons components, including onsite production responsibilities for a specific subset of weapons components. Sandia's component and process engineers support and assist production sites to ensure that product design and definition and associated manufacturing processes are accurately qualified. This function is essential to maintain production capability. Sandia also accomplishes reconfigurations, which generally consist of unscheduled and new activities related to the production of components at Sandia. These activities include establishing and characterizing production processes, purchasing and fabricating special tooling, purchasing production materials, and supporting production and "shelf-life" programs. Sandia also supports prototyping capabilities to develop limited-life components.

An independent quality assessment function has been mandated in recognition of the critical impact that the design, fabrication, and overall quality of weapons and weapons components inevitably have on the subsequent safety, security, and reliability of the stockpile. This function includes the evaluation of weapons systems and software production, including software quality engineering.

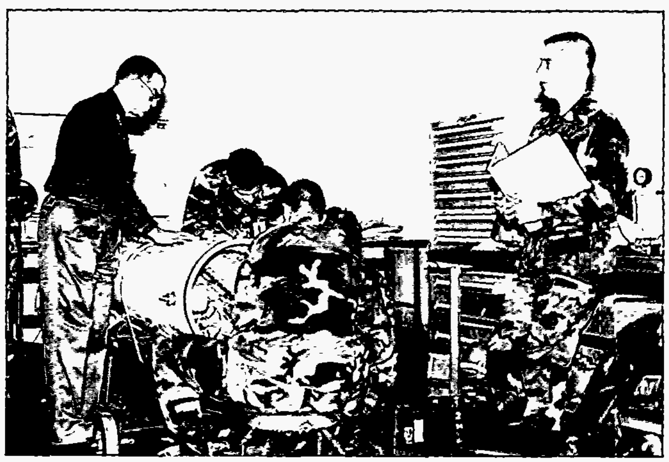
Sandia also must maintain the metrics, measurements, and calibration standards necessary to ensure the quality and consistency of design, testing, production, and maintenance processes across the nuclear weapons complex. Sandia's Primary Standards Laboratory Metrology Program ensures accurate measurements by developing and maintaining primary standards traceable to national standards and by calibrating and certifying customer reference standards. Principal activities include physical and electrical standards and calibration, measurement standards, and technical surveys and audits of integrated contractors. In addition, this program supports other DOE programs, government agencies, industry, and universities by providing technical support and consultation, technical surveys, and measurement audits.

Many of Sandia's most important responsibilities involve broad-based engineering support activities necessary for the general support of the stockpile. These tasks include ensuring ongoing compatibility with delivery systems, supporting the manufacture of weapons replacement components and materials, producing spare and rebuilt components and materials, resolving field problems, and preparing guidance for retirement and limited-life component exchanges. We also provide safety assessments of stockpiled weapons, technical support for weapons definition and data management, component capability support, waste and hazard minimization testing, and production liaison support for activities related to reconfiguration. Additional production support is associated with the need for continual monitoring, assessment, analysis, and evaluation of the condition, security, and overall quality of the stockpile.

Sandia provides field engineering support to the military throughout the service life of every nuclear weapon in the stockpile. These responsibilities include support for the periodic replacement of limited-life components. We support all areas of use control, handling, shipping, storage, and maintenance. We design and maintain the use control subsystems (including permissive action links) that ensure the nation's nuclear weapons can be used only with proper authorization. We develop and maintain the equipment and capabilities for the safe and secure transportation and storage of nuclear weapons. We design the ancillary technical equipment that enables military personnel to test and monitor the status of weapons in the stockpile. We conduct the stockpile sampling and surveillance program for the DOE as well as specific surveillance activities associated with Sandia components and subsystems. We support retrofits that improve the safety or use control of stockpiled weapons or correct defects discovered through stockpile surveillance. Ultimately, we support the dismantlement of weapons retired from the stockpile.

Sandia also has responsibilities to train and support military personnel authorized to handle nuclear weapons. The primary activities in this area include military instructor training, stockpile refresher training for DOE and DOD personnel, training and support for explosive ordnance disposal, development of field training videotapes, investigation and resolution of unsatisfactory reports and field engineering problems submitted on stockpile weapons, and preparation of DOE technical publications on stockpile maintenance and modification. We also conduct user-satisfaction evaluations. Our military liaison obligations are defined in six memoranda of understanding between the DOE and DOD. Sandia also manages the DOE Joint Nuclear Weapons Publication System and provides field engineering support at military locations around the world for field retrofits and other weapons maintenance and modification functions.

The DOE and Sandia consider nuclear weapon safety to be of the highest importance. Therefore, Sandia, the DOE, and the DOD have mandated the establishment of an organizationally independent group for the safety monitoring, review, assessment, and evaluation of standard weapons designs and stockpile maintenance practices.

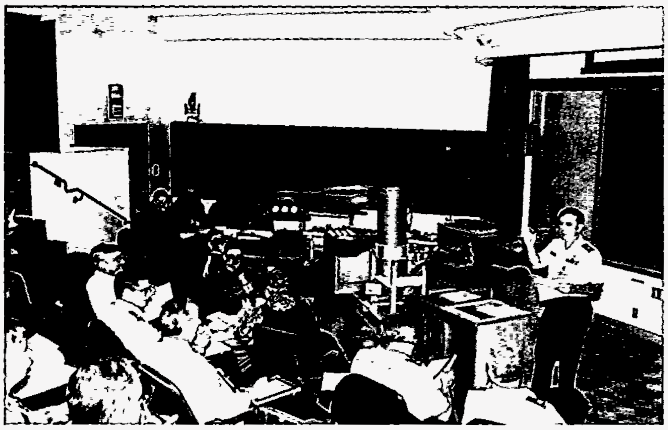


Sandia provides field engineering support to the military.

In keeping with this mandate, a Sandia independent assessment organization reports directly to the executive vice president concerning

- technical membership in DOE nuclear explosive safety studies;
- technical support of the DOD nuclear weapon system safety group;
- technical evaluation of unsatisfactory reports, significant engineering investigation reports, and significant findings investigations for safety impact;
- technical evaluation of Sandia weapon assessment reports;
- technical support of DOD weapon system safety assessments and special studies in support of the armed services and the Defense Special Weapons Agency;
- evaluation of nuclear weapon technical publications;
- development and use of internal independent weapon surety assessments for the enduring stockpile, retrofits, testers, tooling, ancillary equipment, and transportation;
- development of safety assessment methodologies;
- surety training for a number of customers;
- development of internal assessment programs to ensure compliance with DOE orders; and
- technical membership in accident response groups and nuclear explosive search teams.

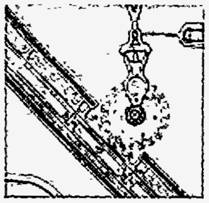
Focal areas include assessments of transportation container safety and assessment of the stockpile and DOE operations for nuclear detonation and plutonium dispersal safety. Sandia's independent assessment group is part of the Joint Task Group and Laboratory Task Group involved in manual, operational, procedural, and product change proposal reviews. The independent assessment group maintains the records and results of these activities in an electronic data base, participates in international surety forums, and provides technical consultation to other agencies.



Joint Task Group training session at Sandia's Weapon Training Center.

6.1.1.4.3 Enhanced Surveillance (DP040101)

The weapons of the enduring stockpile are rapidly aging past their original design lives. In the past, stockpiled weapons were modernized or replaced every ten to fifteen years. Under those conditions, degradation from the aging of materials or components was not a significant factor in weapons safety or performance. Today, however, weapons remain in the stockpile much longer, and the credibility of the deterrent is dependent on a shrinking pool of these aging weapons. The stockpile is also now more uniform than at any time since the 1950s, and this situation raises the risk that a common mode failure could compromise the remaining deterrent. At the same time, our smaller production complex has less capacity to rapidly correct a large unanticipated problem in the stockpile. All these factors narrow the margin of error that can be tolerated in the remaining weapons and drive the need for tighter stockpile surveillance to ensure that the deterrent continues to be both trustworthy and credible.



Today, with reduced numbers, longer service lives, and constraints on all forms of empirical testing, opportunities for a desirable level of stockpile sampling have eroded. At the same time, the context for stockpile surveillance has changed. In the past, the safety, security, and reliability of the stockpile were consistently pulled forward by the technological and engineering advances and the constant research, testing, review, and assessment associated with each new weapon development effort. Thus, the entire stockpile benefited from a continuous process of material and design review and modernization. Today, with no new weapons being developed, the synergistic link between the maintenance of the stockpile and an ongoing weapons development and replacement process has been broken, drastically changing the nature of our stockpile surveillance needs.

Sandia is addressing these concerns through the Enhanced Surveillance Program and by expanding our knowledge of aging in modern industrial materials, advancing our knowledge of aging effects, and developing computational models to predict aging effects. We are also exploring the expanded use of advanced sensor technology to help reduce the cost of heightened surveillance while still providing the additional monitoring needed to detect failure processes before they can impact the deterrent.

The Enhanced Surveillance Program is proceeding along three paths. First, by accumulating data from both accelerated aging experiments and dismantled weapons, Sandia is improving the capability to detect, measure, and track the time-dependent properties and byproducts of aging in weapons materials and components. These properties and byproducts serve as "signatures" that reveal the progress of aging degradation over time. We are advancing our ability to use these signatures in assessing and predicting deterioration from aging. Some of this work has already yielded results.

Second, we are integrating our empirical and theoretic work in materials science to further accelerate the development of computational models of the actual behavior of aging components and subsystems. We focus on identifying deterioration effects to formulate specific mitigating strategies and techniques. For example, we have used computational modeling to support the application of advanced desiccant technologies that minimize the harmful long-term effects of moisture on delicate electronic components. Unlike common silica gel desiccants, our zeolite molecular sieves adsorb water at low humidity and can be molded into plastics that fit particular locations or even serve as structural members. When designing these desiccants, we model moisture flow in packaging materials, through seals, and in weapons storage environments. In addition to determining precise desiccant requirements, the model allows us to predict desiccant reliability during changes in temperature or humidity.

Third, we are developing sensors that can be built into weapons to constantly and automatically monitor the presence of aging and deterioration signatures. We are also developing communications techniques to contact and monitor such sensors without dismantling or otherwise disrupting the weapon.

These three paths provide the technical basis for risk management decisions required to support continued stockpile certification and life extension planning for nonnuclear components. A number of such efforts are in their initial stages. Sandia's Predictive Materials Stewardship Science Project is developing a predictive capability to quantify the performance and reliability of stockpile materials throughout their service lives. Specific materials used in the stockpile are identified based on their susceptibility to aging deterioration. The materials of concern are then prioritized by their potential impact on the performance and reliability of weapons. Present efforts focus on stress voiding, the degradation of energetic materials, thermomechanical fatigue in solders, O-ring embrittlement, and slow crack growth in glass and ceramics. Our Enhanced Component Surveillance Project focuses on the impact of aging in components and subsystems. Efforts are directed toward widely used components with identified aging concerns. This component category includes electromechanical, electronic, and energetic subassemblies. Sandia's Future Surveillance Tools Project focuses on the development of intelligent sensors, advanced communication technologies, and automated approaches that enable more precise and accurate stockpile surveillance across a broader range of parameters, at lower cost, and with reduced human interaction.

6.1.1.4.4 Advanced Manufacturing, Design, and Production Technologies (DP040104)

The Advanced Design and Production Technologies (ADaPT) Initiative is developing and deploying new information and manufacturing technologies that will revolutionize the way the DOE realizes nuclear weapons products. The goals of this initiative are to eliminate design and manufacturing defects in refurbished stockpile hardware while reducing both the time and costs of production. The ADaPT Initiative uses promising research and development efforts that can be used to meet stockpile management objectives identified through the Stockpile Life Extension Program. The initiative is structured into two programs: the Process Development Program and the Distributed Computer-Aided Design and Manufacturing Program.

In the Process Development Program we are focusing on continuous and innovative improvement of materials and processes to support long-term stockpile needs for limited-life components.

The Distributed Computer-Aided Design and Manufacturing Program is composed of two subprograms: Enterprise Integration and Integrated Product and Process Design/Agile Manufacturing. Our work in the Enterprise Integration subprogram includes efforts to establish high-speed secure telecommunications at the production sites to support technical data exchange and enable the various parts of the nuclear weapons complex to operate as an integrated "virtual" enterprise. The Information and Data Management Project will provide a weapons-data shared information environment that complies with classification and need-to-know requirements. In this project, a product information management system will be developed to provide access to information about products, requirements documents, design, production data, process information, and inspection/quality data. The Enterprise Modeling Project will seek to accurately model the nuclear weapons complex for use in simulating, planning, and evaluating innovative technology approaches, predicting production capacities and inherent limitations, interpreting the impact of changing stockpile requirements, and assessing weapons system management strategies before making major investments or policy decisions. The project is expected to improve efficiency and performance while lowering costs and facilities requirements.

Sandia pioneered the use of integrated product and process design in the 1970s, when we applied concurrent engineering techniques to the design and production of integrated circuits. Concurrent engineering techniques have since proven their value for helping designers balance the product design and manufacturing processes. Although these techniques are now industry standards, Sandia is developing them further. We are using computational modeling and simulation technologies to develop modular design tools that concurrently optimize designs for performance, manufacturability, inspection, environment, procurement, and cost. We are creating linked virtual prototyping environments in which a product and its manufacturing processes are designed concurrently. These techniques reduce time and labor during the design phase, contribute to improved product performance, lessen manufacturing risks, shorten the overall product realization cycle, and cut costs. Similarly, an agile manufacturing operation is one that benefits from the use of advanced materials and techniques while allowing flexible manufacturing processes to be established rapidly and modified, upgraded, or replaced easily. Sandia is pioneering the use of direct fabrication, a concept that allows seamless transfer of electronic renderings of designs to unit processes that fabricate hardware. Thus, Sandia is far along in the newly emerging fields of integrated product and process design and agile manufacturing. We are now initiating projects to apply these techniques to limited-life components; arming, fusing, and firing systems; and gas transfer systems. In addition, to minimize developmental risk, we emphasize the development of relatively discrete, modular, and highly versatile manufacturing cells that can be reconfigured to fabricate a variety of different electrical or mechanical components. These cells can house diverse manufacturing processes, each with automated planning and control. This approach provides the capability to produce needed parts without potentially costly commitments to fixed factory configurations.

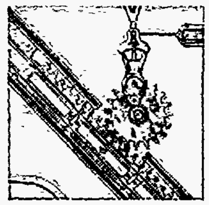
6.1.1.4.5 Radiological/Nuclear Accident Response (DP0402)

Sandia provides technical support to develop and maintain readiness to respond to accidents or incidents involving nuclear materials, including nuclear weapons. Included in these response efforts are the Radiological Assistance Program, the Accident Response Group, the Nuclear Emergency Search Team, and the Joint Technical Operations Team. We participate in the readiness mission for each of these response missions. In the event of an accident involving a US nuclear weapon, Sandia supplies technical experts in nuclear weapons, weapons safety, and health physics as part of the Accident Response Group. All are specially trained to support field efforts for the safe recovery of damaged US nuclear weapons. In support of the Accident Response Group, Sandia has developed training materials and field equipment for use in weapons recovery; provided training and systems program planning; planned and implemented field and tabletop exercises; and assisted in the nuclear safety evaluation of specialized equipment and procedures. To support the Accident Response Group, we are developing systems using proven modern methodologies and technologies to provide greater operational flexibility, safety, training, and exercises that are comprehensive and cost efficient. In addition, we are adapting remotely controlled robotics technology to reduce hazards to personnel. The Sandia Nuclear Emergency Search Team has historically focused on mitigating radioactive aerosols generated during violent disablement of improvised nuclear devices, predicting consequences of such dispersals, devising methods of rendering improvised nuclear devices safe, and developing field-portable methods for determining the types of explosives in such devices. Sandia also is responsible for providing leadership and management of Phase 3 of the Joint Technical Operations Team for the DOE. Phase 3 involves designing methodologies for the disassembly of nuclear-related devices and/or weapons. Sandia is developing equipment requirements, procedures, and training plans to execute the Phase 3 mission.

6.1.1.4.6 Tritium Source (DP040302)

Sandia provides technical support to the DOE and the Nuclear Regulatory Commission concerning tritium produced in both commercial light water reactors and accelerators. Sandia participated in scoping studies to evaluate licensing requirements, vulnerability assessments to evaluate the effectiveness of existing safeguards and security measures, and preparation of the Accelerator Produced Tritium Conceptual Design Report. We expect to continue providing technical assistance, which will in turn support both the primary tritium production option and a Nuclear Regulatory Commission safety evaluation report. Safeguards and security assessments will also be conducted at selected facilities, and we expect to continue supporting accelerator-produced tritium with materials testing and safety analyses.

6.1.2 Office of Fissile Materials Disposition (GA)



The Office of Fissile Materials Disposition is chartered by the DOE to develop strategies and direct activities that provide for the safe, secure, cost-effective, and inspectable long-term storage and eventual disposition of surplus US weapons-usable fissile materials in a manner that encourages reciprocal actions abroad. Sandia continues to provide support to this office in three main areas:

- technical integration of program elements,
- logistic and administrative oversight for the US/Russian Plutonium Disposition Development Program, and
- technical expertise in the areas of robotics and automation.

Technical integration efforts involve monitoring national laboratory technical support activities, facilitating communication to support technical objectives, and ensuring that required data and analyses are fully integrated with programmatic and technical requirements.

Funding for the US/Russian work comes primarily from legislation intended to reduce the proliferation dangers of Russian weapons materials. A series of test and experimental activities has been established by US scientists and their Russian counterparts to demonstrate verifiable conversion of plutonium from weapons. Sandia has assisted the US/Russian Steering Committee and Working Group in defining joint US/Russian research and development projects, scheduling the activities, establishing the reporting format, and writing applicable portions of the joint reports. A major adjunct to this work includes assisting the DOE in working with the Department of State on international agreements compatible with technical progress and programmatic decisions.

Many of the disposition processes will require robotics and automated handling equipment to reduce the exposure of workers and to limit opportunities for proliferation. Sandians from the Intelligent Systems and Robotics Center have contributed significantly to the evolution of such processes.

6.1.3 Office of Nonproliferation and National Security (NN)

Sandia's support for the Office of Nonproliferation and National Security includes research and development for a variety of systems that detect proliferation of weapons of mass destruction, verify international agreements, enhance physical protection at DOE facilities, and assist the DOE in its intelligence mission. Two important aspects of these program areas are information management and support for enhanced control of special nuclear material in the former Soviet Union. Because these program elements are implemented within a political framework of openness and cooperation, Sandia's technology must balance adequate protection of sensitive and classified information with national goals of openness and transparency.

6.1.3.1 Nonproliferation and Verification Research and Development (GC)

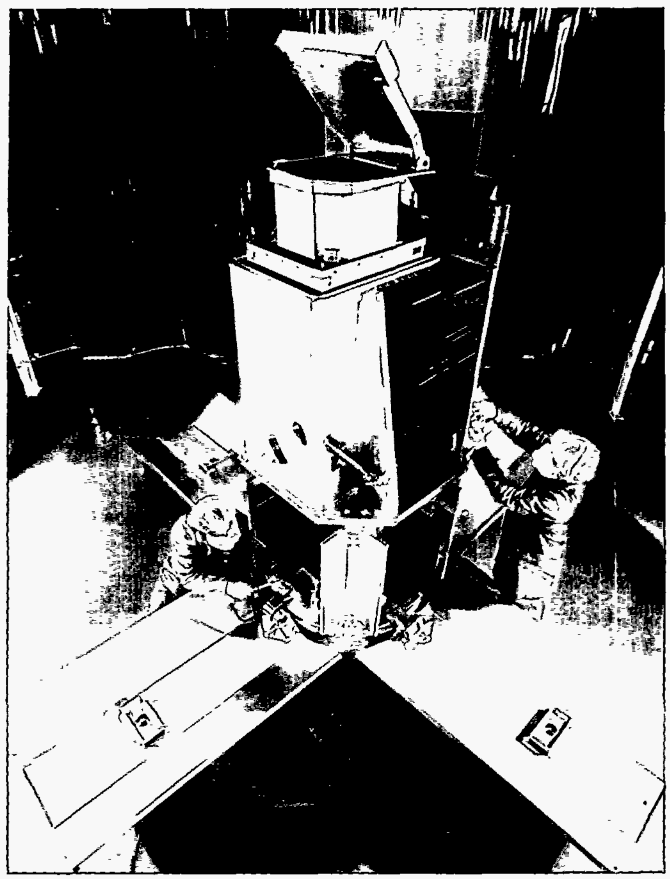
Sandia is developing new sensors to detect low-yield nuclear explosions in the atmosphere. Instrumentation on Global Positioning System satellites now provides continuous worldwide coverage. Seismic data processing technology is also being developed to enhance detection of underground nuclear explosions. In response to the evolving geopolitical climate, the emphasis of this program has shifted from monitoring bilateral agreements to monitoring for covert nuclear testing and supporting a comprehensive test ban. In addition, we are developing models of verification technologies for system performance evaluation. Our activities are part of a multilaboratory effort focused on affordable, deployable, and flexible sensors for seismic, hydroacoustic, radionuclide, and infrasound data acquisition and data processing. These activities are being coordinated and in many cases cofunded by the DOD, which has the operational nuclear test monitoring responsibility within the US government.

We are developing airborne and satellite-based systems and technology for detecting and characterizing proliferation-related activities, including detection of chemical weapons, biological weapons, and missiles. In conjunction with Los Alamos National Laboratory, we are developing a satellite-based, multispectral thermal imaging system. With other national laboratories we are developing laser-based techniques for remote detection and identification of chemical species in effluent plumes. In addition, Sandia is developing specialized chemical microsensors, bioinformation systems, and decontamination technology for nuclear, biological, and chemical weapons and for detecting nuclear smuggling.

We develop synthetic aperture radar systems and processing algorithms for national security applications that may require all-weather, day-and-night capabilities. We are also exploring the integration of synthetic aperture radar with other imaging data and automated data analysis technologies to handle the large volume of data from such systems.

Unattended remote systems are being developed to augment international cooperative monitoring efforts. Data authentication techniques are being developed to provide security for remotely monitored sensor-based systems. The technology base developed for these applications uses input from private industry, universities, other national laboratories, and centers of expertise within Sandia.

Studies are under way to investigate the impact on DOE facilities of nuclear weapon dismantlement and special nuclear materials controls in the context of various treaties and transparency arrangements. This work provides some of the background necessary to support discussions with Russia on nuclear weapon dismantlement.



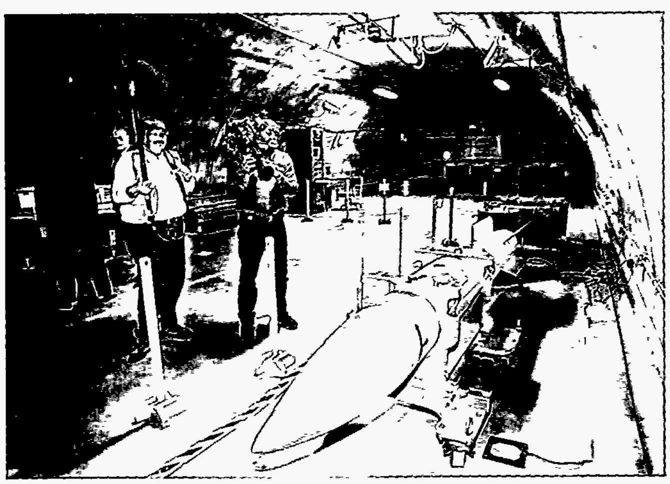
Sandia technicians prepare the multispectral thermal imaging satellite for installation of key subsystems.

6.1.3.2 Nuclear Safeguards and Security (GD)

Sandia supports enhanced physical protection at DOE nuclear weapons facilities. Programs include the evaluation of enhanced sensor and data fusion systems, examination of various biometric characteristics, and development and use of various integrated physical protection systems.

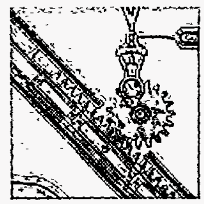
6.1.3.3 Arms Control and Nonproliferation (GJ)

Sandia helps evaluate export licenses in weaponization technology by drawing on our considerable experience in engineering nuclear weapons. Sandia also supports International Atomic Energy Agency activities. We evaluate various proposed inspection regimes, International Atomic Energy Agency information management technology and procedures, and proliferation concerns associated with dismantlement and disposition of weapon materials. Sandia also supports technology development for ongoing International Atomic Energy Agency inspections. Sandia's Cooperative Monitoring Center is used by a number of countries and agencies to evaluate the applicability of arms control technologies and procedures to regional security issues. Prototype monitoring equipment allows representatives of regional parties (from areas such as South Asia, the Middle East, the Balkans, and the Korean peninsula) to perform hands-on evaluation of various technologies and use models to simulate the applications of technical solutions to specific regional problems. Analytic support for the DOE includes treaty implementation analysis, staff support, nuclear testing analysis, and dismantlement analysis. Sandia has supported the DOE's onsite evaluation program since 1983 and continues to evaluate the impact of onsite inspections on sensitive industrial facilities and other issues related to implementation of various treaties. Policy support targets both sides of the policy/technology interface. We support technical analysis of policy options for the DOE and provide national security policy insight to Sandia organizations. Our direct support includes furnishing technical advisors to DOE Headquarters and to various negotiating delegations in Geneva.



CNN news staff videotape an inert nuclear weapon inside a Sandia igloo that serves as a testbed for arms control technologies.

We are reducing the risk of nuclear weapon proliferation (including such threats as theft, diversion, and unauthorized possession of nuclear material) by supporting numerous projects in the former Soviet Union that help achieve the protection and security of nuclear material and facilities. Additionally, cooperative interactions with scientists and engineers in various institutes in the former Soviet Union help to encourage dismantlement of weapons of mass destruction, advance nonproliferation activities, assist former Soviet states in converting their defense-oriented capabilities to civilian market-driven enterprises, and provide Western nations with better access to the science and technology that exist within the former Soviet Union.



6.1.3.4 Material Protection, Control, and Accounting (GJ)

Sandia participates in the multilaboratory Material Protection, Control, and Accounting Program to reduce the threat of nuclear weapons proliferation in the former Soviet Union. This program includes projects in a number of the newly independent states and addresses nuclear material and nuclear facilities operated by both the Ministry of Defense and the Ministry of Atomic Energy. Activities generally include training, hardware installations, and maintenance support.

6.1.3.5 Initiatives for Proliferation Prevention (GJ)

Sandia also participates in the multilaboratory Proliferation Prevention Program (formerly known as the Industrial Partnership Program), which engages scientists, engineers, and technicians from the former Soviet Union in nonmilitary projects. This program is focused on individuals and organizations that have worked on weapons development programs (including nuclear, chemical, biological, and associated delivery systems). The Proliferation Prevention Program provides seed money for research activities and provides links with US industry to commercialize the new activities.

6.1.3.6 Intelligence (NT)

Sandia's support for the intelligence community focuses on foreign technology assessment and technology development. We provide tools for evaluating information relevant to assessing the proliferation of weapons of mass destruction and their delivery systems. In addition, evaluations of information surety, a special expertise required by the nuclear weapons program, are increasingly provided to the intelligence community. We also continue to enhance our intelligence collection and exploitation role by developing new sensor systems and evaluating foreign technologies.

6.1.4 Assistant Secretary for Environmental Management (EM)

Work for the Assistant Secretary for Environmental Management includes activities that support our onsite operations and develop technologies and solutions for national environmental problems. In FY 1998 the DOE, Sandia, Los Alamos National Laboratory, the Environmental Protection Agency, and the New Mexico Environment Department reached agreement on a vision for environmental stewardship that will effectively drive our waste management and environmental restoration operations for the next three years. The vision statement is paraphrased below:

> We will complete all environmental restoration and stabilization efforts and ensure that long-term maintenance and monitoring programs are in place at all New Mexico DOE facilities by the year 2006, at Sandia by the year 2001, and at Los Alamos National Laboratory by the year 2006. Legacy waste identified for removal is shipped for permanent disposal. Effective waste minimization/ pollution prevention programs are in place. These completions are cost-effective and approved, comply with applicable regulations, ensure acceptable risk, and are being implemented in partnership with regulatory agencies and with public participation by the communities of New Mexico.

6.1.4.1 Waste Management Operations

Sandia's Waste Management Program is responsible for the treatment, storage, and disposal of hazardous, low-level, mixed, and solid wastes generated by ongoing mission-related activities and by environmental restoration, decontamination, and decommissioning activities at Sandia sites in New Mexico, California, Nevada, and Hawaii. Beginning in FY 1999, waste management will be transitioned from DOE Environmental Management to DOE Defense Programs.

The Waste Management Program conducts waste operations for hazardous, radioactive, and mixed wastes. These operations are staffed by qualified and experienced personnel. Sandia's treatment, storage, and disposal activities consist of a six-step process: generators formally request collection service; waste management personnel review the requests and certify that the waste meets Resource Conservation and Recovery Act acceptance criteria; the waste is collected, segregated according to Department of Transportation hazard classes, and delivered to the appropriate Sandia interim-storage facility; the waste is stored pending final disposition; waste management staff prepare manifests to identify the quantity, composition, origin, routing, and destination of waste; and the waste is sent to a commercial or government facility for treatment, recycling, or disposal.

Sandia's Generator Interface Program is the technical interface between waste generators and waste management operations. Program staff members help waste generators develop and implement waste management procedures, ensure that these procedures are followed, inspect and evaluate waste generators, recommend actions to reduce waste quantity or hazard level, define radioactive-material management areas, and provide training for waste generators. Staff members also maintain the sections of Sandia's Environment, Safety, and Health Manual dealing with management of chemical, radioactive, and mixed waste; provide technical consultation and liaison services; and serve as the interface between Sandia's Waste Management and Environmental Restoration programs.

To reduce risk and cost within the Waste Management Program, Sandia developed a waste-minimization and pollution-prevention program to decrease waste generation by source-reduction techniques; identify recycling options for waste materials that cannot be eliminated or minimized; and specify treatment options to reduce volume, toxicity, or waste mobility prior to storage or disposal. Waste-minimization activities include pollution-prevention opportunity assessments to identify viable pollution-reduction alternatives; a chemical-information system to track the purchase and use of all chemicals; a pollution-prevention team to enhance employee awareness, source reduction, and recycling initiatives; and a chargeback system that taxes waste generators to fund pollution-prevention initiatives.

Sandia's California and New Mexico sites have a Resource Conservation and Recovery Act permit for operation of our hazardous-waste management facility. Hazardous wastes are disposed at various commercial disposal facilities. Compatible waste streams are consolidated at the hazardous-waste management facility to decrease costs. These consolidated streams are analyzed before disposal in accordance with the facility permit approved by both the federal and California environmental protection agencies. Low-level waste is disposed at the Nevada Test Site in compliance with DOE orders, Environmental Protection Agency requirements, and Nevada Test Site criteria. Sandia/California ships its mixed waste to Sandia/ New Mexico, where it is handled in accordance with the Site Treatment Plan Compliance Order issued by New Mexico.

Hazardous materials generated at the Tonopah Test Range in Nevada are shipped to commercial facilities for disposal within ninety days of generation. Several drums of legacy radioactive materials are stored on site, pending shipment to the Nevada Test Site. No radioactive wastes are currently generated by Sandia operations at Tonopah. The Kauai Test Facility generates small quantities of hazardous wastes, which are handled through the Navy Pacific Missile Range waste management program or by commercial treatment and disposal facilities. No radioactive or mixed wastes are generated at the site.

6.1.4.2 Environmental Restoration Operations

The Environmental Restoration Project addresses legacy contamination resulting from past releases of hazardous, mixed, and radioactive contaminants at approximately two hundred Sandia/New Mexico sites. The project is also responsible for about a dozen sites at Sandia/California and for sites at Kauai in Hawaii, Tonopah in Nevada, and other locations. The total number of sites is about 250.

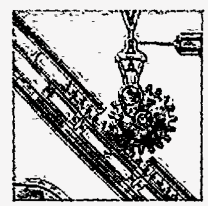
Activities include assessment of the known and potential release sites, followed by remedial action if necessary. Assessment and remediation are in full compliance with all applicable laws, regulations, and DOE orders. The primary regulatory driver for the Sandia/New Mexico Environmental Restoration Project is the Resource Conservation and Recovery Act Hazardous and Solid Waste Amendments. Activities at Sandia's Chemical Waste Landfill are regulated under the applicable Resource Conservation and Recovery Act closure requirements. The primary regulatory drivers for Sandia/California are those laws and regulations governing groundwater quality. Remedial actions at both the Sandia sites are scheduled for completion by the end of FY 2002. However, recent issues related to project scope, budget, and regulatory approval by the New Mexico Environment Department may prolong completion of the project at Sandia/New Mexico by an additional one or two years.

6.1.4.3 Environmental Technology Development

Sandia's Environmental Technology Development Program encompasses a range of customer application needs. Our work covers technology development for waste management, environmental restoration, information management and decision support, and monitoring/sensor applications.

Sandia's research and development supports the destruction or separation of hazardous materials and waste. Our technology in combustion research and chemical sciences is the basis for much of this work. A distinguishing characteristic of our approach is a combination of computational and experimental work that integrates disciplines and crosscutting component technologies. Sandia's Combustion Research Facility is developing a fundamental understanding of both thermal and nonthermal waste-destruction technologies. We have provided significant systems-level development of supercritical water oxidation systems, steam reforming, and incineration processes. For contaminant removal and isolation, we have developed crystalline silicotitanates as an inorganic ion-exchange material for radioisotopes, regenerative mercury filters for mixed-waste treatment, and supercritical carbon dioxide systems for extracting organics from waste.

Environmental restoration technology activities at Sandia focus on better ways to clean up the DOE's contaminated sites. Technologies and systems that lead to quicker, safer, and more efficient site remediation are being developed. We have development, demonstration, and evaluation roles for specific technologies in landfill cover designs, permeable reactive barriers, grout containment barriers, verification and monitoring of cover and barrier integrity, and in situ destruction of contaminants. In addition, the Innovative Treatment and Remediation Demonstration Program applies innovative technology to real problems while providing test and evaluation data needed for acceptance in the future.



Sandia has created the Subsurface Flow and Transport Laboratory (principally supported by DOE Energy Research) to understand the fundamental processes involved in fluid flow and contaminant transport through rocks and soils. This understanding is essential to many DOE programs, including environmental restoration, radioactive waste management, and resource exploitation. This experimental laboratory includes state-of-the-art quantitative flow and transport visualization via high-resolution image acquisition and analysis. Complementary capabilities include field-scale experimental systems and numerical modeling capabilities ranging from continuum-based modeling to nonstandard percolation theory techniques. The laboratory involves academic and industrial users to create a center of excellence serving the needs of geoscience programs within the DOE.

Sandia has a large robotics program that brings intelligence and advanced controls to standard industrial robotics hardware for applications that are typically unstructured or represent small-lot production. For example, hazardous waste cleanup requires affordable systems that retrieve the waste, monitor its condition, ensure environmental and personnel safety, and meet changing legal and regulatory requirements. We bring robotic intelligence into complete systems such as this. Sandia's accomplishments in environmental technology include development of the control system for the multilaboratory light-duty-utility-arm project to assist in the cleanup of underground storage tanks and the field use of a remotely operated telerobotic vehicle for intelligent retrieval of hazardous materials from buried waste sites.

Risk-assessment, decision-support, and information-management methods have been a vital part of many programs at Sandia. Our development of risk management techniques began decades ago during safety studies for nuclear weapons. We extended those techniques during the 1970s, when we developed methods for probabilistic risk assessment and applied them to studies of nuclear reactor safety. Building on those two foundations, we gained expertise that we now apply to projects in a wide range of environmental applications. Our tools and techniques allow us to identify the hazards associated with a technical system, find solutions to problems, determine the risks of identified hazards, and reduce risks to acceptable levels through appropriate design, control, and decision methods. The techniques have particular applicability in the environmental area, where information may be limited and the cost of additional data may be high. These tools enable users to perform risk- and cost-related analyses of site-remediation activities. Analyses allow optimization of the data-collection process for groundwater monitoring, well and sample placement, characterization prioritizing, radionuclide and hazardous-materials risk assessment, and site ranking. Sandia also developed and maintains the Technology Management System, which is used by DOE Environmental Management for tracking environmental technology development.

Sandia has decades of experience in the development and use of methods for sensing and interpreting information about the environment. Applications have ranged from remote sensors on satellite platforms to microelectronic sensors in direct contact with the environment. This technology requires an understanding of various disciplines and technologies. Sandia's program for sensor development employs more than one hundred technical professionals who extend the state of the art in sensor technologies for defense systems, commercial manufacturing, and environmental monitoring. We develop complete systems for monitoring multiple media (air, water, and soils) as well as systems for characterizing conditions during manufacturing or waste-treatment processes. Sandia's work in environmental characterization monitoring and sensor technology includes contaminant monitors such as portable acoustic wave sensors for volatile organic compounds, chromatographic separation/laser detection for monitoring low-volatility organics at molar concentrations, miniature fiberoptic chemical sensors for volatile organic compounds and metals, tunable diode lasers for ammonia, metal-emissions monitors based on laser spark spectroscopy, and mercury monitors. Additional work involves radiation detectors for elemental and radionuclide detection and (ambient-temperature x-ray and gamma ray detectors, and volume-integrating and imaging systems); remote optical monitoring systems (multispectral ultraviolet-light detecting and ranging [lidar] technology and ultraviolet dual-infrared absorption lidar for ozone and water-vapor detection); geophysical imaging and characterization systems (two- and three-dimensional high-frequency seismic and electromagnetic imaging, borehole radar, and ground-penetrating radar); in situ permeable-flow sensors; and time-domain reflectometry sensors for cone penetrometers. We develop methods for emplacing sensors and complete systems for compiling and interpreting the resulting information. Initiatives are under way to develop the next generation of environmental sensors based on applications of fiberoptic and microelectronics technology.

6.1.4.4 Hazardous and Radioactive Material Transportation

A principal task for the Assistant Secretary for Environmental Management is the Transportation Technology Development Program. This program directly addresses ongoing DOE programmatic packaging and transportation needs and includes projects in the following areas:

- engineering-based comprehensive risk assessment of the seaborne transportation of radioactive material;
- development of alternative packaging concepts to facilitate the cost-effective decontamination and decommissioning of closed DOE weapons-manufacturing facilities;
- determination of the cost benefit of applying burnup credit factors to the design requirements for packaging DOE spent fuel;
- advanced technology development to characterize materials used in transportation and waste management;
- work with DOE program offices to identify and evaluate unresolved technical requirements to address packaging systems, design features, and materials compatibility issues;
- engineering analysis to improve and apply thermal- and structural-analysis codes, develop code modules, and create data bases specific to transportation problems;
- certification and regulatory support that provides technical expertise for various DOE efforts;
- environmental and systems planning to develop and apply systems-analysis techniques, risk-assessment codes, and data relating to transportation-systems operations;
- testing to support package certification, confirm new design concepts, and provide results for code confirmation and risk assessments;
- state-of-the-art mobile data-acquisition capability to support Nuclear Regulatory Commission certification testing;
- transportation automation and technical assistance, including the TRANSNET technology partnership facility;
- transportation intelligent monitoring, which develops technologies to improve emergency response systems for DOE activities;
- geographic information systems development and integration to provide links for transportation risk assessment, preferred-route-determination algorithms, environmental-justice analysis, and accident-rate-prediction codes; and
- source-term-containment evaluation, which develops information and analysis techniques to set requirements for allowable package leakage.

The Transportation Technology Development Program has direct application to a number of entities in the DOE's Environmental Management Office. EM-76 and the National Transportation Program provide technical support to a wide range of transportation issues. EM-60 provides support for the interim storage, transportation, and disposal of DOE-owned spent nuclear fuel. EM-36 provides systems analysis and conceptual packaging design for the interim storage, transportation, and disposal of greater-than-Class C wastes. EM-30 and EM-40 provide systems analysis, technical development, and waste management to mitigate the impact of decommissioning and decontaminating DOE facilities.

6.1.4.5 Nuclear Waste Repositories

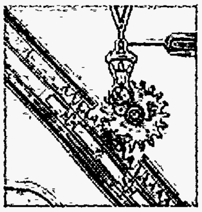
6.1.4.5.1 The Waste Isolation Pilot Plant

Sandia is responsible for scientific studies and performance modeling to enhance and demonstrate the long-term behavior and containment properties of the Waste Isolation Pilot Plant repository and its suitability for long-term disposal of the DOE's transuranic waste. Sandia has provided a detailed geotechnical understanding of the Waste Isolation Pilot Plant site (located near Carlsbad, New Mexico) and scientific research on issues related to the disposal of transuranic waste. Sandia has served as the scientific advisor for the project since its beginning in the 1970s, and we will continue to provide scientific assistance for the recertification phase to meet the requirements of the 1992 Waste Isolation Pilot Plant Land Withdrawal Act and applicable long-term regulations. Sandia plans to provide ongoing scientific assistance throughout the thirty-five-year operational phase of the facility, particularly in support of the five-year recertification applications required by regulation.

Sandia's technical activities focus on studies in four areas: near-field investigations, far-field investigations, seals engineering, and performance assessment implementation.

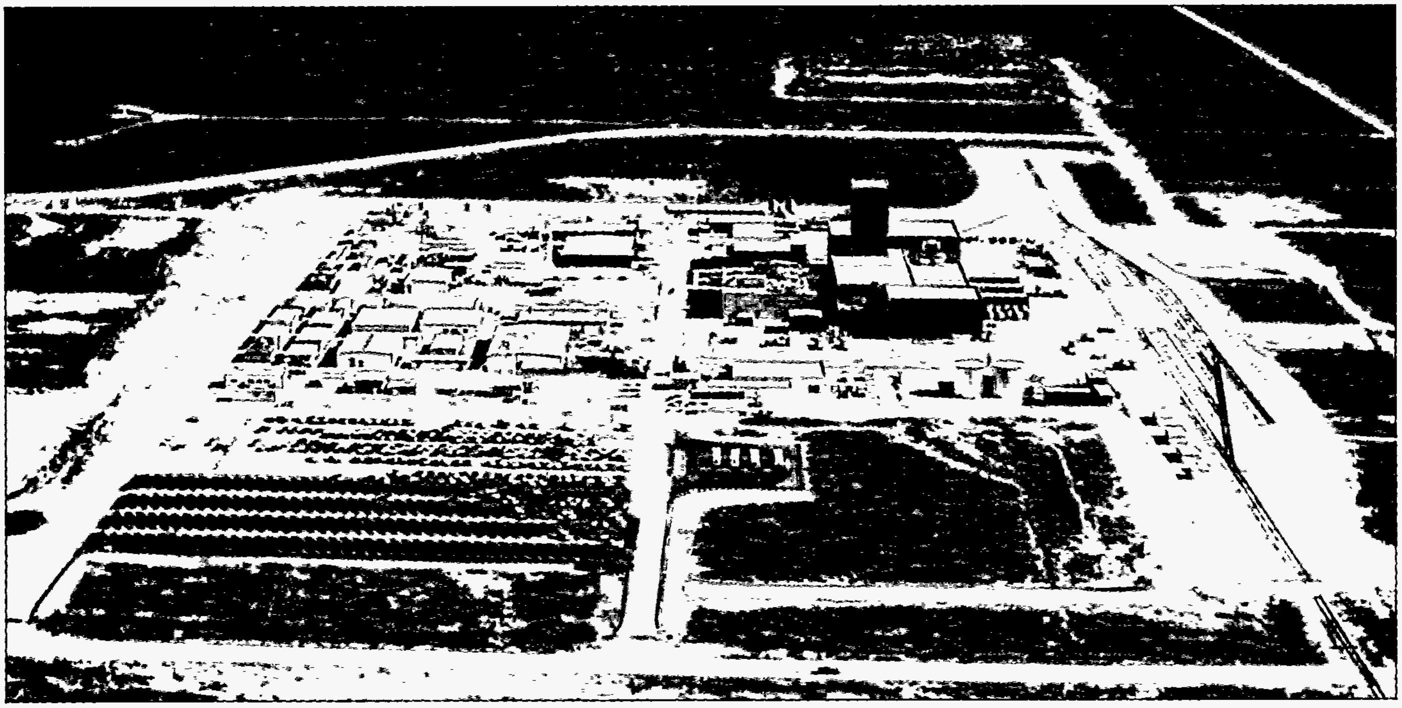
Near-field investigations include

- disposal room and drift system studies to understand how wastes will interact with the repository's bedded salt and human-intrusion boreholes,
- laboratory studies to determine how waste forms may degrade and chemically interact with engineered backfills,
- investigations of the disturbed rock zone around excavations in the salt, and
- sealing systems and rock mechanics studies to aid design of barriers that prevent wastes from escaping through mined entrances.



Far-field investigations include

- Salado hydrology and transport studies to characterize liquid and gas flow in the repository rock salt, and
- non-Salado flow and transport studies to determine the properties of formations overlying the repository.



Sandia conducted detailed analyses of the Waste Isolation Pilot Plant to support certification activities.

Seals engineering includes

- seal-material development and modeling,
- seal design and modeling, and
- rock mechanics and disturbed rock zone behavior and modeling.

Performance assessment implementation includes

- modeling of long-term repository behavior with planned and potential wastes, and
- development of "desktop" and other improved performance-assessment modeling capabilities.

Disposal room and drift system activities consider backfill, brine, simulated waste, waste containers, disposal rooms, and test designs for laboratory and field experiments. Experiments in the past have provided an understanding of important waste interactions to support development of source-term and gas-generation models. Current emphases in experimental work focus on chemical and mechanical backfill performance and the response of the disposal system to borehole intrusion.

Sealing systems and rock mechanics experiments in laboratory and field settings have determined the properties of salt, concretes, clays, and other fillers. These experiments support the design of a shaft sealing system and the modeling of its long-term performance.

Laboratory and field studies of Salado hydrology and transport have measured hydrologic parameters of the salt such as permeability, threshold pressure, and two-phase flow. Experimental results support models of brine and gas flow into and away from the repository.

Non-Salado flow and transport experiments have used laboratory and field studies to measure hydrologic and chemical transport parameters of formations overlying the repository. Laboratory experiments continue to provide additional support for models of radionuclide transport properties under present and anticipated conditions.

Performance assessment uses input from data bases and models of the preceding activity areas to model the predicted long-term performance of the repository. The results included in the compliance application that the DOE submitted to the Environmental Protection Agency in October 1996 successfully demonstrated compliance with regulatory requirements. Additional modeling work will be performed to provide the Environmental Protection Agency with the basis for a recertification decision in 2003.

Other activities concerning integration and management include responses to inquiries from oversight groups, definition of the waste inventory parameters needed for performance assessment, and quality assurance for all facets of the above efforts.

Activities in FY 1999 will focus on improving our understanding and modeling capabilities for the near-field and far-field processes at the Waste Isolation Pilot Plant and the incorporation of this understanding into user-friendly performance assessment calculations that may be performed at desktop computers. These activities may include experimental work to evaluate the impact of future transuranic wastes on facility performance, analyses of the results of monitoring and performance verification testing, and calculations that update performance assessment results.

Sandia will devote increased attention to cooperative international research activities in the above areas to advance the Waste Isolation Pilot Plant as an established center of excellence for waste management science.

6.1.4.5.2 Greater Confinement Disposal Project

Sandia has been selected by the DOE Nevada Operations Office to lead technical compliance assessment analyses for the Greater Confinement Disposal Project. The project site, located within the Nevada Test Site, has been proposed for the permanent disposal of a small amount of transuranic waste that does not meet the waste acceptance criteria for other waste repository programs. These wastes have been included in a category termed special-case wastes, requiring an alternative disposal method. In order for the waste to remain emplaced, the Greater Confinement Disposal Project must demonstrate compliance with the Environmental Protection Agency's standards for disposal of high-level waste, transuranic waste, and spent fuel.

Sandia's role in the Greater Confinement Disposal Project includes development and implementation of a strategy to demonstrate regulatory compliance, conceptual model development, performance assessment activities, site characterization activities supporting performance assessment, analyses to identify the suite of potential special-case wastes and evaluate alternative systems for their disposal, program integration, and implementation of an overall project strategy.

6.1.4.6 National Transuranic Waste Program

The DOE established the National Transuranic Waste Program to ensure that all transuranic waste under the DOE's purview is effectively managed from generation through disposal. This transuranic waste management program has six elements: generation, storage, and retrieval; characterization; certification; treatment; packaging and transportation; and disposal. Sandia supports the National Transuranic Waste Program by

- developing long-term guidance to coordinate and integrate DOE transuranic waste activities throughout the complex;
- developing a computer simulation model to evaluate the preparation and flow of transuranic waste from generation and storage locations in the DOE complex to final disposal at the Waste Isolation Pilot Plant;
- developing decision support systems to address specific DOE waste management issues;

- developing comprehensive disposal recommendations for all transuranic waste throughout the DOE complex;
- conducting legal and regulatory research needed to develop DOE policy for transuranic waste management issues;
- supporting characterization, transportation, and packaging projects for disposal of remotely handled transuranic waste; and
- facilitating participation of the program's stakeholders (generator and storage sites; the DOE; regulators; and state, local, and tribal governments).

6.1.4.7 Spent Nuclear Fuel

Sandia is providing technical support for the DOE National Spent Nuclear Fuel Program. The DOE spent fuel inventory includes foreign research reactor fuel as well as fuel in production and research reactors in this country. The foreign research reactor fuel is US fuel provided to foreign governments for research purposes. The DOE is returning this fuel to the United States on a thirteen-year shipping schedule.

Sandia support includes identification of potential technical issues and resolution of issues affecting preparation of spent nuclear fuel for ultimate disposal. Performance assessments are under way, including an articulation of the standard for commercial spent nuclear fuel and an initial comparison between the commercial spent nuclear fuel standard and the data available for DOE spent nuclear fuel. Technical issues arising from this comparison include the need for more sophisticated spent fuel measurement techniques, complex-wide coordinated spent fuel characterization and acceptance criteria, and a complex-wide quality assurance and quality control process. Resolution of such technical issues will provide assurance that DOE spent fuel will be accepted for disposal, even after long periods of interim storage.

6.1.4.8 Studies for Disposal of Defense Spent Nuclear Fuel and High-Level Waste

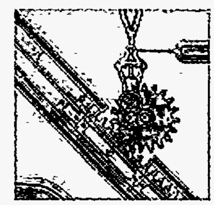
Sandia's Nuclear Waste Management Program Center is assisting the DOE Environmental Management Office with the development of a safe, cost-effective technical strategy for the interim management and ultimate disposition of domestic and foreign spent nuclear fuel that is under the DOE's jurisdiction. The center is using its core competencies in the six areas below.

6.1.4.8.1 Nuclear Criticality

The possibility and consequences of a nuclear criticality within a geologic repository are being evaluated. A detailed and comprehensive nuclear-dynamics consequence analysis is being conducted. The study is demonstrating that the occurrence of an unrestricted criticality is unlikely if spent nuclear fuel is disposed of in a repository sited in unsaturated volcanic tuff.

6.1.4.8.2 Performance Assessment

The postclosure performance of a hypothetical repository holding DOE-owned spent nuclear fuel and high-level radioactive waste in unsaturated tuff is being assessed. The performance assessment emphasizes integration with the repository issues and the concerns of the Division of Civilian Radioactive Waste Management. Technical objectives include identification of fuel characteristics that have the most influence on performance and system aspects that control the probability of forming a critical amount of fissile material. We will use the most current information on the Yucca Mountain repository site, including data not yet published.



6.1.4.8.3 Safeguards and Security

A significant quantity of DOE-owned spent nuclear fuel destined for the proposed repository at Yucca Mountain contains highly enriched uranium. Several presidential and cabinet-level policy decisions and proliferation issues may affect the disposability of this fuel. These policy decisions are tied to treaties, transparency initiatives, and performance requirements that may present obstacles to the long-term storage or disposal of DOE's highly enriched uranium fuel. A roadmap is being developed to assess potential proliferation-policy and technical safeguards issues associated with the disposition of DOE-owned highly enriched uranium fuel. The roadmap considers alternative paths for disposal, including the current condition of the fuel and assumed permanent disposal in a geologic repository.

6.1.4.8.4 Nondestructive Assay and Nondestructive Examination

The quality assurance records for some of the DOE spent nuclear fuel inventory may be inadequate for meeting the certification requirements governing disposal in a repository. This part of the inventory would then have to be characterized. An evaluation of known nondestructive assay and nondestructive examination techniques is being conducted to support the characterization of DOE spent nuclear fuel. The evaluation defines the capabilities and limitations of each technique relative to the spent nuclear fuel to which it applies. Another review of DOE spent nuclear fuel will address the various types of fuels, cladding conditions, and enrichments that may require nondestructive testing before certification for repository disposal.

6.1.4.8.5 Transportation

DOE Environmental Management must supply the transportation system for DOE and Navy spent nuclear fuel. This system must be compatible with numerous fuel types, site requirements, and DOE transportation and repository requirements. To ensure meeting DOE commitments to safely store, transport, and dispose of spent nuclear fuel, a technical basis is needed for the design and procurement of a national transportation system for DOE spent nuclear fuel. This system must meet the logistics demands of sites and DOE radioactive waste management regulations. An engineering study and transportation plan are being completed to examine issues such as size versus payload for casks, co-shipment options, optimum and coordinated site transportation schedules, and repository throughput.

6.1.4.8.6 Quality Assurance

License approval for the proposed repository will require a robust quality assurance program. The lessons learned from the development of a quality assurance program for the Waste Isolation Pilot Plant are being applied to the DOE National Spent Nuclear Fuel Program through presentations, workshops, and hands-on training at sites with spent nuclear fuel inventories.

6.1.5 Assistant Secretary for Energy Efficiency and Renewable Energy (EE)

Sandia supports the DOE's National Energy Strategy goal of providing secure and environmentally acceptable energy supplies by improving energy infrastructure surety and energy production, conversion, and use. Drawing on more than twenty years of experience in energy research and technology development, our programs include solar electric technologies, wind energy, geothermal energy systems, industrial and transportation applications, fossil energy programs, electric power distribution systems, and energy storage systems for utilities. These programs are closely coordinated with industry, allowing Sandia to develop strong technology partnerships and to focus research and development on major national needs. We also provide technology in risk assessment that aids the industry in understanding the impacts of utility restructuring.

Sandia is a resource for the nation in systems analysis, risk assessment, technology development, and engineering design. Staff members in our program areas of renewable energy, fossil energy, and energy efficiency initiate and maintain technical collaborations with industry and users to reduce the cost of renewable energy and to curb pollution.

We work in cooperation with the DOE and in partnership with industry to strengthen the competitive position of US industry through demonstration projects. Our efforts are international and support the DOE's global policy. We apply Sandia-wide capabilities in engineered materials and advanced manufacturing technologies to assist industry in improving the manufacturability and cost competitiveness of renewable energy systems.

6.1.5.1 Electric Energy Systems (EB)

In coordination with industry, Sandia is developing practical, high-temperature superconducting wire to improve the efficiency of electric motors, generators, and electric utility equipment.

This work helps optimize high-temperature superconducting materials and conductor fabrication technology, which is necessary to the development of devices that can improve the efficiency of electric power generation and distribution systems.

6.1.5.2 Energy Storage Systems (EB)

Sandia continues to collaborate with industry and academe to develop advanced stationary energy storage components and systems for the DOE Office of Utility Technologies. Cost-shared contracts with industry partners are used to develop both advanced technologies and highly integrated components and systems. Sandia's technical expertise is used to manage these contracts, analyze the benefits of storage in utility and renewable energy systems, evaluate prototype storage components, and conduct applied research. Successful development of cost-effective energy storage systems will increase the energy security of the nation and improve the reliability of the electricity supply, which is estimated to be worth $150 billion annually.

6.1.5.3 Hydrogen Storage and Utilization (AL)

The environmental impact of hydrocarbon use and the national dependence on foreign petroleum supplies are sources of increasing public concern. Hydrogen, an abundant and versatile energy carrier, offers significant advantages over other alternative fuels, including the potential for zero harmful pollutants and zero carbon dioxide emissions. In addition, hydrogen can be produced domestically from renewable energy sources.

Sandia is uniquely positioned to advance the use of hydrogen with programs that span most of the DOE's hydrogen research. These programs include basic and applied hydride material research, hydrogen storage systems engineering, basic and applied hydrogen combustion research for stationary and mobile applications, and the development of advanced carbon materials for use in proton-exchange-membrane fuel cells.

Sandia is developing improved hydride storage materials for fixed-site infrastructure and transportation applications. This activity is aimed at improving hydride materials and developing and demonstrating storage systems that fully utilize the volume density and safety advantages of hydrides. This effort focuses on magnesium alloy hydrides because of the relatively low cost of these materials and their potential weight advantage over other hydride systems.

Sandia is developing carbon-based materials for use in proton-exchange-membrane fuel cells in partnership with International Fuel Cells, Inc.

Sandia leads the Russian/American Fuel Cell Consortium, part of an international agreement between the DOE and the Ministry of Atomic Energy of the Russian Federation. This agreement includes projects on improved separator plates for phosphoric acid fuel cells and advanced catalysts for oxygen reduction.

Sandia provides the technical and management lead in hydrogen implementation projects in remote area power production applications. Sandia is also developing methods for producing clean hydrogen with dehydrogenation catalysts and advanced separation membranes.

A collaborative design team from industry, the University of Miami, Sandia, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory is designing and fabricating a hydrogen-fueled internal combustion engine coupled to an electric generator. The objective is to optimize the engine and generator for efficiency while maintaining zero harmful emissions.

Sandia analyzes complex problems relevant to the hydrogen energy field. Engineering systems analysis has been used successfully to solve problems ranging from analyzing the detailed chemical and physical behavior of solar thermal hydrogen production technologies to the use of hydrogen in renewable distributed energy systems. We provide this type of fundamental analysis as a core competency to the hydrogen community. Sandia also has responsibility for developing and managing the DOE hydrogen clean corridor activities.

6.1.5.4 Geothermal Systems (EB)

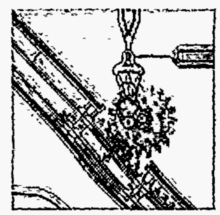
Sandia's work in geothermal systems will increase the nation's proven geothermal reserves and assist industry in expanding the use of geothermal power. We are developing new drilling and completion technologies to help expand the commercial use of US geothermal resources. Many of the technologies we develop in this area can also be used in petroleum and mineral extraction.

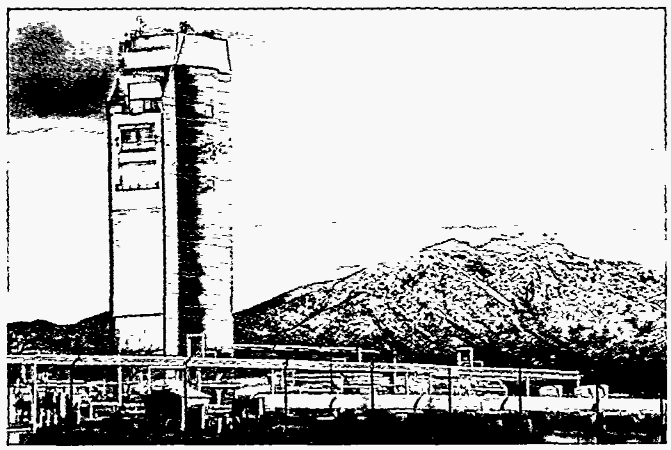
A large portion of the cost of generating electricity from geothermal sources is associated with drilling and completing wells. For this reason, our major work includes slimhole drilling for geothermal exploration and reservoir assessment, technology to reduce drilling costs associated with loss of circulation, high-temperature instrumentation for geothermal wells, wireless telemetry to transmit downhole data to the surface, and advanced drill bits for reducing drilling costs. Most of these projects are conducted in cooperation with industry partners.

6.1.5.5 Solar Energy (EB)

6.1.5.5.1 Concentrating Solar Power

Engineers in Sandia's concentrating solar power programs work with users and manufacturers to improve reliability, decrease costs, and increase acceptance of concentrating solar power technologies for power generation. We provide technical support to Solar Two; support industry development of commercial dish/Stirling systems; conduct research and development of advanced components, including dishes, heliostats, and receivers for dish, trough, and power tower systems; design, analyze, and test components and systems at industry sites and at the National Solar Thermal Test Facility; and operate an industry support activity that promotes the use of concentrating solar power technologies through services to manufacturers, operators, and decision makers.





Sandia's Solar Tower is an essential part of the National Solar Thermal Test Facility.

6.1.5.5.2 Photovoltaics

Sandia's photovoltaics work is centered on improving the cost-effectiveness of photovoltaic energy systems produced by US industry and used worldwide. We work to reduce startup costs and improve system reliability. We team with industry, utilities, and other users to accelerate development and acceptance of the technology at home and abroad.

Within the DOE complex, Sandia has lead-laboratory responsibility for crystalline and multicrystalline silicon-cell technologies, and for balance-of-systems and systems engineering. Through the National Center for Photovoltaics partnership, we collaborate on all aspects of photovoltaic technology with the National Renewable Energy Laboratory, which has lead responsibility for photovoltaic cells and modules. We provide the technical lead for balance-of-systems efforts and provide technical support to the DOE in deployment and validation of photovoltaic systems. We assist industry by providing technical assistance, accurate performance measurements, reliability testing, and evaluation.

6.1.5.5.3 Wind Power

Sandia employs a multifaceted approach to the development of economical wind systems for power generation. First, we conduct applied research in aerodynamics, structural dynamics, fatigue, materials, manufacturing, controls, and systems integration to understand unsolved technology problems and to provide better design tools. Second, we apply our analytic and experimental capabilities to solve specific technical problems encountered by industry. These problems typically impede the deployment of reliable, cost-effective solutions for domestic and international markets. Finally, two new efforts investigate how rare atmospheric events can impact wind turbine long-term structural integrity and how advanced data handling techniques can be successfully applied to the difficult field environment of operating wind turbines. Our work is conducted under the auspices of the DOE's Office of Energy Efficiency and Renewable Energy. In all our approaches, we use formal and informal teaming arrangements to work closely with wind turbine manufacturers, wind farm developers and operators, and other DOE laboratories.

6.1.5.6 Industrial Sector (ED)

6.1.5.6.1 Combustion Technology

The Combustion Research Facility at Sandia/California is a DOE Office of Energy Research user facility, accommodating experimental, theoretic, and computational investigations into reducing energy consumption and environmental impacts, enhancing fuel flexibility, and broadening science and engineering foundations. Our combustion research work utilizes unique laser-diagnostic as well as computational-modeling capabilities.

Sandia researchers collaborate with industry on combustion projects that reduce noxious emissions (without compromising fuel efficiency), improve technologies for internal combustion engines and various industrial processes, and develop environmental technology systems for the destruction of hazardous wastes.

6.1.5.6.2 Materials Processing by Design

Sandia's materials processing programs work to improve existing processes and to develop new commercially and environmentally acceptable methods for the glass, chemical, petroleum, and semiconductor industries. This work explores the underlying physics, chemistry, thermodynamics, and fluid mechanics of new processes for manufacturing commercially important chemicals, powders, composites, coatings, and membranes. Our present focus is on development of predictive models of high-temperature chemicals and materials synthesis processes.

6.1.5.6.3 Advanced Industrial Materials Research

Sandia's materials research work in the industrial technologies program provides computer-aided design, synthesis, characterization, and testing of new materials with the potential for energy savings and waste reduction in industrial applications. This work is performed with industrial cooperation and cost-sharing. The focus is on using selective inorganic thin films for energy savings by improving performance of light gas membranes and catalysts, synthesizing composites by reactive metal infiltration, and optimizing composites manufacturing.

6.1.5.6.4 Industrial Waste Reduction Program

Sandia collaborates with industry to develop and commercialize cost-effective waste reduction technologies and practices. This program focuses on reducing wastes generated during manufacturing and improving the energy efficiency of industrial processes. The goal is to stimulate, facilitate, and coordinate development and transfer of waste reduction and energy saving technologies to industry.

6.1.5.6.5 Catalysis and Separations Science and Engineering

Catalysis and separations underlie nearly all processes for producing fuels and chemicals and directing environmental protection and restoration projects. Catalysis is involved in more than 20 percent of the nation's gross domestic product (approximately $1 trillion annually), and new separation technologies offer the potential of multibillion dollar cost savings when used in energy-intensive industries and for the cleanup of industrial and radioactive waste sites. Consequently, the gains in economic competitiveness, energy efficiency, and environmental stewardship through improved catalytic and separation processes are significant.

The Center for Catalysis and Separations Science and Engineering provides a cost-effective, science-based, applications-oriented program that includes state-of-the-art predictive capabilities for design and performance and sophisticated experimental capabilities. The center focuses on problems of national interest and emphasizes strong interactions with government-sponsored programs and industrial partners. The center is a matrixed partnership of Sandia organizations that builds on existing facilities, personnel, and capabilities (e.g., high-performance computing, simulations at multiple length scales, advanced materials synthesis, engineering science, materials performance evaluation, and surface analysis). Industry provides the focus for program activities, either through partnerships with individual companies or through consortium arrangements. Other national laboratories and universities provide unique expertise and capabilities through a virtual center led by Sandia.

6.1.5.7 Transportation Sector

Sandia is developing technology to reduce the environmental consequences of automobiles by working on advanced materials; advanced manufacturing processes; and advanced batteries, fuel cells, and hybrid vehicle systems. This work is conducted primarily in support of the goals of the Partnership for a New Generation of Vehicles. Sandia is developing more efficient engine technology, improved catalyst and emission systems, and improved batteries for electric vehicles.

Sandia has established capabilities in instrumentation, sensing, analysis and control of manufacturing processes, development and application of lightweight materials, supercomputing, structural analysis, fluid dynamics, combustion, mesh generation, and visualization. Nurtured primarily to meet the requirements of our nuclear ordnance mission, these capabilities have also been supported by the Basic Energy Sciences, Energy Efficiency, and Environmental areas of the DOE. Building on these capabilities, we have used the technology transfer process to establish new programs with the automobile industry.

Sandia has a cooperative research and development agreement with the US Advanced Battery Consortium for the development of electric vehicle battery technologies. The objective is to advance these technologies to a level that will encourage industry to become a partner in the development program. If successful, industry would begin development and commercialization of batteries for electric vehicles.

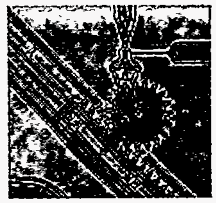
Sandia has initiated several new cooperative research and development projects in materials and materials processing with the domestic automotive industry through the US Automotive Materials Partnership. Projects focus on developing new and improved light metal components and improved manufacturing processes.

Sandia scientists and engineers are also developing new materials, fuel processing catalysts, and improved manufacturing processes for batteries, fuel cells, and supercapacitors. This effort could lead to vehicles with electrochemical propulsion systems.

6.1.6 Office of Civilian Radioactive Waste Management

Sandia's major activities for the Office of Civilian Radioactive Waste Management address the geologic disposal of spent fuel and high-level radioactive waste.

The Yucca Mountain Site Characterization Project[2] is investigating the feasibility of isolating high-level radioactive waste in unsaturated volcanic tuff. The potential site is at Yucca Mountain in southern Nevada, adjacent to the Nevada Test Site. As a member of the management and operating team, Sandia collects laboratory and field data, develops detailed models for individual processes, assesses the behavior of the total system, and estimates its long-term performance for comparison with regulatory standards. Sandia's specific responsibilities in this multifaceted project include



- identifying the features, events, and processes that might affect the repository during the 10,000-year regulatory period, then constructing scenarios to develop numerical models that describe the future states of the repository system;
- conducting laboratory and field experiments to assess the effects of disturbances from the construction and operation of a repository, including thermal and mechanical changes induced in the host rock by hot waste;
- developing and evaluating conceptual designs for seals in the repository's boreholes, shafts, and drifts;
- using geostatistical data to construct three-dimensional representations of Yucca Mountain lithology to predict the location of rock units and to run numerical simulations of the total system;
- using geophysical techniques and direct observation to assess rock-mass quality in the exploratory tunnel as an aid to construction;
- conducting studies that investigate the effects of climate change on infiltration and on the resulting percolation flux through the repository;

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[2] The Yucca Mountain Site Characterization Project is funded via an inter-DOE work order. Funding is included in chapter 9 under the entry for All Other Federal Agencies.

- conducting a performance assessment by abstracting appropriate models from detailed process models, linking coupled processes, performing stochastic calculations of radionuclide releases for the scenarios, and deriving complementary cumulative distribution functions for the releases; and
- developing decision-analysis capabilities to aid in cost-efficient data collection.

The information obtained from these studies is being combined with information from management and operating teammates in total-system performance assessments to help judge the suitability of Yucca Mountain as a repository. Ultimately, the Yucca Mountain Project test and analysis results will be major parts of the license application that the DOE will submit to the Nuclear Regulatory Commission. Completion of these assessments is essential to timely waste emplacement because assessments must be available for the commission to examine as it appraises the suitability of the repository.

Sandians Mike Riggins, Ronnie Taylor, Moo Lee, and Jeff Danneels prepare a field test at Yucca Mountain.

6.1.7 Office of Nuclear Energy

6.1.7.1 Nuclear Energy Research and Development (AF)

Sandia operates the Light Water Reactor Technology Center for the DOE and has a significant role in the Nuclear Energy Power Optimization Program and the Nuclear Energy Research Initiative. Nuclear power is an essential component of this nation's energy supply, and its environmental advantages are becoming increasingly important as worldwide concern over the emission of greenhouse gases grows. The United States has invested more than $200 billion in nuclear power facilities that generate 20 percent of the nation's electricity. If plant life could be extended for an average of ten years, $170 billion would be saved. Our research and development, conducted as part of the Nuclear Energy Power Optimization Program, will lead to improved safety, reliability, and cost effectiveness of commercial light water reactors and will support the license renewal process for existing light water reactors. As part of the Nuclear Energy Research Initiative, we are conducting research to support the development of innovative nuclear energy systems that are safe, reliable, economical, and resistant to proliferation.

6.1.7.2 Isotope Production and Distribution Program (ST)

The DOE has designated Sandia's nuclear facilities as the site to produce molybdenum 99, from which the medical radioisotope technetium 99m is later extracted. Technetium 99m is involved in approximately 10 million nuclear medicine procedures each year in the United States. The US radiopharmaceutical industry and nuclear medical community require a reliable supply of medical isotopes to conduct these procedures. The current supply depends on a single aging Canadian reactor, and there is no backup other than limited production in Europe and South Africa. Congress mandated that the DOE Office of Nuclear Energy, Isotope Production and Distribution develop a domestic capability. Sandia's Annular Core Research Reactor and Hot Cell Facility will be used to meet this mandate and produce molybdenum 99. We will be an essential supplier of radioisotopes and could become a national focal point for research in nuclear medicine. Other activities include support for development of optimized production and processing, cooperation with private industry, and technology transfer.

6.1.8 Assistant Secretary for Fossil Energy

Sandia's Fossil Energy Program encompasses both the upstream and downstream technology needs for enhanced US fossil energy production. Upstream activities include advanced reservoir diagnostics accomplished by geophysical imaging and sensor development and increased production accomplished by numerical and physical simulation of reservoir response. The mechanics of the wellbore and near-wellbore area and the hydromechanics of enhanced production and completion engineering (e.g., hydraulic fracturing and pump dynamics) are also investigated. Downstream activities for underground oil and gas storage include prediction of physical properties, advanced processing, catalysis, development of sensors and controls, and environmental monitoring. Other fossil energy activities include indirect liquefaction, biomass conversion, and coal combustion.

Our primary customers are DOE Fossil Energy through the National Petroleum Technology Office and the Federal Energy Technology Office; the Advanced Computer Technology Initiative; and work-for-others agreements with major oil companies, independents, service industries, and associations such as the Gas Research Institute.

6.1.8.1 Coal and Downstream Oil Processing (AA)

6.1.8.1.1 Downstream Processing, Coal Conversion, and Fuel Cells

This program develops materials, catalysis and separation technology, sensors, and controls. Important program elements are stochastic approaches to kinetic calculation; multiphase flow characterization; hydrous metal oxide ion exchangers; exploration of hydrogenation activity for heavy feedstocks; diagnostic instrumentation for catalyst assessment and reactor dynamics; inorganic membranes for gas purification; and catalyst support material. Our research utilizes Sandia's unique small-scale continuous flux reactors.

6.1.8.1.2 Coal and Biomass Combustion

A broad program of research is under way to gather fundamental information on the combustion of coal and biomass fuels. Bench, pilot, and full-scale experiments are conducted. An important element is development of in situ sensors to monitor combustion of these fuels. This work utilizes the coal combustion laboratory and the biomass fuels simulator at Sandia's Combustion Research Facility.

6.1.8.2 Natural Gas and Oil Production (AC)

This program supports DOE Fossil Energy's research and development in the technology areas of diagnostics and imaging; oil recovery; drilling, completion, and stimulation; and environmental protection. This program utilizes Sandia's strengths in imaging, understanding, and modeling complex rock, soil, hydrologic, and geochemical interactions. Such research also draws on Sandia's expertise in materials science, sensor development, explosive technology, robotic and intelligent systems, and full system engineering.

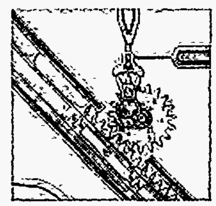
6.1.8.3 Strategic Petroleum Reserve (SA): Storage Facilities Development

Sandia has experience in developing safe underground storage for oil and gas, both for the Strategic Petroleum Reserve and for commercial underground storage. The underground storage program includes efforts on long-term performance modeling, cavern design, and cavern remediation. The program also develops and fields instrumentation to provide long-term cavern monitoring and to validate cavern design. The technology developed for cavern creation, testing, and operation is being applied to commercial cavern development for natural gas storage.

6.1.9 Office of Energy Research Science and Technology Programs

Sandia maintains numerous projects that contribute to the DOE's science and technology mission. These projects include research in scientific computing, basic energy sciences, and magnetic fusion energy sciences. Research in global climate change is a growing responsibility, and advanced computational techniques and information technology are an integral part of this research. Sandia stresses three important themes in these activities:

- excellence in scientific research,
- integration of research and development with DOE technologies, and
- impact on US industrial competitiveness.



Every phase of Sandia's development cycle integrates science and technology. Examples include geoscience and technology, combustion science and technology, and scientifically tailored materials. In each case, basic research is integrated directly into the objectives of DOE technology programs. Our projects also involve numerous interactions with US industry.

We are committed to maintaining the excellence of our basic research. The strength of the program results from a capable staff whose work earns them a high level of external recognition.

6.1.9.1 Magnetic Fusion Energy Sciences (AT)

Sandia's Magnetic Fusion Energy Sciences Program is developing a technology base for the design of in-vessel components that will perform satisfactorily in fusion plasma environments. We study the interactions of plasmas and materials, the behavior of materials exposed to high-heat fluxes, and the interfaces of plasmas and fusion reactor walls. Extensive analyses of prototypes are required before components can be qualified for operation in fusion machines. The process involves selecting, specifying, and developing materials for components exposed to high-heat and particle fluxes. Materials samples and prototype components are tested in Sandia's Plasma Materials Test Facility, which uses high-power electron beams to generate high-heat fluxes that simulate fusion reactor environments. Materials and components are also exposed to tritium plasmas in Sandia's Tritium Plasma Experiment, located at Los Alamos National Laboratory. Materials from these tests are characterized using Sandia's accelerator facilities for ion beam analysis.

Sandia directly supports US and international fusion machines. This support includes tritium removal inventory support and materials postmortem analysis for the recently closed Princeton tokamak fusion test reactor; materials analysis and diagnostic development for the General Atomics DIII-D Advanced Divertor Project; and measurements of plasma/wall interaction in the C-Mod tokamak at the Massachusetts Institute of Technology. We participate in collaborative experiments on the Joint European Torus in the United Kingdom and on the JT-60 tokamak in Japan.

In all these experiments, Sandia participates in machine operation and provides specialized diagnostics and data analysis for evaluating plasma/material interactions, boundary layer plasma control, and plasma-facing components. We also continue to collaborate on plasma/material interaction and high-heat-flux issues with colleagues in Europe and Japan. At the DOE's direction, Sandia has entered into cooperative exchanges on plasma-facing component development with several laboratories in Russia.

In 1992 an international agreement was reached by the United States, Japan, the European Union, and Russia to begin a six-year engineering design for the International Thermonuclear Experimental Reactor (ITER). A three-year extension of the agreement is being negotiated. Sandia provides personnel to help manage the program for the US ITER Home Team. Sandia also has a major role in research, development, and design of plasma-facing components for the US effort. Continued international cooperation is essential to the success of the reactor. Domestically, development of plasma-facing components for the project is a cooperative effort of Sandia, other national laboratories (Argonne, Idaho, Los Alamos, and Oak Ridge), a university (California at San Diego), and industry (headed by Boeing and including Raytheon, General Atomics, and Westinghouse). Sandia is coordinating this cooperative effort for the US ITER Home Team, and Sandia staff have been awarded two DOE Distinguished Associate Awards for their ITER-related work.

Because of the increased focus in US fusion energy sciences on more compact, alternative concepts to the conventional tokamak, the issues of plasma/material interactions will be of greater importance in the future. Sandia is acting as a central resource for resolving these problems with plasma-facing components via alternative concepts. Discussions are under way for Sandia to assume a research and development role for the National Spherical Torus Experiment (United States), the W7-X stellarator (Germany), and the Large Helical Device stellarator (Japan). We have also started discussions with the inertial fusion energy community on future collaborations.

6.1.9.2 Scientific Computing: Massively Parallel Computation

Sandia's computational sciences program creates technologies for the revolution in engineering. The program develops numerical methods for solving scientific and engineering problems, a software infrastructure for parallel computing, and techniques for distributed computing. The work in numerical methods focuses on massively parallel computing. A key challenge is the development of algorithms that scale to tens of thousands of processors. Software infrastructure research includes work in parallel operating systems, mesh generation, static and dynamic load balancing, visualization, and user interfaces.

Sandia has played a leading role in massively parallel computing for more than a decade. During the past five years, most of the world records for computational speed have been set by Sandia and Intel. Sandia is the only institution in the world that has twice won the Gordon Bell Prize, which is given annually for the most significant achievement in parallel computing. Our researchers have won numerous other national awards and have received patents for their inventions. Sandia's software is licensed worldwide.

Computational technologies are playing an important role in a wide range of Sandia programs. Examples include simulating the performance of weapons, analyzing weapons safety issues, and computation-based design and manufacturing. An important goal for the future is the creation of an easy-to-use design analysis environment that seamlessly integrates model development, analysis, and postprocessing.

Distributed computing technologies are key to fulfilling our future computing requirements. Sandia is pioneering new techniques that will leverage commercial off-the-shelf hardware and software to create a rich computing infrastructure. The Computational Plant Project is creating many of the needed technologies. A significant Computational Plant Project prototype system is operational and will be significantly enhanced during FY 1999.

6.1.9.3 Basic Energy Sciences (KC)

Sandia supports DOE Basic Energy Sciences with several research efforts. Larger projects include combustion research and scientifically tailored materials. Smaller projects include geoscience and engineering research.

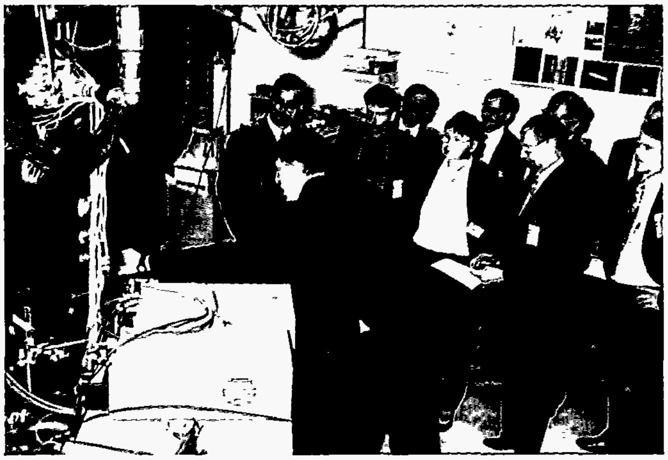
6.1.9.3.1 Chemical Sciences

Sandia's largest project in chemical sciences is housed at the Combustion Research Facility. In this user facility[3], Sandia staff and visiting scientists develop advanced research methods and apply them to the study of fundamental combustion processes.

The long-range objective of the Combustion Research Facility is to maximize energy efficiency, fuel utilization, environmental protection, industrial productivity, and equipment design. DOE Energy Research-supported studies include combustion chemistry, combustion diagnostics, reacting flows, and combustion modeling.

Work in combustion chemistry improves our understanding of the complex chemical processes involved when fuels burn. We determine the rates and mechanisms of elementary chemical processes with emphasis on the close coupling of experiment, theory, and modeling. Modeling of experiments conducted in low-pressure

[3] See section 8.2.2 for a complete list of Sandia user facilities.



Sandian Larry Baxter leads a tour of the Combustion Research Facility for a group of Swedish scientists and researchers.

flames yields insight into the dominant chemical reactions of combustion. Related efforts address fundamental questions of molecular dynamics and support the modeling of processes important to energy-producing technologies. The formation and destruction of nitrogen-containing pollutants, the oxidation of hydrocarbons, and the chemical paths leading to soot precursors in rich flames are emphasized.

A primary thrust of the research program is the development of advanced combustion diagnostic techniques. Because of their nonintrusive nature and improved versatility, laser-based optical techniques receive the strongest emphasis. Laser-induced fluorescence, quantitative imaging, cavity-ringdown absorption spectroscopy, and nonlinear optical wave mixing are among the diagnostic methods being developed. These techniques are used to measure temperatures, species concentrations, and other parameters important to understanding combustion phenomena.

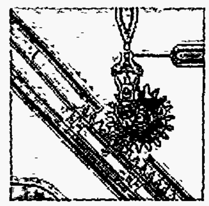
A multidisciplinary program in reacting flows establishes an important link between studies of combustion chemistry and the world of practical combustion. This program increases our understanding of the fundamental interactions between chemistry and fluid dynamics in combustion. Results are used to improve predictive capabilities for turbulent combustion of hydrocarbon fuels. Research includes investigation of primary turbulent transport in flows involving complex fluid mechanics but simplified chemistry.

Sandia's combustion modeling program develops numerical methods to predict the mutual influences of chemical reactions and fluid transport. Our current modeling focuses on developing a fundamental understanding of important subprocesses so that future simulations will contain more realistic chemical and physical descriptions of combustion phenomena. Distributed and massively parallel computer architectures are enabling rapid advances in the realistic representation of the coupling between turbulence and fully detailed chemistry.

Major users of the Combustion Research Facility include those supported by the Assistant Secretary for Energy Efficiency and Renewable Energy and the Assistant Secretary for Fossil Energy. Users conduct industry-oriented research in transient and continuous combustion (including coal and biomass processes) and in advanced materials synthesis.

The DOE facilitates a vigorous program that attracts approximately one hundred long-term users to the Combustion Research Facility every year. Visiting scientists from industry, universities, and government-sponsored organizations conduct basic and applied combustion research and publish their findings. Their participation helps transfer new combustion technology to a large user community. A postdoctoral research program provides advanced training for combustion scientists and engineers and enhances the facility's research productivity.

The continuing programs at the facility help maintain US preeminence in the science and technology of combustion. Facility staff represent the United States on International Energy Agency programs in combustion energy conservation. International Energy Agency activities involve collaboration with foreign scientists in engine studies and coal research through an informal exchange program. The Combustion Research Facility remains the US focal point for generating and disseminating new knowledge that advances the clean and efficient utilization of fuels in combustion.



6.1.9.3.2 Materials Sciences

Sandia's Materials Sciences Program has three elements: scientifically tailored materials, defects and impurities in solids (computational materials science), and synthesis and processing. Efforts in this program emphasize research that supports advanced manufacturing and materials performance relevant to DOE and industrial technologies.

6.1.9.3.2.1 Scientifically Tailored Materials

Sandia's research in scientifically tailored materials combines theory and experimental capabilities in solid-state sciences, atomic-level diagnostics, and materials synthesis and processing to produce new classes of materials for energy applications, defense needs, and industrial applications.

Scientifically tailored materials research explores how capabilities developed in various projects can be used to enhance US competitiveness in materials science and technology. We frequently interact with representatives from industry, universities, and other national laboratories to define critical needs and plan collaborative efforts. Many cooperative research and development agreements with industry have originated from research in this area.

Research continues in the physics and chemistry of ceramics synthesis and processing, the use of energetic particle beams for the synthesis and study of materials, high-temperature superconductors, tailored surfaces and interfaces for materials applications, chemical vapor deposition sciences, artificially structured semiconductors, advanced growth techniques and epitaxy science, transport in unconventional solids, atomic-level science of interfacial adhesion, and synthesis and processing of nanometer-sized clusters for energy applications. Considerable synergy exists among these program elements. Common themes are synthesis and processing, epitaxial materials growth, surfaces and interfaces, and the uses of energetic particle beams. In addition, Sandia's program includes the following studies begun in the past several years: localized corrosion initiation at nano-engineered defects in passive films; wetting and flow of liquid metals and amorphous ceramics at solid interfaces; field-structured anisotropic composites; and composition-modulated semiconductor structures for photovoltaic and optical technologies. The last is a joint effort with the National Renewable Energy Laboratory.

Research on compound-semiconductor strained-layer superlattices, quantum well structures, and other artificial structures is pioneering work. A strained-layer superlattice consists of many thin layers (each a few tens of angstroms thick) of alternating single-crystal semiconductor materials. Superlattices typically are made from the more common periodic table class III to V semiconductors. The multiple thin layers behave macroscopically like new semiconductor materials. Their structures exhibit electronic and optical properties entirely different from those of the constituent materials. The combination of thin layers, lattice strain, and novel patterning allows flexibility in tailoring the properties of these new materials. Sandia is using these new semiconductors to develop high-speed field-effect transistors, optoelectronic emitters, detectors, novel optoelectronic mirror devices, and broadband light sources.

Chemical vapor deposition science explores the basic physics and chemistry of chemical vapor deposition used in the synthesis of materials, particularly thin films. Our research has concentrated on semiconductors and materials used to make semiconductor devices. However, the understanding gained in this research is applicable to other classes of materials such as reduced-friction coatings resistant to corrosion and wear, high-temperature superconductors, and optical materials.

Basic research in energetic particle synthesis and the science of materials focuses on the interactions of ion, electron, laser, and plasma beams with metals, semiconductors, and dielectrics. This research on materials synthesis and modification uses the unique capabilities of energetic particle beams to create new materials, determine their properties, and advance materials processing by elucidating fundamental processes.

We study ceramics to understand the atomic and molecular processes that govern their structure and properties. The goal is to improve ceramics processing by gaining a better understanding of the underlying chemical and physical principles.

Research continues on the atomic-level science of interfacial adhesion as we seek to understand the nature of the physical and chemical interactions that bind solid surfaces. Although adhesion problems in materials science and engineering are pervasive, solutions usually are found through trial and error. Developing a scientific basis to select material combinations that provide specific interfacial characteristics will bring significant technological and economic gains.

The scientifically tailored materials program is investigating atomic-level processes that control the growth and properties of thin-surface layers. This program is also exploring the use of ion, laser, and electron-beam excitation of surfaces during epitaxial growth of semiconductors to control the kinetic energy of surface atoms and extend the range of tailorable epitaxial materials. Additionally, we are examining potential applications of boron-rich solids, which have unique bonding, electronic, and transport properties when used as high-temperature semiconductors. These refractory materials appear promising for use in high-efficiency thermoelectric energy generators and as neutron detectors.

We also are exploiting Sandia's patented technique for producing novel nanometer-sized clusters with potential applications in energy technologies. These clusters are aggregates of a few to a few thousand atoms or molecules whose properties are neither like bulk materials nor like individual atoms or molecules. The clusters represent a totally new class of materials with novel electronic, optical, and chemical properties. Our research emphasizes inexpensive metal and semiconductor clusters as alternatives to precious metal catalysts for coal liquefaction, environmental remediation, and solar photolysis.

6.1.9.3.2.2 Defects and Impurities in Solids (Computational Materials Science)

Crystalline defects and impurities often determine the properties of solids. This program seeks to understand and control such imperfections, which are crucial to technological applications of solid materials.

Unique experimental and theoretic tools developed in this program are combined to study structural defects and impurities in solids and on surfaces. The experimental tools are high-resolution transmission electron microscopy, high- and medium-energy ion scattering instruments, video low-energy electron diffraction, surface analysis, scanning tunneling microscopy, and low-energy electron microscopy. Theoretic tools developed and employed include quantum chemistry codes, local density approximation/ pseudo-potential methods, the embedded atom method, and cluster functional methods for large-scale atomic-level computer simulations.

These tools are used to study grain boundaries, interfaces, and surfaces in metal alloys and intermetallic compounds; impurity segregation to these boundaries; and interactions with dislocations, gas bubbles, and defect clusters. Growth of metal layers on substrates is investigated using scanning tunneling microscopy, low-energy electron diffraction, and low-energy electron microscopy. Theoretic models are developed for the nucleation and growth kinetics of thin film layers. High-resolution transmission electron microscopy is used in conjunction with large-scale computer simulations to resolve the dislocation core structure in intermetallic compounds and analyze the dislocation network configuration and evolution during plastic deformation.

Many of the results from this research are used in concurrent development and engineering projects at Sandia and other national laboratories. In addition, results are disseminated to materials science programs at universities and industrial research and development laboratories via the Sandia visiting scientist program in computational materials science. Collaborations with industry are also established through cooperative research and development agreements.

6.1.9.3.2.3 Synthesis and Processing Center

Sandia coordinates activities within the DOE Center of Excellence for the synthesis and processing of advanced materials. This center is a cooperative venture that involves Sandia and eleven other national and university laboratories. The center brings together elements of the existing basic energy sciences core programs at these laboratories and also includes appropriate DOE Basic Energy Sciences-funded university grant research. The center enhances the science and engineering of materials synthesis and processing to meet the DOE's programmatic needs and facilitate the technological exploitation of materials.

Synthesis and processing are essential elements of materials science and engineering that deal with the assembly of atoms or molecules to form materials, the manipulation and control of structures from the atomic to the macroscopic scale, and the development of processes to produce materials for specific applications. Synthesis and processing span the range from fundamental research to technology applications.

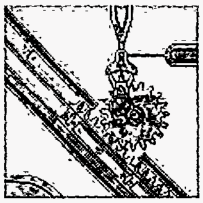
Research in this area ranges from the creation of new materials and the improvement of the properties of known materials to the understanding of such phenomena as diffusion, crystal growth, sintering, and phase transitions. In application, synthesis and processing translate scientific results into useful materials by developing processes capable of producing high-quality, low-cost products. A technology steering group has been formed to guide the research and development agenda of the center.

The center has developed a number of coordinated, focused multilaboratory projects. The selection criteria for technical activities in these projects are outstanding science with a clear relation to technology, strong existing or potential connections to DOE-funded programs, and strong existing or potential in-kind partnerships with industry. At present, the center is emphasizing eight multilaboratory projects:

- metal forming,
- materials joining,
- tailored microstructures in hard magnets,
- microstructural engineering with polymers,
- processing for surface hardness,
- mechanically reliable surface oxides for high-temperature corrosion resistance,
- high-efficiency photovoltaics, and
- design and synthesis of ultrahigh-temperature intermetallics.

6.1.9.3.3 Geosciences

Basic research in geoscience develops an improved understanding of near-surface geologic processes. The mix of projects changes every two to four years in response to evolving DOE initiatives and geoscience research. Sandia's geoscience research supports many different DOE technology programs, including nuclear waste repository design, fossil energy exploration and storage, environmental remediation, global climate change, and geothermal energy exploration. Presently, geoscience research is directed at geophysical imaging of the subsurface and experimental rock mechanic processes, the geochemistry of low-temperature fluid/mineral interfaces, the modeling of multiphase flow through geologic media, and the hydrology of fluid flow through rock fractures and porous media. Basic research in geoscience has four fundamental thrusts: geochemistry; geology, geophysics, and earth dynamics; energy resource recognition and evaluation; and hydrologic and marine sciences.



Sandia's geochemistry research projects emphasize a mechanistic and often atomistic understanding of interfacial and bulk mineral processes using a combination of experimental, analytic, and theoretic techniques. Projects include high-precision measurements of cation self-diffusion in carbonate minerals using isotopic thin films, determination of in situ clay precipitation and growth kinetics using atomic force microscopy or x-ray scattering techniques, and quantification of environmental controls, such as temperature and organic acids, on silicate mineral dissolution kinetics. One new computationally intensive project uses empirical and ab initio molecular codes to simulate clay mineral bulk structures, relaxed surface structures, and fluid/clay sorption interactions. This research provides new kinetic data and a better understanding of diagenetic, weathering, and materials science processes.

Projects in geophysics and earth dynamics are focused on experimental, analytic, and numerical efforts to understand fractured geologic media and to better interpret geophysical imaging of subsurface structures. Projects in rock mechanics include a combined experimental and analytic study of shear strain localization as a precursor to faulting and macroscopic fracture of rock, and a combined analytic and theoretic study of brittle failure processes in rocks and porous geomaterials caused by grain boundary effects, damage state, and load path. The geophysical projects are computer intensive and are designed to improve subsurface imaging of complex geostructures and fluid flow. These projects include an appraisal of three-dimensional inversion techniques to interpret field and synthetic seismic and electromagnetic data, development of numeric waveform inversion algorithms to accommodate three-dimensional heterogeneity, and development of massively parallel computational approaches and algorithms for terabyte three-dimensional data sets.

One energy resource recognition and evaluation project combines experiments and computer simulations to predict transport phenomena in concentrated, multiphase, dispersed systems, particularly when flowing through geologic media. This research will develop a particle-level massively parallel capability that will be used to refine continuum-based models.

Hydrologic and marine sciences research focuses on detailed physical experiments and high-resolution numerical modeling of fluid flow and transport in porous and fractured media. Projects involve definition of capillary, gravitational, and viscous forces controlling fracture flow and transport of two-phase fluids, understanding gas/liquid processes in soils or rocks and the media properties that govern permeability upscaling, and exploration of mass and heat transport in porous media and fractured rocks. Sandia's hydrologic research also includes development of massively parallel physical and numerical models to simulate field-scale, multiphase flow and transport in geologic media. Improved models for fluid flow through complex geologic media, including porous and fractured rocks, will result from these geohydrology projects.

6.1.9.3.4 Engineering Sciences

Sandia's research in engineering sciences seeks to improve our understanding of the physics of multiphase flows, complex flows through porous media, fluid/structural interactions, and complex geomechanics. We are investigating the flow of suspensions of solid particles in Newtonian and non-Newtonian liquids by conducting experiments, improving computational methods and models, and developing new theories. We are teaming with the Massachusetts Institute of Technology, Los Alamos National Laboratory, the University of New Mexico, and New Mexico Resonance to better understand the effects of flow and boundaries on the microstructure of suspensions and how this microstructure influences the macroscopic suspension behavior in such applications as the manufacturing of composite materials and near-well-bore processes in oil and gas production. To date this work has led to verification of advanced two-phase constitutive models in general Navier-Stokes solvers, and this in turn will allow science-based computational simulations of a wide range of manufacturing processes and natural geoscience processes.

We are also working closely with the DOE's Pittsburgh Energy Technology Center and Air Products to develop advanced diagnostics for noninvasive characterization of multiphase slurry-bubble flow processes. Our efforts to improve electrical impedance tomography and gamma-densitometry tomography diagnostics and associated data collection/reduction algorithms are designed to resolve the different phases quantitatively in the near future. This work is needed for hydrodynamics characterization at scales relevant to industries that support advanced energy conversion processes (such as the Fischer-Tropsch reaction system for indirect liquefaction). Under the sponsorship of the DOE's Office of Industrial Technologies, we are working with Los Alamos National Laboratory, Pacific Northwest National Laboratory, seven industrial partners, and five universities to investigate multiphase turbulent flows of interest to the chemical industry. This work involves development of advanced multiphase diagnostics and an industrial-scale testbed for gas/solid flow, the acquisition of detailed data sets at industrially relevant conditions, and the development and validation of advanced computational models of turbulent gas/solid flow.

In fluid/structure interactions, we are developing dual-use computational tools that will enable the oil and gas industry to better design deep sea pipelines and umbilicals, eliminating technical obstacles to accessing known oil reserves in the Gulf of Mexico. We are also developing and validating a statistical model of molecular mixing in turbulent flow and are using optical techniques to investigate the supercritical oxidation process for destroying toxic and hazardous wastes.

6.1.9.4 Biological and Environmental Research (KP)

During the past several years, global climate change has become an important component of national and international science and policy agendas. Although most scientists agree that human-made, energy-related emissions will cause a greenhouse warming effect, uncertainty exists about the magnitude, timing, and distribution of this phenomenon. To better understand such issues, the US government has begun a global climate change research program, with the DOE as a major participant. To support the DOE in this role, Sandia draws on its expertise in remote sensing, field testing, and systems engineering to assist both the Atmospheric Radiation Measurement Program and its airborne adjunct, the Atmospheric Radiation Measurement Unmanned Aerospace Vehicle Program.

6.1.9.4.1 The Atmospheric Radiation Measurement Program

The DOE's Atmospheric Radiation Measurement Program seeks to better understand earth radiation field/cloud interactions by studying these processes at intensively instrumented cloud and radiation testbed sites. Sandia's three key roles in these activities are described below.

6.1.9.4.1.1 Development and Monitoring of New Instruments

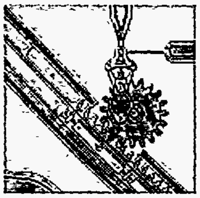
The cloud and radiation testbed sites are designed as climate observatories. As such they require highly sophisticated instrumentation that can operate in the field around the clock, 365 days a year, with minimal operator attention. One critical need is the measurement of water vapor profiles. Water vapor plays a key role in cloud formation and in propagation of the earth's thermal energy through the atmosphere, yet existing instrumentation lacks the vertical and temporal resolution required to provide the desired water vapor profiles. Over the past several years, we have developed the next generation of a laser remote-sensing technique (raman light detecting and ranging [lidar]) for providing high-vertical-resolution water vapor profiles during both night and day. In 1996 we successfully implemented this system in a fully automated field unit now in place at the Oklahoma cloud and radiation testbed site and operating continuously as one of the baseline instruments. We are working on two other activities to field sophisticated measurement systems as part of the routine suite of cloud and radiation testbed instrumentation. The first activity involves the site integration, algorithm development, and data handling of wide-field-of-view cameras developed by the Scripp's Institute for measuring cloud distributions in the sky. The second involves the fielding of highly accurate radiometers developed by the National Aeronautics and Space Administration and the Scripp's Institute to measure solar flux.

6.1.9.4.1.2 Development of Portable Measurements Stations

Although the Oklahoma cloud and radiation testbed site has a large suite of individually emplaced instruments, the strategy for succeeding sites is to use a set of instruments in a self-contained, easily transportable vessel. These self-contained sets of instruments (known as radiation and cloud stations) have made possible the placement of both tropical and Alaskan cloud and radiation testbed sites, despite reduced budgets. As the field integration manager for the radiation and cloud stations, Sandia has led a multilaboratory team in designing, constructing, and testing the system, which provides power, a full suite of instruments, data handling, and work space. The first atmospheric radiation and cloud station (ARCS) was successfully emplaced on the island of Manus in Papua, New Guinea and marked the opening of the tropical western Pacific atmospheric radiation measurement site. A second ARCS is being tested for deployment to Nauru, the second of three tropical Pacific sites. Also, modified polar ARCSs, have been developed and deployed to a site on the North Slope of Alaska.

6.1.9.4.1.3 Site Manager for the North Slope of Alaska Cloud and Radiation Testbed Site

Our site on the North Slope of Alaska began operating in 1997. At present this site consists of two locations: a long-term facility at Point Barrow at the northernmost tip of Alaska and a short-term instrument suite aboard an ice-breaker circling the Arctic Ocean in the Arctic gyre. The North Slope of Alaska and adjacent Arctic Ocean locales were chosen because the polar region is the heat sink in the world's climate and because the pole has extremes of insolation (six months of day and six months of night), humidity (wet summers and dry winters), and surface albedo (highly reflective snow that melts). These extremes provide a stringent test of the understanding of the earth's radiation/cloud interactions. As the manager for this site, Sandia is responsible for planning, implementation, and operation. Also, we work closely with scientists at the University of Alaska to formulate the science plans and coordinate the atmospheric radiation measurement program with other research activities in arctic environments, especially the National Science Foundation's Surface Heat Budget of the Arctic Program.



6.1.9.4.2 Unmanned Aerospace Vehicle Program

The Atmospheric Radiation Measurement Program described above emphasizes ground-based measurements. However, we realized from the outset that airborne measurements are critical for providing information about radiative fluxes, water vapor profiles, and cloud top properties in the atmosphere. An ideal measurement platform is an aircraft that can hover continuously at high altitudes above a cloud and radiation testbed site. The DOE asked Sandia to formulate and lead a multilaboratory program to develop the necessary instrumentation and measurement techniques to use unmanned aerospace vehicles for climate measurements. In 1996 we developed the Altus, a mid-altitude unmanned aerospace vehicle, and conducted a record-setting scientific flight of twenty-six continuous hours over the Oklahoma cloud and radiation testbed site. In 1997 the Altus set a new altitude record of 43,500 feet for a single-stage turbocharged engine and was used as part of a large test at the atmospheric radiation measurement site. The radiation flux profiles obtained there, in conjunction with the simultaneous in situ aerosol and cloud microphysical sampling conducted by manned aircraft, constitute a unique data set for testing radiation models. Activities are under way for the next mission, to be conducted jointly with the National Aeronautics and Space Administration, in which we will use a two-stage turbocharged Altus to extend these measurements to altitudes over 60,000 feet to enable studying tropical cirrus clouds and their effects on the radiation budget.

6.1.10 Integrated DOE Activities (Work for Other Department of Energy Locations, Contractors, and Offices)

Sandia performs work for other DOE elements as requested to support programmatic and institutional requirements. Requests may include special programs administered by DOE Headquarters, DOE field offices, and facilities within the nuclear weapons complex (including integrated contractors). The DOE's portions of alliances among the DOE, its managing and operating contractors, and industry are included in this category.

Ongoing support activities include site safeguards and security in New Mexico and Nevada and environmental and site studies. Ongoing services include vehicle fleet maintenance, fuel and repairs, local telephone support, and utilities. Other activities are intermittent and may include such activities as training and classes, performance assessments, peer reviews, specific data collection, and technical studies related to programmatic support.

Requests from integrated contractors are managed in relation to program work from the DOE that requires Sandia support. Collaborations between DOE laboratories may be funded in this manner, as may minor tasks to support deliverables to the DOE.

6.2 Work for Non-DOE Entities (Work for Others)

Approximately 25 percent of Sandia's programmatic work is conducted for agencies other than the DOE. Sandia's non-DOE efforts leverage and strengthen our capabilities for our DOE programs. They also make cost-effective use of our existing federal investments for technological needs. Work for Others encompasses conventional defense, strategic defense, counterproliferation and nonproliferation, treaty verification, environmental cleanup and monitoring, energy uses, high-performance computing, safeguards and security, radiation effects, materials development and characterization, law enforcement, microelectronics, manufacturing, photonics, robotics, transportation, and space efforts. The technology base developed through our work for the DOE has established expertise and capabilities not found in industry or in other government agencies. Therefore, these opportunities to contribute technological solutions to agencies other than the DOE help solve national needs. Work for Others also benefits the supported agencies by leveraging multiagency funds and helping maintain Sandia's abilities to perform DOE missions.

Before undertaking a Work for Others project, we ascertain that the work complies with applicable laws and federal regulations. Projects must be consistent with and complementary to Sandia and DOE missions. The work must not adversely impact Sandia's execution of assigned DOE programs or be in direct competition with the domestic private sector. We also ascertain that the work will not burden DOE programs in the future. Work for Others sponsors utilize Sandia's unique facilities and resources to resolve critical technical issues. Often this work is completed jointly with private industry, requiring our involvement as needed to meet the sponsor's objectives.

6.2.1 Department of Defense

6.2.1.1 Air Force

Sandia provides support throughout the Department of the Air Force. Pentagon-initiated programs link to the unified commands of the DOD, DOE Defense Programs, field agencies, program offices, and Air Force technology planning integrated product teams. All combine to form the foundation of sponsors that Sandia supports within the Air Force. A fairly large amount of support is concentrated in work for the Air Force Technical Applications Center, the Space and Missile Systems Center, the Aeronautical Systems Center, and the Air Force laboratories. We provide research and development, prototyping, modeling and simulation, proof of concept, and hardware and software deliverables. Testing, studies, and data analysis are other common deliverables. Sandia provides technology in the areas of remote sensing and verification, environment and energy, safeguards and security, command and control, testing programs, military systems, microelectronics, aerospace systems, and component engineering. The Air Force relies on combinations of our skills in nuclear burst detection, advanced sensors, space and seismic phenomenology, spacecraft components and survivability, applied energy, and nuclear energy. Also, multiple memoranda of understanding between the DOE and the Air Force support joint efforts on much of our Air Force-sponsored work. Sandia's future work with the Air Force will include completion of long-term projects as well as involvement in partnerships between the DOE and the Air Force where goals are common or complementary. We expect partnering to continue between industry and Sandia to meet Air Force requirements.

Ongoing projects include the following: research and development technologies in support of aircraft fire suppression, comprehensive test ban treaties, integrated correlation and display systems, electromagnetic pulse sensors for global positioning system launches, electronic safing and arming devices, high-efficiency solar cells, imaging systems, military strategic/tactical and relay testing support, protection of nuclear assets, physical security support and intrusion detection, radiation environment testing and certification, radiation-hardened components, radiation safety, battery development, space sensors and ground stations, laser capabilities, material characterization for weapons applications, structural testing of large land-based antennas, tagging technologies, simulation of high-frequency radar systems, automatic target recognition techniques, precision munitions and penetrating weapons assessments, reliability testing, designated seismic stations for the Comprehensive Test Ban Treaty, modeling for applications to conventional munitions, weapons of mass destruction countermeasures, parachute system development, flight data vulnerabilities analysis, miniaturized components, microwave technology, and a space nuclear thermal propulsion system.

6.2.1.2 Army

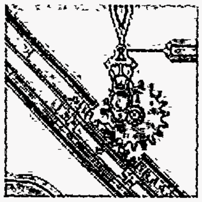
Sandia provides support throughout the Department of the Army. As with other military services within the DOD, many efforts sponsored by the Army are conducted in support of the unified commands. Our sponsor base within the Army includes the Chemical and Biological Defense Agency, the Battle Command and related Battle Laboratory, the Communications Electronics Command, the Soldier Systems Command, and the Medical Research and Materiel Command. Major portions of our work for the Army support the Space and Strategic Defense Command, the Tank-Automotive and Armaments Command, the Test and Evaluation Command, and the Missile Command. Sandia provides technology in the areas of environment, aerospace systems, military systems, safeguards and security, testing facilities and conditions, microelectronics and photonics, high-performance computing, international security, transportation, and applied energy. Other Sandia support includes nuclear weapons transport, safing and arming technology, parachutes, target recognition, battlefield survivability, land mines imaging, radiation testing, and robotics.

Ongoing projects include the Strategic Target System, laser tracker support, solar testing, radar tagging, surveillance and reconnaissance ground equipment, ground-based intercepts, structural response of artillery projectiles, nuclear weapons surety, security and survivability, conceptual design and prototyping for an advanced Patriot missile, protection of national critical infrastructures, safer diversionary devices, fabrication engineering for transport packaging of munitions, landmine countermeasures, missile aging and surveillance, mine detectors, evaluation of multiple launch rocket system warhead flight performance, radiation sensing, photometric data, advanced materials characterization, autonomous target recognition, radiation hardness surveillance testing, radiation effects on electric components, testing of a postboost vehicle, theater ballistic missile characterization, missile countermeasures, and studies of reduction in health care costs through medical technology.

Major programs within the Army that Sandia supports include the counterproliferation mission and the Strategic Target System. We expect to continue providing substantial support for nuclear weapons surety and conventional weapons effects.

The Strategic Environmental Research and Development Program is an environmental technology research program led by the DOD (whose executive agent is the US Army Corps of Engineers) and includes the DOE and the Environmental Protection Agency as partners. This program has been in place for several years and has matured into a stable program whose goal is to improve DOD mission readiness through environmental research. Sandia historically has been the major DOE laboratory participant in the Strategic Environmental Research and Development Program. Activities include atmospheric remote sensing and assessment, emissions monitoring for Clean Air Act Amendment compliance, kinetic mechanisms for supercritical water oxidation, solar detoxification of secondary wastes, landfill characterization system technologies, plutonium and uranium metal-forming technologies, electron beam melting, geothermal research and development, fuel testing, and in-process scrap recycling for uranium.

6.2.1.3 Navy

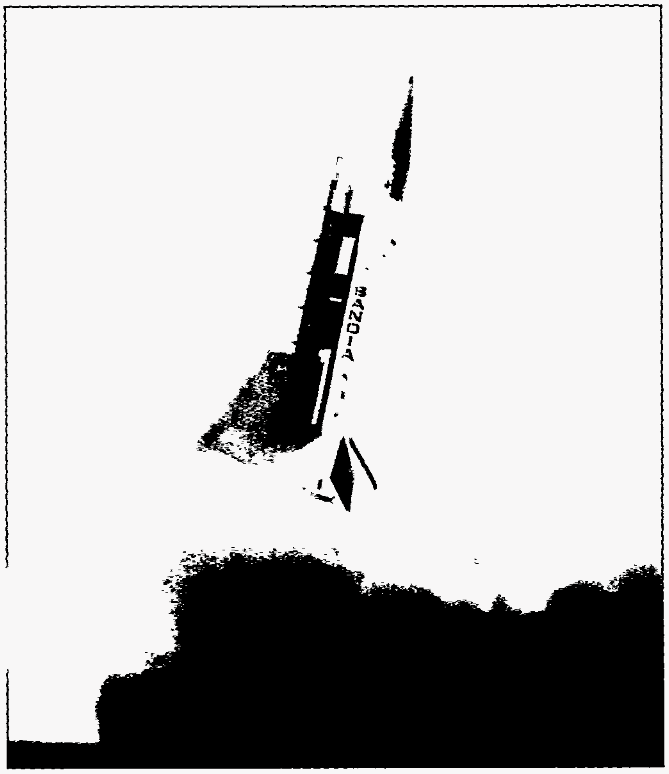


Sandia supports several Navy program executive offices. We also support the Office of Naval Research; the Naval Air Systems Command; the Naval Air Warfare Center; the Undersea Warfare Center; the Surface Warfare Center; the Facilities Engineering Command; the Naval Command, Control, and Ocean Surveillance Center; and the Pacific Fleet Command. Some of the work we perform for the Navy supports the unified commands. Sandia provides technology in the areas of nuclear weapons safing and arming, conventional weapons effects, mine detection, environmental effects, materials characterization, testing facilities, missiles, and robotics. These capabilities and some of our unique facilities provide the basis for our support to the Navy. Among the Sandia competencies used are component engineering, aerospace systems, high-performance computing, fusing and technical support, nuclear waste management, environmental technology, command and control, information surety, various testing technologies, materials science and technology, military systems, support for the United Kingdom's Trident stockpile surveillance program, renewable energy technology support, safeguards and security, microelectronics and photonics, and advanced manufacturing technologies.

Ongoing projects at Sandia use capabilities in such areas as adversary detection; stockpile surveillance; redesign of subsystems for the Tomahawk missile; chemical identification of sea mines; robot control technology; delayed detonation; environmentally conscious development of new propellants, explosives, pyrotechnics materials, and production facilities; rocket flight experiments and high-velocity impacts; component aging studies; optical ordnance systems; extended-life thermal batteries; surety assessment of the DOD SmartCard Program; explosively loaded structures response modeling; submarine-launched missiles support; oxidation of surrogate Navy waste in supercritical water; ship-based intercepts of ballistic missiles; operational tests of weapons; synthetic aperture radar battle damage assessment; and characterization of optically initiated detonators.

For the Office of Naval Research, Sandia is assessing the risks of radionuclides released from the former Soviet Union into the marine and terrestrial environments of the Arctic, North Atlantic, and North Pacific oceans. We will integrate the work of Sandia and other participants to identify the most important processes and parameters for long-term monitoring and for assessing the risks to the entire northern sea system.

Sandia also continues to provide support for launches from the Kauai Test Facility.



Sandia's Red Crow rocket system was launched from the Kauai Test Facility in April 1998.

6.2.1.4 Ballistic Missile Defense Organization

Because of the interrelationship of DOD departments, some of the work Sandia conducts for the Ballistic Missile Defense Organization is actually funded by the military services. We also support the Ballistic Missile Defense Organization through its offices in DOD Headquarters, the Program Management and Operations Office for Theater Missile Defense, the Phase One Engineering Team, and the Technology Readiness Program. Sandia provides technology in the areas of countermeasures, space technology, pulsed power, threat definition, smart targets, rocket launch services, reentry vehicle technology, missiles, smart mines, sensors, testing, instrumentation, control technology, radiation hardening, microwaves, and computing. Some support is based on our experience in nuclear weapons design and on the DOE's Inertial Confinement Fusion Program.

Sandia also provides technology in the areas of radiation-hardened satellite communications transceivers; flight tests; analysis of strategic defense systems; and development, analysis, and testing of potential countermeasures.

6.2.1.5 Defense Special Weapons Agency

Sandia supports the Defense Special Weapons Agency with technology in the areas of testing, physical protection, tamper protection, transportation of nuclear materials, arms control verification, radiation testing and safety, simulation, and weapons storage. In conjunction with the DOE, the Defense Special Weapons Agency assists the former Soviet Union in safely reducing its nuclear arsenal. Sandia provides technology in various testing programs, military systems, aerospace systems, international security, safeguards and security, fusing and technical support, microelectronics and photonics, and high-performance computing.

Project support also includes Belarus and Ukraine physical protection activities, assistance in nuclear material protection control to the Republic of Kazakstan via the International Atomic Energy Agency, Russian railcar modifications, synthetic aperture radar for open-skies-related activities, research and development for arms control verification and compliance technology, consultation on radiation safety, modeling and testing analysis of radiation effects, ion-beam and x-ray simulation support, development of advanced assurance and reliability, fuel fire testing and modeling, upgrades of adverse weather sensors for munitions, field testing of anti-intrusion devices, research and development of intrusion detection, and conventional weapons testing. Vital programs that Sandia supports include cooperative threat reduction programs with Russia and general technical assistance to the TOPAZ program.

6.2.1.6 Defense Advanced Research Projects Agency

Sandia provides support to the Defense Advanced Research Projects Agency's Defense Sciences Office, Computing Systems Technology Office, Electronic Systems Technology Office, Sensor Technology Office, Microelectronics Technology Office, and Advanced Systems Technology Office. Many agency-sponsored projects are managed by the individual military services that act as executive agents. We also work with many industry partners to supply requested support to the agency. Because many of the products that interest the Defense Advanced Research Projects Agency apply to both defense and industry, we foresee continued industry partnering. Consortia such as the Semiconductor Manufacturing Technology Consortium (SEMATECH) will continue to be important in our support to the agency. Several Sandia facilities are used to support the Defense Advanced Research Projects Agency. Sandia technology is provided in the areas of high-performance computing, microelectronics and photonics, military systems, advanced manufacturing, materials science, and international security.

Support to the Defense Advanced Research Projects Agency includes development of flat panel displays, material characterization studies, technology for high-pressure diesel engines, machine tooling that advances flexible fabrication technology, secure operating systems, high-temperature superconducting thin-film manufacturing, cleaning methodologies for specific materials, lithography advancement, ultrasound imaging for diagnosis of battlefield wounds, microelectronics memories, joint surveillance target attack radar system platform studies, and tagging systems. Additional support includes landmine detection, long-range mesoscale mobile platforms, high-performance computing platforms, and integration of a synthetic aperture radar target indicator with unattended ground sensors to form a small integrated sensor operation.

6.2.1.7 Other Department of Defense

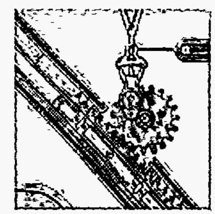
In addition to projects initiated by agencies within the DOD, many efforts originate from the Office of the Secretary of Defense and other offices within the DOD. In this area, Sandia conducts ongoing activities to support the joint DOD/DOE Munitions Technology Development Program established through a memorandum of understanding. The program is a research effort to develop innovative warhead explosives and fuse technologies to improve nonnuclear munitions technology across all service mission areas. Technology coordination groups of technical experts from the DOD and DOE establish deliverables and monitor activities. Sandia also provides the following directly to the Office of the Secretary of Defense: security support for the US European Command/North Atlantic Treaty Organization; instrument concepts for theater missile defense; conceptual approaches to commercial nuclear electric space transportation; and laser tracking. Additionally, the DOD and DOE have a memorandum of understanding for counterproliferation work. The terms of this memorandum involve Sandia's supplying counterproliferation architecture analysis to the DOD. Under the sponsorship of the Arms Control and Disarmament Agency, the Sandia Cooperative Monitoring Center conducts workshops and training for numerous countries to demonstrate technologies for monitoring potential hostile actions with the goal of preventing conflict arising from misinformation or speculation.

Future activities will use Sandia's expertise in the munitions and counterproliferation programs and our ability to aid the DOE in leveraging program capabilities to meet DOD needs.

6.2.2 Nuclear Regulatory Commission

Sandia supports the Nuclear Regulatory Commission with research, analysis, and technical assistance in the safety assessment and licensing of commercial nuclear fuel-cycle facilities. The primary emphasis concerns reactor safety research; lesser but significant emphasis concerns decontamination and decommissioning safety. Sandia will continue to investigate accident phenomenological research, evaluate the adequacy of safety systems, and develop risk-based regulatory processes.

Examples of reactor safety activities include the development of risk assessment methodologies and their application to the regulatory process; experimental and analytic investigations of core meltdown phenomena and properties of fission products; investigations of potential safety consequences of plant aging; and analyses, experiments, and tests to determine the structural integrity of reactor containment buildings. Sandia is also developing decision analysis methods associated with evaluating radioactive sites. Future activities will include support to the Nuclear Regulatory Commission for transferring information to nuclear utilities and commission staff and inspectors.



Sandian T. Y. Chu and Commissioner Nils Diaz of the Nuclear Regulatory Commission examine a simulated nuclear reactor vessel at Sandia's Explosive Dynamics Site.

6.2.3 Department of Transportation

Sandia's support to the Department of Transportation includes research and consultation on the safety, security, and efficiency of the nation's transportation systems. We also assist the Federal Aviation Administration with physical security of commercial airports and the safety of passenger and cargo aircraft. An ongoing project for the Federal Aviation Administration involves methods to perform nondestructive inspection of aging aircraft. Although our primary support activity is the Advanced Transportation Program, technology is drawn from many of our DOE programs. Sandia capabilities are used in the areas of packaging, radioactive materials transport, thermal characteristics, materials characterization, tamper-resistant containers, fire modeling, and systems engineering. Individual states, the border patrol, and the travel and transportation industry are all possible partners for the technologies being developed to meet Department of Transportation needs.

Ongoing efforts include nondestructive inspection of Coast Guard aircraft, an aviation safety system development and validation center, advanced automatic train control, a Federal Aviation Administration explosives detection portal, urban/rural intelligent corridor application, a prototype transit bus using advanced electric propulsion, fire modeling for aircraft safety, package performance standards guidance, commercial vehicle safety, airport vulnerability assessments, and an automatic vehicle location system evaluation.

6.2.4 National Aeronautics and Space Administration

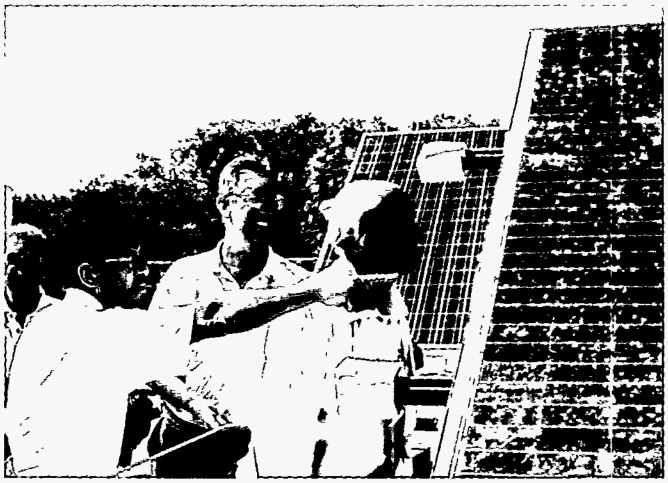
Sandia's support for the National Aeronautics and Space Administration (NASA) encompasses support to the Jet Propulsion Laboratory, Johnson Space Center, Wallops Flight Facility, Marshall Space Flight Center, Stennis Space Center, Kennedy Space Center, Goddard Space Flight Center, and NASA Headquarters. It includes partnerships with universities and NASA research centers. We provide technical support for spacecraft safety and reliability, monitor projects for specific missions, evaluate space events, develop sensors and micromachining technology, furnish imaging techniques, support several metrology areas, assist with reentry and recovery efforts, and assist with onboard experiments. Sandia provides technology in the areas of remote sensing and verification, development testing, and exploratory military systems. Sandia also provides expertise in space phenomenology (e.g., temperature microelectronics, analysis of material characteristics, parachute systems, aerodynamics, and environmental monitoring).

Ongoing support activities for NASA include developing capillary electrophoresis for continuous monitoring and environmental analysis; coupling capillary electrokinetic chromatography with immunochemistry techniques to solve complex chemical analysis problems; developing portable hydrogen sensors and x-ray radiation detectors; mapping terrain using the scannerless range imager; developing a remote sensor and instrumentation system for the Mars lander; conducting spacecraft shielding studies; developing ultrahigh-temperature ceramics for advanced thermal protection, assessing the Hyper-X rocket reentry vehicle and separation system, and developing rocket recovery systems and a rocket booster decelerator subsystem.

6.2.5 Department of State

Sandia's work for the Department of State includes the Technical Assistance Safeguards, Nonproliferation, and International Affairs programs. We provide technical support to the International Atomic Energy Agency in its role of verifying compliance with nonproliferation treaties. We also provide technical assistance to the Department of State for management of the International Science and Technology Center in Moscow, and we provide renewable energy project development, evaluation, and related support for Mexico's renewable energy rural electric applications project.

Our support to the International Atomic Energy Agency through the Department of State and the DOE's Office of Nonproliferation and National Security complements our International Security Program role and is also the foundation for some Defense Special Weapons Agency projects to assist the former Soviet Union with safely reducing its nuclear arsenal. The International Atomic Energy Agency employs both material accounting procedures and containment and surveillance techniques to provide safeguards measures required by the Treaty on the Non-Proliferation of Nuclear Weapons. We are developing or analyzing secure containers, spent fuel attribute testers, and item monitoring equipment. Newly developed containment and surveillance equipment is being demonstrated. We provide training, maintenance, and documentation; containment and surveillance consultation; and assistance with training and inspection of physical security systems.



At Sandia's Photovoltaic Systems Evaluation Laboratory, Sandian Roger Hill shows a delegation from Mexico the latest renewable energy technologies.

6.2.6 Environmental Protection Agency

Sandia provides support to the Environmental Protection Agency (EPA) via an interagency agreement. Numerous memoranda of understanding also exist between the DOE and the EPA for joint research and development. To support EPA efforts we team with other agencies and associations. A consortium for site characterization technology includes the EPA's National Exposure Research Laboratory and the Naval Research Engineering Laboratory.

Future activities will include development of the consortium for site characterization technology and testing, and evaluation of innovative technologies and software products. We are developing sensors to control hazardous waste emissions and air pollution. We are supporting the EPA's Superfund Project. Ongoing activities include development of new detection methods for environmental monitoring and chemical analysis and technology development for cleanup activities.

Research and support will likely concentrate in the areas of pollution prevention; waste minimization; environmentally sensitive engineering and manufacturing; hazardous and mixed waste treatment; ecological research, monitoring, and assessment; water reduction in manufacturing; geostatistical software tests; and environmental risk assessment.

6.2.7 Other Federal Agencies

Ongoing and future activities are expected with the National Institute of Justice (to apply our technology base in safeguards, security, and firearms), the Department of Interior (environmental issues), the Department of Agriculture (sensors and environmental issues), the Arms Control and Disarmament Agency (dismantlement and reconstitution of nuclear weapons stockpiles in other nations), the Defense Intelligence Agency (application of our technology base), the National Science Foundation, and the National Security Agency.

6.2.8 All Other Reimbursables

Nonfederal sponsors, private organizations, state and local government organizations, and foreign customers benefit from the ability to partner with Sandia for efforts ranging from research and development to testing and characterization using a wide variety of technical resources at the laboratories. The work is undertaken to complement existing DOE programs and to make available to sponsors unique capabilities not available from private industry or university sources. Sandia also seeks to transfer appropriate technology to industry, governmental organizations, and universities.

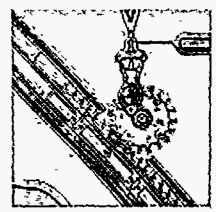
Partnership opportunities between Sandia and nonfederal partners can be established via many different types of agreements, including cooperative research and development agreements, designated capabilities arrangements, memoranda of understanding, personnel exchanges, technical assistance, user facilities agreements, and Work for Others projects.

6.2.8.1 Designated Capabilities

Designated capabilities are preapproved by the DOE and documented in an umbrella statement of work. For a complete listing of Sandia designated capabilities see section 8.2.1.

6.2.8.2 Technology Deployment Centers/ User Facilities

Technology deployment centers or user facilities consist of physical facilities, equipment, instrumentation, and personnel that are available to industry, university, other laboratory, and state and local government users. A complete listing of these facilities is provided in section 8.2.2.



6.2.8.3 Work for Others (Nonfederal)

Sandia performs tasks for nonfederal sponsors through Work for Others funds-in agreements, which are bilateral sales contracts between Sandia and the sponsor. The tasks must be consistent with the mission of the DOE and Sandia, and must not place the DOE or Sandia in direct competition with the private sector. A broad range of work is accomplished under the program, including providing radiation-hardened microelectronics components, providing assembly test chips, collaborating on the design of solar cells for solar panels, determining spectroscopic information about chemicals that may be in the atmosphere at remote locations, developing advanced energy storage devices and materials, developing synthetic aperture radar and platforms, testing a lunar probe for the Japanese Institute of Space and Astronautical Science, providing training in physical protection of nuclear facilities and materials, assessing the vulnerability of microprocessor-based systems and software, designing countermeasures against terrorist activities, developing techniques for extracting information about the state of stress in the earth using rock core samples, verifying reactor records of assembly burnup of spent fuel at US nuclear electric utilities, solving very large nonlinear quasi-static problems required for accurate computer models of springback in metal stamping, providing peripheral process equipment with degrees of intelligence to self-adjust without human intervention, and developing stimulation diagnostic technology to improve natural gas recovery.

6.3 Laboratory Directed Research and Development Program

6.3.1 Mission

Sandia's value as a national resource is based on our world-class science, technology, and engineering. These capabilities must remain on the cutting edge because the safety, security, and reliability of US nuclear weapons depend directly on them. Under the guidance of Sandia's Laboratory Director and with the DOE's concurrence, the Laboratory Directed Research and Development (LDRD) Program provides the flexibility to invest in long-term, high-risk, and potentially high-payoff research activities that stretch Sandia's science and technology capabilities.

LDRD supports Sandia's four primary strategic objectives (see chapter 2): nuclear weapons responsibilities; nonproliferation and materials control; energy and critical infrastructures; and emerging national security threats. To meet these objectives, LDRD promotes innovative research and development by funding initiatives that are one, two, or three years in duration and that attract exceptional research talent across disciplines.

Sandia's LDRD Program provides the leadership necessary to do the right research in the right way. The insight that management brings to the knowledge generated from basic research will allow Sandia to manage its intellectual assets for the benefit of the entire nation. The LDRD Program has three strategic goals:

- to conduct leading-edge, use-driven research supporting all mission assignments but focusing primarily on our national security mission;
- to provide scientific and technical leadership through increased emphasis on collaboration; and
- to improve communication about and support for the program.

6.3.2 History

Throughout its history, discretionary research at Sandia has reflected changing societal, political, and environmental needs. A perceived nuclear threat prompted the Atomic Energy Act of 1954, fostering research and development to maximize scientific and industrial progress. During the 1973 and 1974 oil embargo, the Energy Research and Development Administration redirected research toward energy-related concerns. Congressional legislation in 1977 (Public Law 95-39) led to employee-suggested research, which assumed its present form as LDRD in 1991.

Authorized by federal law and implemented under DOE Order 413.2, LDRD is Sandia's sole source of discretionary research funds (see Table 6.1). LDRD is financed by an assessment on all costed work at Sandia. Atomic energy defense activities are supported directly by 67 percent of LDRD projects, although atomic energy defense activities provide only 48 percent of LDRD annual funding. More than 90 percent of LDRD projects provide benefits in basic and applied research to national security needs. In FY 1998 LDRD funded 219 projects in ten programmatic areas.

Table 6.1. LDRD Funding (Millions)

FY 1997	FY 1998	FY 1999	FY 2000
71.0	72.0	72.0	72.0

6.3.3 Impact

LDRD uses recognized metrics to track and assess the impact of Sandia research both qualitatively and quantitatively. Metrics include intellectual property, programmatic performance, citations in relevant literature, and customer satisfaction.

The intellectual property metric is based on patent applications and copyrights. These have been trending upward. In 1992 Sandia patent applications totaled fifteen and copyrights totaled six. By 1995, patent applications totaled forty-four and copyrights totaled thirty.

The programmatic performance metric is based on awards and milestones. *R&D Magazine*'s R&D 100 Awards acknowledge the most promising technologies emerging from industrial, academic, and federal laboratories. In 1997 five of Sandia's eight R&D 100 Awards were associated with LDRD-supported projects. Other recent awards include two Lockheed Martin NOVA Awards, *Discover* Magazine's Award for Technological Innovation in Sight, and two Basic Energy Sciences Materials Science Awards. Also, FY 1997 LDRD projects reached 72 percent of their milestones, an increase of 16 percent since tracking began in FY 1993. During this period, notable increases were also measured in the number of publications, patents, and copyrights issued.

The metric based on citations in relevant literature pioneered by the Institute for Scientific Information focuses on institutional and national performance measures. This analytic method measures impact on the scientific community by tallying the number of times published research is cited by other researchers. At least four thousand of the most influential journals worldwide are reviewed. Citations of Sandia's LDRD-related published papers were tallied in research publications from thirteen federal laboratories, the top 112 federally funded US universities, and eleven internationally recognized corporations. Citations of Sandia's LDRD-related publications during the most recent five-year period (1992-1997) ranked 3.09 times the world average in computer sciences, 3.32 times the world average in engineering, 1.60 times the world average in materials science, and 1.86 times the world average in physics. Sandia's LDRD publications outranked IBM and Intel in computer sciences, Stanford University and the California Institute of Technology in engineering, Sony and Hewlett-Packard in materials science, and the National Aeronautics and Space Administration and Hughes in physics for the same period.

To measure customer satisfaction, our LDRD Program uses reviews, surveys, and number of awards to determine success in meeting expectations.

6.3.4 Process

The LDRD process rigorously evaluates proposals. The process minimizes the time to identify, review, and fund research; establishes meaningful metrics for tracking and assessing impact of the work; and maintains the highest degree of customer satisfaction.

LDRD management balances top-down guidance with bottom-up technology ideas, fostering a "community of excellence" by emphasizing collaboration, partnerships, and ongoing external technical and programmatic peer review. Investigations are funded in incremental, radical, and fundamental research, producing benefits in both the near and far terms. Percentages are shown in Table 6.2.

Table 6.2. Percent of LDRD Funds Invested in Short- to Long-Term Research

Fiscal Year	Incremental (0-1 year)	Radical (2-4 years)	Fundamental (5-10 years)
1995	26%	57%	17%
1996	29%	48%	23%
1997	16%	68%	16%
1998	25%	67%	8%

The process begins when upper management establishes a framework for strategy and investments, followed by a call for proposals. Electronic submittal of proposal briefs has increased the number of ideas submitted and has minimized the time invested in preparation. Each proposal is assessed for technical merit, growth potential, impact on future laboratory activities, and the degree to which it supports Sandia's strategic goals. The DOE gives final concurrence.

A critical factor in determining proposal approval is the degree of collaboration involved. Sandia's LDRD Program has created partnerships with industry, government, and academe. This collaborative network (see Table 6.3) enables us to keep pace with rapid technological change, avoid duplication of effort, and increase the flow of knowledge. Collaborations more than doubled from FY 1996 to FY 1998, from 29 percent to 79 percent of all projects.

Table 6.3. LDRD Collaborations

Fiscal Year	Universities	Government Agencies	Industrial Companies
1996	34	13	38
1997	64	18	57
1998	122	44	67

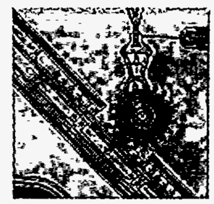
In FY 1997 almost all funded projects had dual-use (defense and industrial) applications and supported all DOE critical technologies. In FY 1999 Sandia will invest in science and technology competencies and in roadmap technologies. Sandia's science and technology competencies are in

- materials science and technology,
- computer sciences,
- electronics and photonics, and
- phenomenon modeling and engineering simulations.

Our roadmap technologies are in

- sensing and intelligent controls,
- manufacturing and process sciences,
- information systems and technology,
- directed energy, and
- surety science.

The project selection process is extremely competitive. Only about 16 percent of proposed ideas meet established criteria, and fewer than 11 percent are funded.



6.3.5 Results

Outcomes are the best measure of achievement for LDRD-funded work. As previously discussed, citation analysis is a reflection of intellectual debt. The ultimate measure of success is customer satisfaction with the product.

For 1998, 219 individual research and development projects are under way. Although the LDRD Program's contribution to some of the most successful research at Sandia is not always visible, many noteworthy technologies (described below) have been developed with LDRD participation.

6.3.5.1 Atomic-Level Studies of Surfactant-Directed Materials Growth

Sandia's nanotechnology is taking advantage of surface impurities in semiconductor thin films. We are using massively parallel computers to model atomic-scale interactions and atom-tracking microscopes to convert surface impurities to useful features. This will improve semiconductor devices of the future. Our work in this area has won two awards, including the American Vacuum Society's Peter Mark Award.

6.3.5.2 Automated Geometric Model Builder Using Range Image Sensor Data

Sandia is developing computer codes to construct realistic, three-dimensional models of physical environments. Our scannerless range imager furnishes the data for these models. This imager, invented and patented by Sandia, is a unique camera system that provides distance and reflected-light intensity to each pixel in a field of view. Computer images of terrain are developed from the camera data. These terrain images can be used to enhance remote security systems, plan clandestine activities, and rapidly assess hazardous environments.

6.3.5.3 Integrated Micromachine Technology

Microelectromechanical systems show great promise. They play a key role in the miniaturization of mechanical components in products from the most advanced weapons systems to automobiles. Microelectromechanical systems have the potential to miniaturize systems, decrease costs, and increase robustness. By leveraging existing investments in semiconductor manufacturing technology, an integrated microelectronics/microelectromechanical systems technology has been developed for building systems on a chip. In addition, mechanical locking and energy coupling prototypes with applications in weapons safing and arming have been demonstrated. Sensors have also been developed for next-generation arming, firing, and fusing systems. Micromachines will support the "lab on a chip," a vital element in detecting chemical weapons. This technology was among *Industry Week*'s "Top 5 Technologies of the Year" and also won an *R&D Magazine* R&D 100 Award.

We are combining Sandia's expertise in micromachine sensors and in rapid prototyping. Testing new concepts in a relatively short time will make our microsensors widely available to the manufacturing community for both defense- and nondefense-based technologies.

6.3.5.4 Direct Manufacturing Technologies

Manufacturing weapons components directly from a computer model can revolutionize both weapons production and industrial production of a spectrum of structural components. For example, industry is now refining Sandia's laser-spray fabrication process.

Modern manufacturing often uses robots to assemble components, but current production processes are limited to procedures based on orthogonal motion. Engineers are applying more complex motions to the fabrication of Sandia components to reduce manufacturing time and cost while increasing product quality. This process is being scaled to both micro- and macro-environments.

6.3.5.5 Scaled Asynchronous Transfer Mode End-to-End Encryption

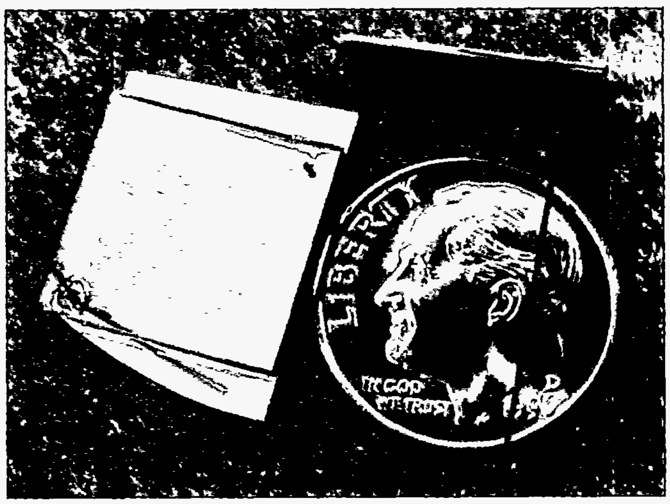
Data transmission security has important defense and other applications, including the DOE's Accelerated Strategic Computing Initiative. We are designing data encryptors to encode data being transmitted in high-speed computer networks. These encryptors will operate in the 2- to 10-gigabit-per-second range. This technology has earned five patent disclosures, one copyright, and an *R&D Magazine* R&D 100 Award.

6.3.6 Future Directions

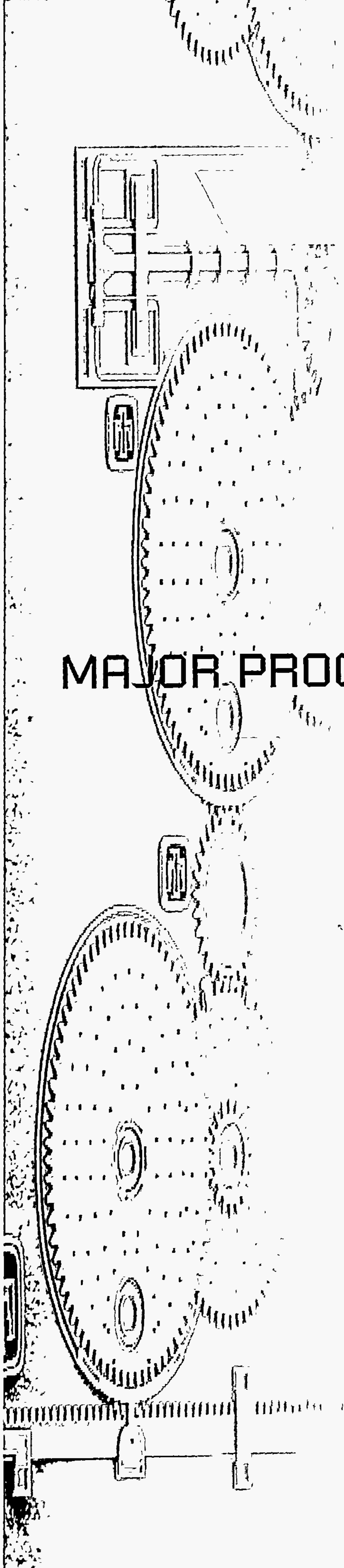
Future work will continue to emphasize and strengthen collaborations, solidifying Sandia's position in the forefront of the global research and development community. The LDRD Program will continue to develop tools necessary to assess the impact and value of ongoing and future research.

The Mapping and Navigating Science Project is becoming increasingly important. This project maps the ebb and flow of research in different scientific disciplines, creating landscapes from citation data. The maps reveal trends and relationships in science, making it possible to track emerging research and pinpoint opportunities for collaboration. This project will provide decision makers with a real-time, easily comprehended, visual interpretation of research and development trends.

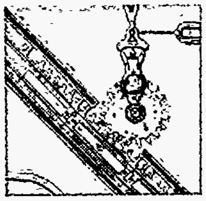
A continuing role for Sandia's LDRD Program is clear. The program is respected for the excellence of its innovative research and teamwork that continue to support the nation's science and technology needs. Sandia's LDRD investigations are an essential component of the DOE's ability to respond to changing needs and requirements and to maintain the preeminence of the national laboratories in the areas of science and engineering.



The LDRD Program funded development of the "lab on a chip," which can detect the presence of chemical agents.



MAJOR PROGRAMMATIC INITIATIVES



This section presents proposals for consideration by the DOE or reimbursable sponsors. Sandia's strategy for implementing major initiatives has several components. The primary component is to improve Sandia's capabilities so that greater value will accrue to the DOE and the government. Project proposals respond to DOE needs and may introduce novel technologies with potential for new classes of commercial applications. Consistent with good stewardship of public resources, all work will include a high degree of collaboration with other federal laboratories, industry, and universities through cost-sharing arrangements. Sandia will also help support the research and development needs of small and midsized businesses through special cooperative arrangements and technology outreach programs.

The subsections below propose either new work or major program enhancements designed to improve Sandia's capability to meet the needs of government customers. The detailed funding tables in chapter 9 do not include the related resource requirements presented below because these proposals are either new or enhanced program elements.

7.1 Nuclear Weapons

(for the Assistant Secretary for Defense Programs [DP])

7.1.1 Assuring National Capabilities in Radiation-Hardened Microelectronics

Radiation-hardened microelectronic components are critical to almost every DOE defense mission, initiative, and program. These components largely determine the reliability of a weapon system, the precision of weapon delivery to the target, and the operability of the weapon in the potentially severe environments encountered during delivery. Satellites that monitor compliance with international arms control agreements also require such specialized performance from their microelectronics. In the face of a growing potential for widespread proliferation of weapons of mass destruction, the need for enhanced processing power and assured survivability of critical electronics to attack-hardened and deeply buried targets will only continue to increase. The importance of radiation-hardened microelectronics also extends to a wide variety of DOD needs. Thus, we must ensure the preservation of essential capabilities in radiation-hardened microelectronics.

Of the total chip market, the market share of radiation-hardened microelectronics needed by the DOE and DOD remains at no more than half of 1 percent. Special techniques and nonstandard design techniques are required to enhance the radiation resistance of integrated circuits and devices, neither of which is of interest to high-volume commercial vendors. Although some discrete transistors from commercial suppliers can still meet radiation requirements, high-performance commercial integrated circuits cannot meet mission requirements for radiation resistance. A decade ago there were fifteen suppliers. Now only two vendors remain to bid on the production of replacement radiation-hardened digital circuits required for the Stockpile Life Extension Program, and they face financial risk because of the high infrastructure cost and limited market. Only one vendor remains to build the radiation-hardened nonvolatile memories for the circumvention and codes storage applications that require Sandia technology and designs, and that vendor licenses Sandia-developed radiation-hardening technology and receives production support from Sandia scientists and engineers. No vendors are available to supply the custom radiation-hardened analog components needed for interfacing all weapon sensors to programmers and fuses. Of additional concern, many of the microelectronic parts in current weapons systems and components were made by suppliers no longer in the business, and some parts use technologies that have been obsolete for more than a decade. In addition, the availability of weapon-specific components that support exploratory technologies for future stockpile upgrades (such as high-performance radiation-hardened digital circuits, radiation-hardened analog complementary metal-oxide semiconductor circuits, radiation-hardened vertical-cavity lasers, and pioneering integrated micromachines) is now assured only through continued development at Sandia. If remaining vendors are unable to supply stockpile needs for current or future technologies, the DOE would face a substantial delay without Sandia's microelectronics program. Such a delay would affect large portions of the stockpile if a common mode failure occurred in a critical microelectronic component.

As insurance, in FY 1998 Congress authorized the National Defense Electronics Partnership, which mandates that Sandia retain the institutional memory for radiation hardening technology and sustain the supporting infrastructure for developing radiation-hardened microelectronics. Through the National Defense Electronics Partnership, volume production would be performed by vendors in the private sector (such as the one that fabricates radiation-hardened nonvolatile memories using Sandia-developed technology and Sandia production support). However, Sandia would provide components in modern and older technologies for volumes too small to be of interest to the private sector. This focused program allows Sandia to sustain and develop radiation-hardening technologies for quick transfer to industry as needed. This approach expedites the entry of new suppliers into this specialized market through technology transfer of proven weapons-specific designs and technologies from Sandia. Because Sandia must continuously exercise the process of designing, producing, and validating radiation-hardened microelectronics, this capability also provides a limited in-house production capacity that could furnish replacement parts while new suppliers are being established.

Congress has designated Sandia as the contingency development and fabrication facility for radiation-hardened microelectronics. We have been a leader in radiation-hardened microelectronics research and development for thirty years. We developed the materials, production processes, and designs for radiation-hardened semiconductors that are critical components in the stockpile. Although many of the presently deployed integrated circuits were manufactured by Sandia, most were the result of partnerships between Sandia and commercial vendors. However, with few companies now willing to produce radiation-hardened microelectronics, Sandia must assume a more active role in ensuring reliable supplies of these vital components.

Sandia meets these responsibilities through the existing Microelectronics Development Laboratory by using facilities, equipment, and staff that the DOE has already assembled. The Microelectronics Development Laboratory provides 36,000 square feet of operational clean room space equipped to manufacture 0.5-micron semiconductors on six-inch wafers. The laboratory is upgrading to 0.35-micron circuit capability on industry-compatible eight-inch wafers so that Sandia can either rapidly transfer radiation-hardened integrated circuit designs and technology to industrial partners or manufacture such circuits if needed. Sandia is also equipped to provide the integrated circuit design, packaging, testing, failure analysis, and technology development required to support the nation's need for radiation-hardened integrated circuits. With Sandia serving as a contingency supplier of last resort, both the DOE and DOD would have a vital baseline of continuity as private industry advances to new generations of integrated circuit technologies.

However, despite a one-time supplemental appropriation from Congress in FY 1998, funding such a substantial program remains a constant challenge. In the past, we would have preserved these capabilities by shifting resources within our core weapons program. Today, continued funding decreases have eliminated this option. Since 1992 Sandia has attempted to maintain critical microelectronics capabilities through a combination of technology transfer funding and funds and equipment contributed by industry, but remaining technology transfer funding is being reduced, and core stockpile stewardship funds have been redirected to other initiatives. As a result, Sandia has little flexibility to support equipment partnerships or generate industrial contributions and virtually no flexibility to shift other funds into microelectronics.

Without commercial suppliers of radiation-hardened analog components, with the remaining vendors of radiation-hardened digital components at risk, and with firms unwilling to design microwave and optical systems to meet radiation requirements, Sandia must maintain an adequate internal capability. Otherwise, neither the near-term supply of radiation-hardened components for current stockpile requirements nor the development of technologies for future stockpile needs can be properly guaranteed. We are requesting that the one-time funds provided by Congress to the DOE to support Sandia's microelectronics program in FY 1998 be sustained until a national solution can be obtained through interagency partnering.

Because the suppliers of semiconductor manufacturing equipment and consumables (e.g., wafers, photoresists, and chemicals) are driven by the $150 billion annual market for commercial microelectronics, we must modify our equipment and technologies in parallel to be able to obtain equipment and maintenance for our production. Therefore, we will modify our radiation-hardened microelectronics technologies in step with the mainstream commercial microelectronics industry.

Also, as integrated circuits become smaller, new mechanisms will dominate the radiation response of microelectronics technologies.

Table 7.1.1. Funding Requirements for Sustaining National Capabilities in Radiation-Hardened Microelectronics (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

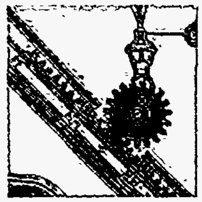
	Year 1	Year 2	Year 3
Operating	20.0	20.0	20.0
Capital Equipment	10.0	10.0	5.0
Total Cost	30.0	30.0	25.0
Direct Personnel	53	53	53

Consequently, there is a direct interaction among first-principle modeling and simulation, materials studies, functional and radiation testing and characterization, and continuing process development.

Sandia's contingency capability extends beyond the evolution of radiation-hardening technologies so that niche technologies will be available for transfer to interested private-sector vendors. Capabilities not regularly utilized are diminished. For this reason our Microelectronics Development Laboratory conducts development activities that are not of interest to commercial vendors and also delivers components for DOE systems. The latter activity includes production of custom microelectronics at volumes too small to interest private-sector suppliers of radiation-hardened circuits.

To summarize, this initiative serves as an essential element of stockpile stewardship by

- assuring the continued availability of essential radiation-hardened technologies,
- delivering radiation-hardened microelectronics to DOE systems at volumes too small to interest private-sector suppliers, and
- advancing DOE system development activities to sustain and refurbish the stockpile.



7.1.2 Distributed Information System for the Nuclear Weapons Complex

In the past, the nuclear weapons complex relied heavily on large-scale, iterative testing of prototypes for safety assessments, confirmation that components could withstand hostile environments, and validation and certification of stockpile reliability. Today, we face budget constraints, a smaller stockpile with reduced opportunities for stockpile sampling, and increasing constraints on all forms of empirical validation and certification testing. The nuclear weapons complex is thus seeking alternative and less expensive methods that make greater use of computational modeling and predictive analyses. One objective of the Accelerated Strategic Computing Initiative (ASCI) is to accelerate necessary advances in the utilization of high-end computational science and technology. The initiative is helping us make tremendous gains in the development of computing hardware and software. Sandia designers increasingly depend on modeling and simulation, spending more time computing and less time and fewer resources on physical prototyping and performance testing. One of the most critical elements of the ASCI is the distributed information capability that links the high-end computing environments at the national laboratories, the midrange computing environments used in product realization (advanced manufacturing technology) at the nuclear weapons production agencies, and the desk-side administrative computing used across the nuclear weapons complex.

We now wish to enhance our efforts in the development of distributed information systems, capitalizing on emerging trends in industry by continuing to explore the application of commodity building blocks as network nodes and as a means to more efficiently communicate with and access computational assets across the complex. Multiple classes of service are being made available to a range of users that includes administrators, engineers, scientists, weapon designers, weapon analysts, and application developers. The result will be a unified environment supporting both the Advanced Design and Production Technologies (ADaPT) Initiative and ASCI. This effort augments and extends Sandia's pioneering role in distributed computing and secure information transmittal. The effort is creating a system solution for the entire laboratory and a prototype for the nuclear weapons complex, supporting and fulfilling Sandia's responsibilities as the enterprise/system integrator for the complex.

Sandians Rolf Riesen and Ron Brightwell monitor a prototype system at Sandia's computational plant as part of the Accelerated Strategic Computing Initiative.

Table 7.1.2. Funding Requirements for a Full-Spectrum Distributed Information System for the Nuclear Weapons Complex (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2
Operating	7.0	11.0
Capital Equipment	18.0	20.0
Total Cost	25.0	31.0
Direct Personnel	24	35

7.1.3 Sustaining Critical Progress in Model Validation

Faced with budget constraints, a smaller stockpile, and restricted empirical testing, the nuclear weapons complex must shift to alternative validation methods that make greater use of computational modeling, predictive analyses, and virtual testing to sustain and ensure the credibility of the deterrent. An objective of the Accelerated Strategic Computing Initiative is to develop the computing tools to support this shift. Concurrently we must develop our understanding of complex phenomena and materials science to build and refine necessary advanced computational algorithms, models, and simulation capabilities. Sandia is integrating knowledge from advanced experimentation with the development of advanced computational algorithms directly derived from fundamental physical phenomena. Advanced computer models and simulations of these complex phenomena are subsequently being developed, and this work provides the basis for model- and simulation-based life-cycle engineering for weapons applications, particularly the characterization of normal and abnormal environments and the quantification of weapon component and system response to these environments.

The shift to alternative validation methods presents a new role for our testing capability, specifically the experimental validation and certification of analytic models to establish confidence in computational simulations for nuclear weapons surveillance and maintenance. Our efforts in this area are conducted in two programs: the Model Accreditation Via Experimental Sciences for Nuclear Weapons Program, which focuses specialized experimentation directly on the validation and certification of computational models, and the Experimental and Systems Certification Capabilities Program, which builds on this work to establish integrated and efficient system certification capabilities to support the nuclear weapons program. These two programs also drive the development of a new technology base that can provide the unique diagnostics and experimental techniques needed for full-field characterization and high temporal and spatial resolution, capabilities that are essential for phenomenology definition and subsequent model development.

The next major step is to extend the results and transform the research tools from these two programs into practical computational tools that enable broad, engineering-level use of computational modeling and allow simulation of weapons materials and components and their responses to normal and abnormal environments. These activities are leading the shift away from stockpile stewardship practices based on costly and time-consuming empirical testing toward faster and less costly computational modeling and simulation approaches.

However, funding continues to be limited; each year our traditional capabilities diminish through the deterioration of aging facilities and the loss of experienced personnel. We require continued enhancement of our resources to sustain our capabilities and maintain our current rate of progress.

Table 7.1.3. Funding Requirements for Sustaining Critical Progress in Model Validation (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

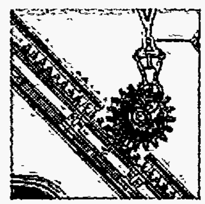
	Year 1	Year 2	Year 3
Operating	10.0	10.0	10.0
Capital Equipment	2.0	2.0	2.0
Total Cost	12.0	12.0	12.0
Direct Personnel	45	40	40

7.1.4 Continuing Production and Production Support Requirements

With "cradle-to-grave" responsibilities for nonnuclear components, Sandia plays a critical role in ensuring the safety, security, use control, and overall reliability of every nuclear weapon in the US nuclear weapons stockpile. Most weapons components are subject to normal aging, have physical limits on their service lives, and must eventually be replaced. Limited-life components in particular have specific service lives based on the constant, relatively rapid, and precisely predictable degradation of their constituent materials. Limited-life components must be regularly replaced before their constituent materials degrade sufficiently to compromise reliability. Maintaining this responsibility in an era of continuously declining budgets has become a challenge, particularly because we are also responsible for the onsite production of an assigned subset of replacement components and the characterization and qualification of replacement components to be procured from commercial vendors.

The present nuclear weapons stockpile is safe, secure, and reliable; however, the streamlining of the weapons production complex, combined with the lack of new weapons designs, has resulted in an aging stockpile. Minimal experience exists to guide us in predicting deterioration under these conditions. With stockpile reductions, the credibility of the deterrent depends on a shrinking pool of aging weapons at a time when the stockpile is also becoming more uniform, which increases the risk that a single, common mode flaw could compromise the remaining deterrent. With reduced numbers and longer service lives, we are seeing reduced opportunities for monitoring and sampling. At the same time, the smaller production complex has less capacity to rapidly correct unanticipated problems in the stockpile. All these factors narrow the margin of error that can be tolerated in the remaining weapons and drive the need for tighter stockpile surveillance to ensure that the deterrent continues to be both trustworthy and credible.

In addition, some of the materials and methods originally used to produce stockpiled weapons are no longer available. In some cases the materials and methods have become commercially obsolete or are no longer obtainable. In other cases, modern safety or environmental concerns have halted the use of older materials and methods. In any case, we cannot simply rely on the ability to replicate components from outdated designs.



These factors have increased both the complexity and the relative cost of maintaining the stockpile, particularly because our additional direct production responsibilities increase the strain on available resources. Sandia's weapon activities budget has declined steadily; our defense programs staffing levels are lower than at any time since 1951. With a continually aging stockpile, we must meet a growing number of maintenance commitments. We are thus increasingly forced to operate in a risk-mitigation mode, balancing immediate stockpile obligations against the need to assure a viable future stockpile.

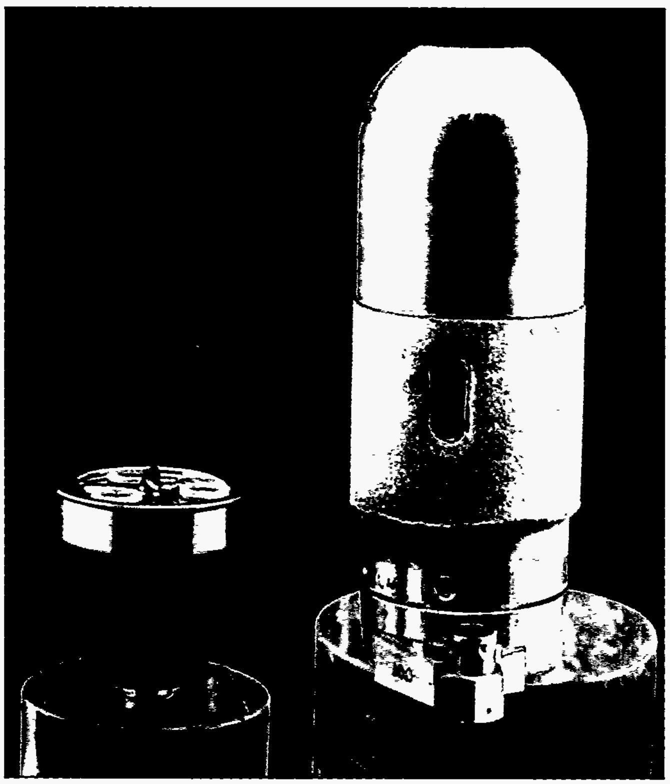
Over the next few years, Sandia's production and production support operations will be challenged to meet the replacement schedule for a number of systems in the stockpile, including thermal and lithium batteries, transformers, gas generators, actuators, inductors, and joint test assembly components. We are compelled to request enhanced funding support to meet scheduled replacement component obligations.

Table 7.1.4. Funding Requirements for Continuing Production and Production Support Requirements (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2	Year 3
Operating	15.0	20.0	20.0
Capital Equipment	0.5	0.5	0.5
Total Cost	15.5	20.5	20.5
Direct Personnel	80	90	90

7.1.5 Sustaining Momentum in Advanced Design and Production Technologies

As resources become less abundant, we are forced to search for alternative methods, technologies, and infrastructures to maintain the stockpile of the future. Sandia's Revolution in Engineering and Manufacturing Initiative, with its core concept of "virtual prototyping," addresses the challenges of this search. The Advanced Design and Production Technologies (ADaPT) Initiative forms much of the foundation for this program. By developing and deploying new information and manufacturing technologies and by enhancing Sandia's pioneering work in concurrent engineering, agile manufacturing, and enterprise integration, ADaPT will help Sandia lead a revolution in the way that the DOE realizes nuclear weapon products. Advanced design and production efforts are structured into two programs within ADaPT: the Process Development Program and the Distributed Computer-Aided Design and Manufacturing Program. These programs use directed weapon projects for the evolution, refinement, proof-testing, demonstration, and deployment of methods and technologies that subsequently will be more broadly implemented across the complex. In process development, for example, we are using a lead zirconium titanate processing project to demonstrate a new approach to the handling and processing of unique, weapon-critical materials for limited-life components.



Sandia supports development and production of neutron generators.

In the Distributed Computer-Aided Design and Manufacturing Program, we are applying our expertise in agent-based information technologies to develop an information and data management system for requirements, design, and manufacturing data on weapons components. We also are developing models of the weapons enterprise that will be used to evaluate and influence production plans, decisions, budgets, and investments required to meet the objectives set by the Stockpile Life Extension Program.

In a related effort, we are implementing a secure communication system to connect the DOE Defense Programs national laboratories and production facilities. We have already established a secure, high-speed, classified network linking Los Alamos National Laboratory, AlliedSignal in Kansas City, and Sandia sites in California and New Mexico. We are also implementing software tools and environments that enable personnel to share information across the complex.

Although developmental efforts are under way within the ADaPT Initiative, the full benefits of the investment are realized in the Distributed Computer-Aided Design and Manufacturing Program Integrated Product and Process Design/Agile Manufacturing subprogram. For example, concurrent engineering techniques (an outgrowth of our early work in integrated product and process development) help designers coordinate product designs and the manufacturing processes used to produce them. We now use computational modeling and simulation technologies to develop modular design tools that enable concurrent optimization of designs for performance, manufacturability, inspection, environment, procurement, and cost. We are creating linked virtual prototyping environments in which a product and its manufacturing processes are designed concurrently. These techniques reduce time and labor during the design phase, contribute to improved product performance, lower manufacturing risk, shorten the overall product-realization cycle, and cut costs—all of which are essential to sustaining the stockpile with a smaller complex and tighter budgets.

Extending the integrated product and process design concept, agile manufacturing uses advanced materials and techniques where flexible manufacturing processes can be established and easily modified, upgraded, or replaced. We are leading the development of direct fabrication, a concept that allows seamless transfer of electronic rendering of designs to unit processes that fabricate hardware.

A number of directed weapon projects that include components such as neutron generators, gas transfer systems, and arming, fusing, and firing systems encompass the full range of electrical and mechanical design needs inherent in nonnuclear weapon components. Successful completion of this initiative will result in a more efficient method for realizing products for the enduring stockpile.

Table 7.1.5. Funding Requirements for Sustaining Momentum in Advanced Design and Production Technologies (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2	Year 3
Operating	17.0	20.0	23.0
Direct Personnel	68	80	92

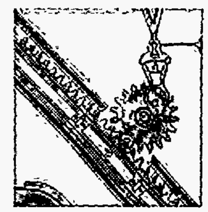
7.1.6 Pulsed Power Technology

Sandia is the DOE center for pulsed power research and the leader in developing fast pulsed power technology. Recent breakthroughs have delivered record power, energy, and temperature performance in z-pinches and achieved state-of-the-art radiographic source parameters in preliminary demonstrations. Pulsed power can generate and deliver high energy and high power at low cost and high efficiency in compact systems. These are important features when considering the construction of advanced experimental facilities. Sandia's pulsed power research has led to the development of unique multipurpose facilities supported by highly advanced diagnostic, calculational, and analytic capabilities.

Sandia's Pulsed Power Inertial Confinement Fusion Program applies low-cost, high-efficiency leverage to the national Inertial Confinement Fusion Program. Sandia addresses high-energy-density physics issues for stockpile stewardship and high yield in the laboratory for application to weapon physics and energy production. Our program builds on technologies developed for radiography and generation of bremsstrahlung radiation. A separate laboratory effort applies nanosecond pulsed power to generate intense, high-energy x-ray sources for hydrodynamic radiography and radiation-effects science research. Sandia's Z Accelerator, Saturn, and High-Energy Radiation Megavolt Electron Source III (HERMES III) are the world's most powerful accelerators for the generation of x-rays, gamma rays, and high-energy-density environments. Sandia's programs for pulsed power research and development, inertial confinement fusion, radiation-effects science, and advanced hydrodynamic radiography are highly interdependent and have benefited greatly from the strong links that connect them.

Sandia leads in the development and application of laboratory x-ray sources using fast z-pinch implosions. Magnetically driven implosions using fast pulsed power generators are the basis for a growing international collaboration on high-power, high-energy laboratory x-ray sources. Additional experiments on the Z Accelerator (which produces more than 2.0 megajoules of x-ray energy) and Saturn (which produces 0.5 megajoules) will provide the technical confidence to proceed with the X-1 Advanced Radiation Source. X-1 is planned to deliver a 16-megajoule laboratory x-ray capability, which would provide the advanced pulsed power needed to achieve controlled high-yield fusion burn to support weapon physics, inertial confinement fusion, and radiation-effects science experiments. The preferred location for X-1 is the Nevada Test Site.

Sandia's Advanced Hydrodynamic Radiography Program applies the compact, high-current inductive voltage adder pulsed power architecture to the national Advanced Hydrodynamic Radiography Program. Our program uses the inexpensive and robust technology developed for the HERMES III radiation-effects science gamma-ray simulator to drive a high-brightness and extremely compact x-ray source. Preliminary studies using the smaller Sandia Accelerator and Beam Research Experiment (SABRE) facility have approached the state of the art in hydrodynamic radiography, and FY 1998 experiments scaled this technology toward full advanced hydrodynamic radiography intensities on HERMES III. These capabilities could be integrated into an advanced hydrotest facility, providing multiaxis and multipulse, high-quality radiographic illumination to simulate primary implosions for nuclear performance and safety certification.



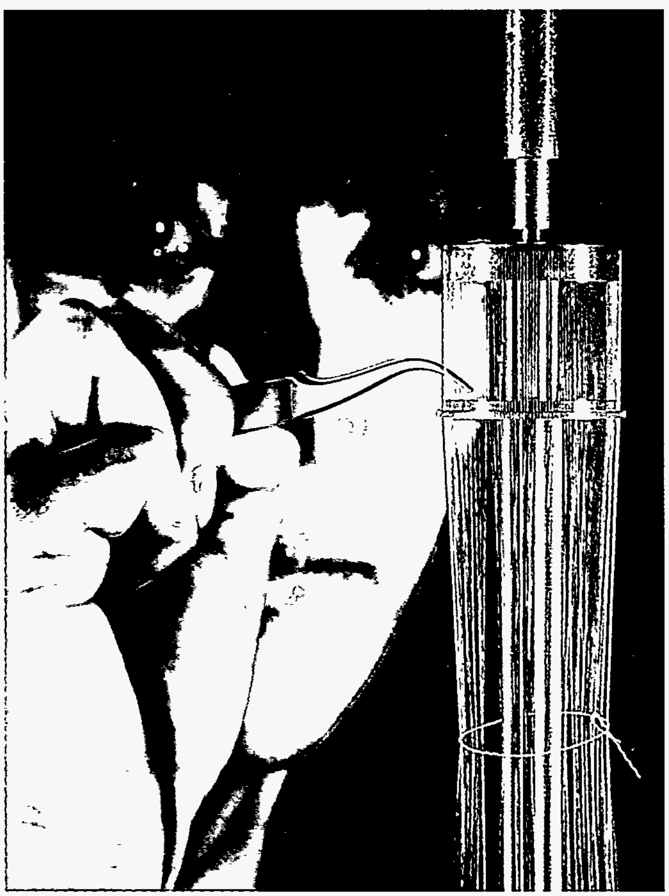
Sandia continues to build strategic relationships with other national laboratories in existing programs such as weapon physics and in new initiatives such as the National Ignition Facility, Atlas, Accelerator Production of Tritium, the X-1 Advanced Radiation Source, and the Advanced Hydrodynamic Facility. We seek to apply our capabilities and competencies for the greatest benefit to the DOE and the nation. We are developing high-average repetitive pulsed power for DOE and DOD programs, and we are exploring the potential for commercial applications.

Pulsed power technology initiatives for DOE Defense Programs consideration are described below. Funding requirements are given in tables at the end of each subsection.

Gary Tilley and Ray Gutierrez conduct maintenance on Sandia's HERMES III Accelerator.

7.1.6.1 Applications of the New Z Accelerator

In September 1996 the Particle Beam Fusion Accelerator II was modified and renamed the Z Accelerator. This accelerator provides a z-pinch driver by redirecting the electrical output of the thirty-six pulse-forming lines through a vacuum feed section. The radiated x-ray power from a wire-array pinch has increased by an order of magnitude during the last two years. The peak radiated power on the Z Accelerator is a factor of four greater than the peak electrical power delivered by the previous accelerator. This evolution in radiated power from Saturn to the Z Accelerator is more than a function of additional wires and larger power supplies. The dramatic increase in radiated power represents a revolution in the understanding of z-pinch-driven x-ray sources. Progress is measured in two parts: first, from simple x-ray production experiments to complex radiation and inertial confinement fusion target experiments that use sophisticated x-ray diagnostics developed for the harsh electromagnetic, shock, and debris environment; second, from a comparatively simple analysis of these x-ray sources to the design and modeling of their performance using two-dimensional radiation-magnetohydrodynamics codes.



Dolores Graham builds a wire array target for Sandia's Z Accelerator.

To profit from this dramatic progress, a balanced program of experiments, theory, modeling, and design will ensure that high-quality data are obtained and that better understanding and new applications to weapons science result. The goal of this programmatic initiative is to demonstrate a well-characterized, reproducible, flexible radiation environment for weapon physics, weapons effects, and inertial confinement fusion experiments.

A suite of standard diagnostics being prepared for internal and external use includes diagnostics to measure the hohlraum temperature (multichannel x-ray diodes, bolometers, and an active shock breakout diagnostic for vacuum hohlraums) and to determine the radiation spectra (time-resolved, transmission-grating spectrometers and space-resolved, time-integrated crystal spectrometers). Other diagnostics characterize the z-pinch plasma and image the hohlraum interior (time-resolved pinhole cameras and an x-ray backlighter) and the neutron emission (neutron time of flight, neutron activation, and total neutron yield). The diagnostic sets include both off-axis diagnostics that view the pinched plasma at the end of long line-of-sight pipes and heavily shielded on-axis diagnostics that view the pinched plasma "end on."

Data from these diagnostics will allow us to benchmark multi-dimensional, radiation-hydrodynamics, magnetohydrodynamics codes. A fully integrated, massively parallel, three-dimensional, radiation-transport, magnetohydrodynamics capability is being developed to evaluate the dynamics of the imploding pinch, model the hohlraum and capsule physics, and improve hohlraum and capsule performance.

Saturn provided the x-ray line radiation from imploding z-pinches that simulated reduced-intensity response of materials to the unshielded x-ray threat from a weapon. With the Z Accelerator, this material response will be simulated experimentally at increased radiation intensities using K-shell line radiation.

The planned experimental program on the Z Accelerator will address issues that directly support Sandia's goal of achieving high yield on the next-generation pulsed power facility. Studies of pulse shaping, radiation drive symmetry, hydrodynamic instabilities, and capsule implosion physics in a z-pinch are planned over the next three years. These studies will support a DOE decision to proceed with an X-1-level facility that can deliver the critical radiation environments to achieve propagating burn for weapon physics tests and a warm x-ray environment for weapons effects studies.

Table 7.1.6.1. Funding Requirements for Applications of the New Z Accelerator (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2	Year 3
Operating	14.2	18.0	15.0
Direct Personnel	14	14	9

7.1.6.2 X-1 Advanced Radiation Source

The X-1 Advanced Radiation Source is a planned laboratory facility with approximately 16 megajoules of x-ray energy output. The X-1 will address Sandia's mission accountability for stockpile system and subsystem validation and certification as well as the inertial confinement fusion objectives of evaluating high-energy-density environments and developing high yield fusion capabilities.

The DOE's Stockpile Stewardship Program (established by Presidential Decision Directive) is designed to use past nuclear test data in conjunction with future nonnuclear test data, computational modeling, advanced experimental facilities, and simulation to deliver comprehensive understanding of nuclear weapons and the effects of radiation on military systems. One goal is to preserve the core intellectual and technical competencies of the United States in nuclear weapons. The cessation of underground testing has also created a need to test the predictions of new and evolving calculational tools that will simulate the physics of weapon implosions over a broad range of pulse widths and energies.

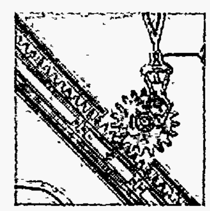
The X-1 will provide a unique, energy-rich drive for exploration of an alternative path to high-yield inertial confinement fusion experiments. The idea for X-1 originated from the need to provide more intense fluences of cold and warm x-rays over large sample areas for weapons effects testing. However, the x-ray environment generated with a z-pinch implosion on X-1 will also be useful for evaluating the performance of inertial confinement fusion and weapon-physics-relevant hohlraums in a regime more comparable to weapon conditions than is achievable with present facilities. The higher-radiated energy will allow studies of increasingly complex radiation flow, accurate measurements of shock timing, and investigations of the effects of hydrodynamic instabilities and mix in weapons relevant to stockpile stewardship at scaled sizes for a variety of pulse widths.

The X-1 will create a high-temperature (up to 300 electronvolts), variable-pulse-width (10- to 100-nanosecond) radiation environment in a large (greater than 5 cubic centimeter) hohlraum. Such a combination of characteristics was formerly achievable only with a nuclear explosion. The variable radiation pulse width in a large-volume hohlraum will enable experimentation for investigating fundamental issues dealing with radiation flow, equations of state, and opacities at high densities and high temperatures. The controlled pulse shape and symmetry in a z-pinch environment that will be demonstrated in the next two years will provide the technical basis to demonstrate that high-yield fusion burn is a realistic goal for the X-1 Advanced Radiation Source. Achieving high-yield fusion burn will provide the radiation environments for significant weapon physics experimentation and will allow radiation-effects experiments in warm x-ray environments (not presently achievable on any simulator).

Extrapolation from results on the Z Accelerator indicates that we should be able to achieve fusion ignition and high yield from the X-1. The strategy for X-1 minimizes technical risk and reduces additional pressure on DOE budgets for the early years while enabling us to proceed toward meeting stockpile stewardship responsibilities. The X-1 will strengthen partnerships among Sandia, Los Alamos, and Lawrence Livermore national laboratories (as well as international partners) in the weapons science and inertial confinement fusion programs while maximizing near- and long-term benefits to the Stockpile Stewardship Program. The unique capabilities of the X-1 complement the capabilities provided by other planned DOE facilities.

Table 7.1.6.2. Funding Requirements for the X-1 Advanced Radiation Source (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2	Year 3
Operating	20.0	25.0	28.0
Direct Personnel	15	15	25



7.1.6.3 Advanced Hydrodynamic Radiography

Evaluating the nuclear primaries of strategic weapons is a principal concern of stockpile stewardship. In the absence of hydronuclear and boosted-yield underground tests, significant improvements in methodologies and experimental capabilities are needed to infer the key nuclear parameters to assess the performance and safety of stockpiled weapons systems. The DOE established a committee consisting of Sandia, Lawrence Livermore, and Los Alamos national laboratories to determine the experimental capabilities and define the technologies needed. The committee determined that advanced radiographic capabilities are required to interrogate an imploded simulant primary from multiple angles to tomographically reconstruct the imploded mass distribution and infer criticality, mix, and shape. For x-ray radiography, these capabilities demand significant improvement beyond the present state of the art: 1 kilorad measured 1 meter from a 1-millimeter-diameter source. A sequence of such radiograph sets is needed to verify performance and nuclear safety. A detailed technical contract has been developed to investigate three technologies with the potential to meet these advanced technical needs of the Stockpile Stewardship Management Plan.

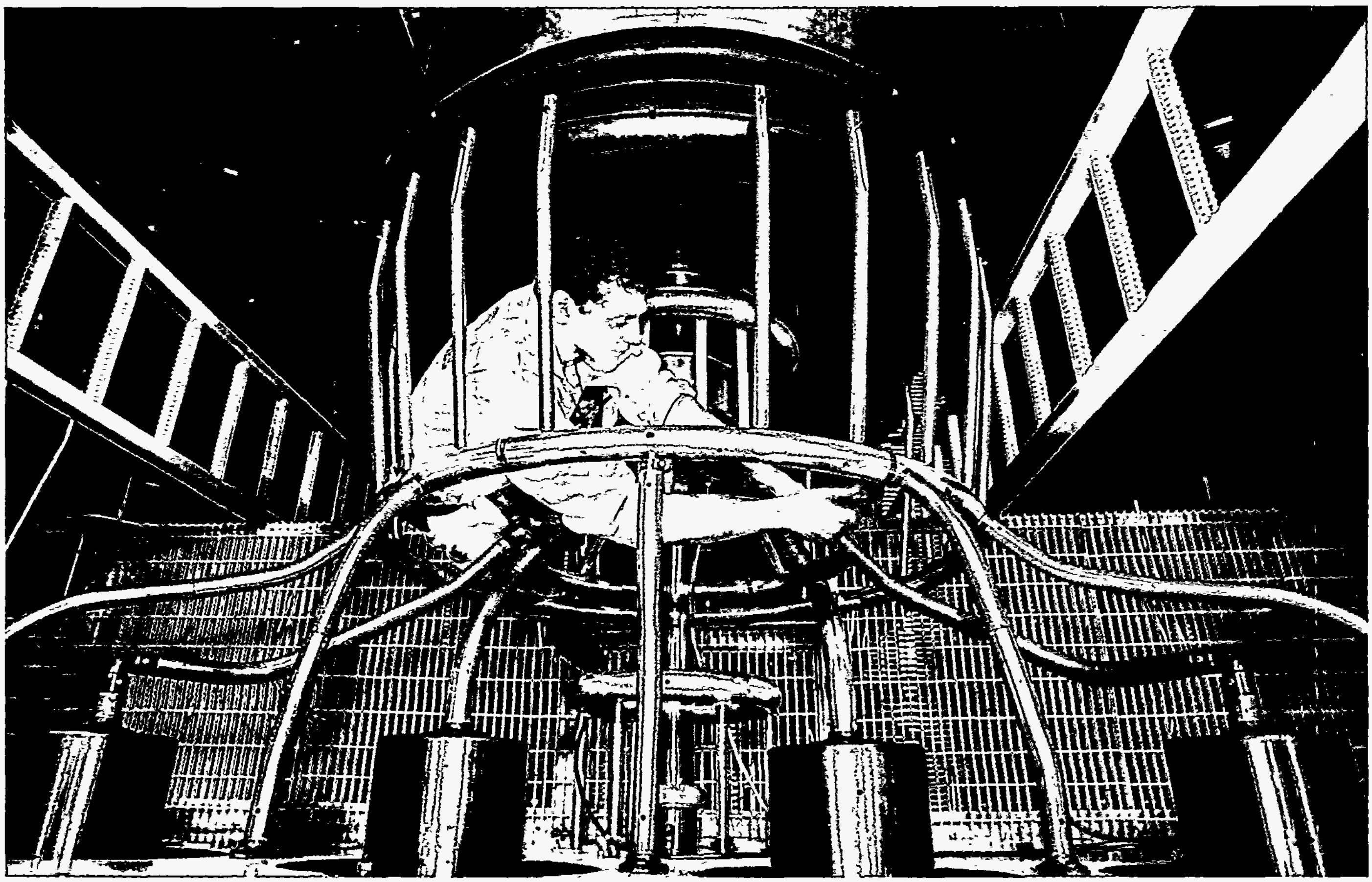
Sandia's compact and cost-effective high-current fast-pulsed-power technology with inductive voltage adder accelerators is a strong candidate to meet these advanced hydrodynamic radiography requirements. The capability to produce a requisite 1-millimeter-scale high-brightness x-ray spot was successfully approached in 1996 in a proof-of-principle experiment using the Sandia Accelerator and Beam Research Experiment (SABRE) facility driving a magnetically immersed diode. The electron beam emitted from a small cathode needle was transported reliably in a strong (30 tesla) magnetic field to a bremsstrahlung converter. These results, in good agreement with particle-in-cell and hybrid simulations of power flow and intense electron beam generation and transport, are equivalent to the hydrodynamic radiography state of the art.

The benchmarked models show the SABRE immersed-diode spot size scales as voltage divided by magnetic field, with 60-tesla fields confining a 40-kiloampere, 12-million-volt electron beam to less than 1 millimeter in diameter. This beam will provide the required 1-kilorad dose in 50 nanoseconds. An experiment to validate this extrapolation was performed on the High-Energy Radiation Megavolt Electron Source III (HERMES III) in FY 1997. The accelerator was temporarily modified to provide a 10-million-volt, 50-nanosecond drive pulse at the appropriate impedance, and a compact 50-tesla solenoid magnet was successfully developed. This experiment demonstrated inductive voltage adder x-ray capabilities closely approaching full advanced hydrodynamic radiography parameters, producing both a 1-millimeter source for a brief period and greater than 1 kilorad of dose in 50 nanoseconds, a step that no other technology can yet attempt. Full performance demonstrations of an Advanced Hydrotest Facility-quality x-ray source will require the construction of a radiographic integrated test stand in FY 1999–2000.

The technical contract for the national program identifies subsequent research required to demonstrate the feasibility of inductive voltage adder technology for advanced hydrodynamic radiography, including multipulse power generation; beam transport, targets, and detectors; integrated multiaxis facility issues; and detailed modeling to assure these experimental parameters will provide the needed nuclear weapon primary physics information. Inductive voltage adder technology has significant growth potential and immediate application to develop a compact, cost-effective, multiaxis advanced hydrodynamic radiography facility to address nuclear stockpile issues, both in scaled ongoing subcritical experiments and in the future Advanced Hydrotest Facility.

Table 7.1.6.3. Funding Requirements for Advanced Hydrodynamic Radiography (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2	Year 3
Operating	6.0	12.0	12.0
Direct Personnel	9	15	20



Josh Mason performs maintenance on a gas switch in Sandia's HERMES III Accelerator.

7.2 Nonproliferation and Materials Control

(for the Office of Nonproliferation and National Security)

Since the Eisenhower Atoms for Peace days, the United States has met challenges of nuclear proliferation. The advanced countries of the world must support the legitimate expansion and use of nuclear power and still prevent the proliferation of nuclear weapons. The International Atomic Energy Agency and the Nuclear Nonproliferation Treaty served the world well in this regard until the 1990s. Now, with the experiences in Iraq and even more recent events in India and Pakistan, the efficacy of that system of proliferation control has been thrown into doubt. To reduce the risk of further proliferation, and to reinstate a regime of effective nonproliferation, the DOE, through its national laboratories, must step forward to reassert US influence and guidance in the international nuclear arena.

7.2.1 Treaty Verification Technology

The DOE Office of Nonproliferation and National Security has responsibility for developing, through the national laboratories, the technology necessary to monitor compliance with negotiated treaties relating to nuclear testing limitations. Over time, these treaties have led to greater restrictions on the testing of such weapons. Thus, technologies to monitor compliance must continue to evolve as these restrictions increase.

Sandia has started a program in conjunction with Los Alamos and Lawrence Livermore national laboratories and the US Air Force to develop sensors and data processing technologies that will provide the nation with the capability to monitor the provisions negotiated in the Comprehensive Test Ban Treaty. These technologies include space-based as well as earth-based sensor systems. The space-based sensors include advanced optical and electromagnetic pulse sensors. The earth-based sensors include seismic, infrasound, radionuclide, and hydroacoustic systems. Successful development and deployment of these systems will allow the United States, and in some cases our international partners, to monitor treaty compliance.

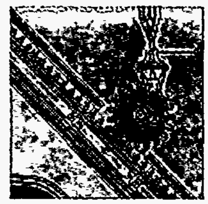
Table 7.2.1 Funding Requirements for Treaty Verification Technology (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2
Operating	57.0	61.0
Direct Personnel	195	190

7.2.2 Nonproliferation Technology

Through the national laboratories, the DOE Office of Nonproliferation and National Security has a long history of responsibility for the development of technology to detect activities associated with nuclear weapons proliferation. Recently the DOE has broadened its responsibilities in this area to include other weapons of mass destruction, notably chemical and biological weapons.

Sandia currently is working in partnership with Los Alamos National Laboratory, the US Air Force, and the intelligence community in the development of new capabilities to detect proliferation of these weapons of mass destruction. We are developing a multispectrum sensor capable of active radiometry and are integrating it into a satellite that will be launched early in 2000. We are also developing an active ultraviolet laser system that can detect materials associated with various proliferation activities.



The key to our continued success in the remote monitoring of proliferation-related activities is the development of more capable sensors with greater resolution and sensitivity. These sensors must also be smaller, lighter, and use less power. To this end, we are forming a partnership with our microelectronics group to develop a very small satellite system. Success in this venture will ensure our continued access to a broad spectrum of space-based sensor platforms.

Table 7.2.2 Funding Requirements for Nonproliferation Technology (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2
Operating	30.0	24.0
Direct Personnel	92	90

7.2.3 Global Nuclear Materials Management

One of the major constraints to nuclear proliferation is restricted access to special nuclear materials. The DOE has always been thoroughly involved in nuclear materials management. By maintaining competent and continuous management of domestic nuclear materials from "cradle to grave," the DOE has met all safety and security requirements. However, new challenges remain.

Sandia and the DOE have begun a program to identify those areas of nuclear materials management that require reassessment or augmentation to meet the nuclear materials management challenges of the twenty-first century. Since the 1970s, US policies have had little discernible effect on nuclear programs in other countries, and our ability to contribute to and influence the international discussion on nuclear matters is declining. A nuclear materials management program would meet the pressing need to reestablish US influence both domestically and internationally. The United States offers the world the best technology and the best example of nuclear materials management. The program proposed by Sandia and its partners would enhance this position, ensuring the DOE's leadership role in global nuclear materials management well into the next century.

Program elements call for a unified approach to materials management in the areas of nuclear weapons, excess defense materials, and civilian materials. This approach includes movement of materials from one area to another, such as movement of excess materials to the civilian category for purposes of irreversible disposition. At Sandia this entails the integration of many existing and future programs under the global nuclear material monitoring role. Such crosscutting integration will include projects supported by several DOE offices. However, the cost estimate in Table 7.2.3 for new funds to support this integration effort assumes support only from the DOE Office of Nonproliferation and National Security. Critical technology requirements must be defined and programs identified to support these requirements; this will ensure the DOE's ability to support US policy independent of future decisions regarding nuclear power, materials disposition, and international treaties or agreements.

Table 7.2.3. Funding Requirements for Global Nuclear Materials Management (Dollars in Constant FY 1998 Millions; Personnel in FTEs

	Year 1
Operating	1.5
Direct Personnel	6

7.2.4 Materials Protection, Control, and Accounting

The DOE's Materials Protection, Control, and Accounting Program has been instrumental in improving the physical protection and accountancy of direct-use nuclear materials in Russia and the other independent states of the former Soviet Union. The technical support of the DOE laboratory complex has led to improved protection of nuclear materials in these independent states. As this program completes its initial goals, however, we are faced with transitioning the long-term obligations for materials protection, control, and accounting to the host countries and to the facilities possessing the materials. This transition is problematic because in general no materials management infrastructure exists in these states or facilities. The breakup of the Soviet Union left a vacuum that must be filled by close attention to the policies of the Materials Protection, Control, and Accounting Program.

Sandia, the DOE, and the other laboratories involved in this program for the past several years are proposing a series of steps to maintain the effectiveness of physical protection and accountability that has been achieved thus far. These follow-on "sustainability" efforts, supported by the DOE Office of Nonproliferation and National Security, are designed to ease the transition of responsibility to the appropriate organizations in the countries involved. The transition will be achieved by a combination of training, cooperative technical programs, and government-to-government information exchanges and agreements.

Table 7.2.4. Funding Requirements for Materials Protection, Control, and Accounting (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1
Operating	42.0
Direct Personnel	51

7.2.5 Transparency and START III

The concept of transparency, initiated during the Strategic Arms Reduction Treaty III (START III) process, has been pursued by the DOE with the assistance of the US national laboratories and the Russian nuclear institutes. Sandia has been instrumental in these efforts and continues to work with the DOE to further the concept. Beginning with a goal of achieving transparency and irreversibility in the dismantlement of nuclear weapons, the work has extended to the whole process of weapons dismantlement, including weapon status monitoring during transportation and storage. To further the process, Sandia has proposed programs to the DOE Office of Nonproliferation and National Security for multilevel data security and data authentication, radiation measurements, and detection and destruction of high explosives. The joint work with the Russian nuclear weapon laboratories should also be extended to involve both the DOD and the Russian Ministry of Defense. The goal of the extended program is to identify and support dismantlement scenarios that are technically and politically feasible and can respond to the policy needs of both countries.

Table 7.2.5. Funding Requirements for Transparency and START III (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1
Operating	2.5
Direct Personnel	8

7.2.6 Waste Legacy/Subsurface Environment

The Subsurface Environment Initiative reduces cost and risk in the management and remediation of subsurface contamination at DOE and non-DOE sites and creates technologies that can be used at a range of federal and industrial sites. Sandia's strategy is to leverage existing funding to secure new funding by integrating research, development, and application within a focused framework of subsurface environmental issues. We are making key Sandia environmental research and development capabilities (such as the Flow Visualization and Processes Laboratory and field-scale environmental testing facilities) readily available to non-DOE customers to further leverage research and development. We are developing strategic technical alliances with academic institutions, other DOE laboratories, and DOD laboratories, and we are developing coordinated funding that links research and development work to demonstration and refinement work. One concentration is utilization of Sandia's capabilities and experience to solve subsurface environmental problems in arid regions. Another focal area links cleanup strategies and technologies within cost and risk frameworks to improve the information base for management decisions.

Table 7.2.6 Funding Requirements for Waste Legacy/Subsurface Environment (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2
Operating	4.0	6.0
Direct Personnel	10	15

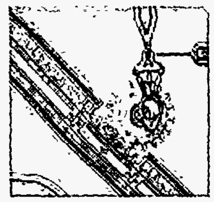
7.3 Energy and Critical Infrastructures

(for the Assistant Secretary for Defense Programs [DP]; the Assistant Secretary for Energy Efficiency and Renewable Energy [EE]; the Assistant Secretary for Nonproliferation and National Security [NN]; the Office of Energy Research [KC]; the Department of Defense; the National Communications System; and other federal agencies and nonfederal entities)

7.3.1 Energy Programs

The United States continues to rely largely on carbon-based fuels for energy needs. The risks of this reliance can be mitigated if funds are devoted to long-term research and development of alternative energy sources for the future.

Sandian Jim Pacheco examines a heliostat that generates alternative energy.



Lack of public support for such research and development may originate from confidence in a carbon-based energy future and problems associated with alternative fuels demonstrations. Sandia can revitalize interest in the role of technology for developing alternative energy sources. First, we have initiated a study of technology improvements that could have the greatest impact. Second, to generate public interest we have initiated four small efforts to develop technologies with the potential for significant long-term impact. Finally, we have begun exploring with industry the application of our Accelerated Strategic Computing Initiative capabilities to revolutionize the design and development of energy systems. This approach reduces time and cost by eliminating much of the full-scale testing of the present approach.

Historically, Sandia's Energy Program has dealt largely with issues such as oil and gas exploration and production, fossil fuel conversion, nuclear reactor safety, renewable energy technology, and energy storage. By viewing energy as one element of the nation's critical infrastructure, we recognize transmission and end-use issues and the important role that Sandia can play because of our surety background. Our initial focus is on the electric grid and the oil and natural gas supply systems. Funding requirements are summarized in Table 7.3 at the end of this section.

7.3.2 Critical Infrastructure Surety

Since the 1940s Sandia has provided engineering and science expertise to protect the nation against foreign military threats. Now, national security is facing a new range of threats, from foreign states to rogue groups within the nation. At the same time, the United States is becoming increasingly dependent on a complex infrastructure, international in scope and vulnerable to this new range of threats. Sandia has capabilities that can improve the surety (confidence that a system will perform in acceptable ways during normal, abnormal, and malevolent circumstances) of infrastructures critical to the security of the United States. Infrastructure surety is the new national security challenge.

7.3.2.1 Critical Infrastructure Interdependencies

The US infrastructure is a complex system of interdependent elements whose uninterrupted operation is vital to the national security and economic well-being of the country. Previous experience has shown that a loss of service in one infrastructure can produce indirect but potentially severe collateral damage as it cascades through other infrastructure elements. Although models of individual infrastructure elements have been developed, currently no comprehensive models of the entire system exist to show the complex interdependencies among the individual elements.

Sandia is addressing this problem by using our strong capability for simulating complex systems. This capability grew from our mission of nuclear weapons stockpile surety, where complex systems such as nuclear stockpile maintenance have been modeled. This work resulted in a strong capability that can be applied to the critical infrastructure problem. The modeling of interdependencies in the US Infrastructure Project is leveraging this capability. Sandia has the world's fastest computers, which are now running detailed simulations of a variety of complex systems. We use agent-based microsimulations and macrosimulations that follow a top-down paradigm. This work ultimately will provide the basis for enhanced indications and warnings capabilities.

7.3.2.2 Consequence-Based Rationale for Infrastructure Surety

Many infrastructures lack threat definition, limiting our ability to efficiently identify critical nodes and design protective measures, and also limiting the degree to which private industry is willing to participate and invest in infrastructure protection. However, industry acknowledges that certain consequences are unacceptable.

Sandia has developed a consequence-based methodology to better assess national infrastructure risk and reliability issues. We have identified important critical nodes, fundamental causes of failures, threat scenarios, and specific failure modes of infrastructures. This consequence avoidance approach has clear appeal for both private industry and government agencies because it can optimize protection strategies. Extending such results to economic modeling may efficiently prioritize allocation of protection options.

A similar approach has been used as the basis for assessment of nuclear power plant and weapon safety. Sandia has led the nation for more than twenty years in the application of probabilistic risk assessment to the problem of designing safe, secure nuclear reactor facilities.

7.3.2.3 Indications and Warning System

The Defense Science Board has warned that an adversary could attack the US infrastructure while disguising the attack as a series of apparently random events by computer hackers. No capability exists within the nation to warn of such attacks, so providing timely indications and warnings may be the most difficult technical challenge we face. Sandia is in a unique position to supply some of the technology needed for a monitoring and detection system. We have developed many pattern-recognition techniques for real-time target detection using a variety of ground-, air-, and space-based sensors. Other technologies available at Sandia include methodologies for determining monitoring regimes; small, inexpensive smart sensors; and advanced information technologies for real-time data collection, security, analysis, availability, presentation, and decision support systems. In addition, new microsimulation models using Sandia's high-performance computers have recently proven viable. Sandia has a key role in counterproliferation and manages several international programs in cooperative monitoring. These programs include the Modular Integrated Monitoring System, the Integrated Nuclear Materials Monitoring System, and the Integrated Intrusion Detection and Access Control Automation System. These DOE-funded programs provide a technical basis for designing an effective warning system for the US infrastructure.

7.3.2.4 Information Surety

All major elements of the US infrastructure increasingly depend on information technology. This dependence creates new vulnerabilities that can be exploited by an adversary, increasing concerns about information surety. Sandia has extensive capabilities for protecting information systems. These include vulnerability analysis, risk analysis, design of information systems with high assurance, and cryptographic research.

7.3.2.5 Physical Surety

Sandia's physical protection technologies include systems analysis, target identification, facility characterization, and threat and security effectiveness evaluation. We also develop and evaluate technologies for exterior and interior sensors, entry-control devices such as badges, contraband detection, access delay materials (including active barriers such as sticky foams and smoke), alarm communication and displays, response force equipment, and insider protection. For twenty years we have implemented security systems in a variety of environments for many entities. We have a range of facilities available to support research and development in these technologies. As a result of Sandia's mission in nuclear weapons stockpile surety, we have developed physical infrastructure elements that are robust in normal, abnormal, and hostile environments. We use this stockpile surety expertise in other areas. We are using high-performance computing to develop models of structures to understand their response to their environments, to predict possible failure modes, and eventually to control the manner in which failure occurs. We are developing models to show the response of buildings to explosions and to investigate the failure modes of glass (the major cause of injury to personnel). We have also developed an overview course in infrastructure surety for civil engineers (CE551 at the University of New Mexico) in order to transfer this expertise to the engineers who will design our future infrastructure.

7.3.2.6 International

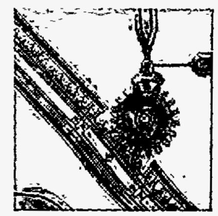
The Institute for Global Approaches to Infrastructure Analysis supports Sandia's critical infrastructures strategic objective and US national security interests by providing solutions to decision makers throughout the world to help manage indigenous and transnational infrastructure issues. Institute solutions will include policy portfolios; real-time decision-support information systems; and the design, development, and deployment of strategic technologies. Such work will leverage our existing expertise and technology base while moving Sandia into a new segment of the international arena.

7.3.2.7 Consensus-Based Strategic Planning

Sandia has developed a number of consensus-based strategic planning techniques, including prosperity games and vital issues processes. We have applied these techniques seventy-five times during the last five years to such varied areas as national security, environmental quality, economic competitiveness, energy security, health care, and water resource management.

7.3.2.8 Transportation Surety

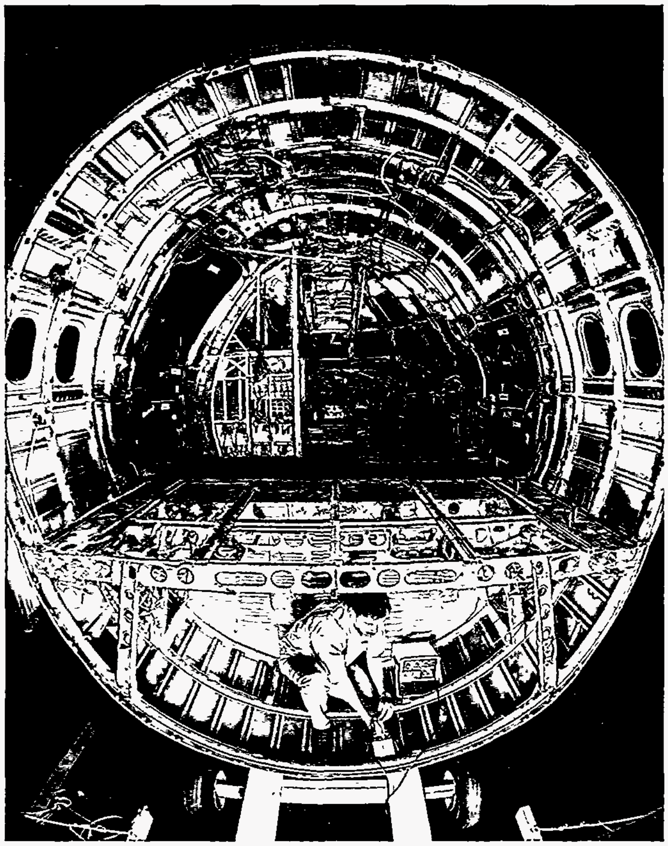
Sandia has extensive experience as a systems laboratory tasked with engineering and ensuring the safety, security, and reliability of very high-consequence systems (nuclear weapons and power systems). This experience, coupled with our broader expertise in engineering and science, human factors, information systems, and aviation safety provides a unique capability to assist the Federal Aviation Administration in preparing for the future.



Sandian Rudy Matalucci leads a group that applies surety principles to make buildings safer.

To this end, Sandia is involved with several complementary projects. One is the Airworthiness Assurance Nondestructive Inspection Validation Center, which initially focused on the structural problems of aging aircraft but has grown to include developing and validating new and improved inspection and maintenance technologies and deploying them to civilian and military users.

Another project involves the Aviation Safety Critical Elements and Necessary Tasks Program, which consists of several elements supporting both aviation regulation and certification and the Office of Aviation Research. Our nonintrusive explosives detection portal shows promise at detecting very small quantities of explosive residue on both baggage and personnel.



Sandian Mike Valley inspects the fuselage skin in a DC-9 at the Sandia/Federal Aviation Administration Airworthiness Assurance Nondestructive Inspection Validation Center.

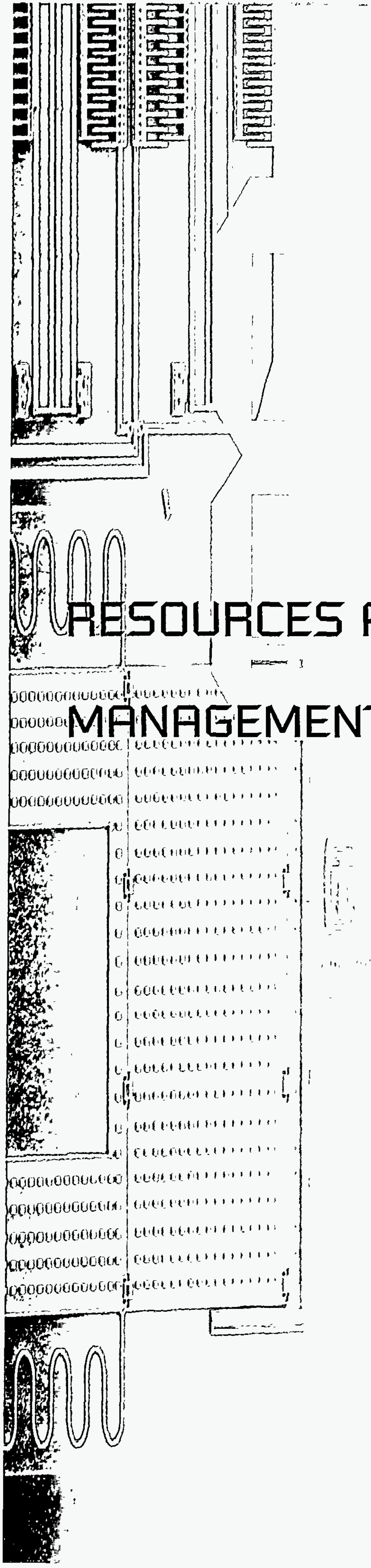
7.3.3 Systems and Policy Analysis

Critical domestic and international infrastructure protection requires early identification and understanding of economic, political, technological, environmental, and social trends that may create serious future threats. The consequences of these trends and of major policy responses must be systematically identified and understood. Early identification of trends, forces, and discontinuities can provide lead time to develop advanced technological solutions.

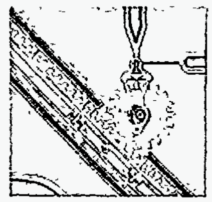
Such systems and policy analysis at Sandia will identify emerging issues related to the surety of critical infrastructure, develop a policy- and technology-based comprehensive understanding of the issues, and identify specific areas in which technology will make a difference. Where appropriate, Sandia's technology will link with domestic and international institutions.

Table 7.3 Funding Requirements for Energy and Critical Infrastructures (Dollars in Constant FY 1998 Millions; Personnel in FTEs)

	Year 1	Year 2
Energy Programs		
Operating	4.0	6.0
Direct Personnel	14	20
Critical Infrastructure Protection		
Operating	2.0	5.0
Direct Personnel	10	25
Systems and Policy Analysis		
Operating	1.0	1.0
Direct Personnel	4	5
Totals for Energy and Critical Infrastructures		
Operating	7.0	12.0
Direct Personnel	28	50



RESOURCES AND MANAGEMENT OF RESOURCES



8.1 People

Sandia's outstanding technical staff, administrative support staff, and skilled labor are the key to our mission success. We strive to attract and retain a diverse world-class work force, to promote inclusion of all employees in achieving Sandia's business objectives and the DOE's strategic goals, and to create a work environment that promotes well-being and job satisfaction. Sandia's vision is to have the best workplace for people and the best performance from people to support "exceptional service in the national interest."

8.1.1 Laboratories Composition

As of September 1998 Sandia had 7,573 regular employees (Table 8.1). This work force includes high-school through graduate-level students, postdoctoral appointees, and people on limited-term assignments. Employees are located in Albuquerque, New Mexico; Livermore, California; the Pantex plant in Texas; the Waste Isolation Pilot Plant in Carlsbad, New Mexico; the Kauai Test Facility in Hawaii; and the Tonopah Test Range in Nevada. In addition, Sandians help support the Yucca Mountain Project in Nevada and are on special assignment in Washington, DC.

Table 8.1. Laboratory Staff Composition (9/25/98)*

	PhD	MS/MA	BS/BA	Other	Total
Professional Staff					
Engineers	663	1,063	219	6	1,951
Scientists	704	462	195	14	1,375
Other Technical Areas	18	162	169	421	770
Management/Administration	29	383	182	187	781
Support Staff					
Technicians	0	18	215	832	1,065
All Other	1	34	150	1,446	1,631
Laboratories Total Staff	1,415	2,122	1,130	2,906	7,573

*These numbers represent an actual head count and are not adjusted for full-time equivalency.

Sandia's work force is tailored to support our enduring national security role and to meet new and emerging technical challenges. Approximately 68 percent of Sandia's employees are in engineering or science-related technical positions and have an average of 14.8 years of service. Most hold college degrees. Other employees work in administrative areas, crafts, and skilled labor. Three labor unions represent about 16 percent of the employees at Sandia/New Mexico.

Skills in demand at Sandia include a wide range of information technology specialties and various engineering disciplines such as electrical and mechanical engineering. Other disciplines include materials science, physics, chemistry, and mathematics—providing Sandia with a broad range of technical capabilities.

8.1.2 Planning and Evaluation

Sandia's Human Resources staff works with line organizations to plan our future. Planning ensures Sandia's continued success and the individual's ability to contribute in a rapidly changing environment. "People," one of the eight corporate strategic objectives, falls in the purview of Human Resources.

Executive management develops Sandia's Corporate Strategic Plan, in which three- to five-year "vital few" goals are established and from which tactical goals are derived for the current year. These tactical goals, cascaded into division and center plans throughout Sandia, are then linked with individual performance goals for the year. Establishing this "line of sight," linking individual performance goals to the Corporate Strategic Plan goals, helps Sandia align personnel with present and future missions.

Human Resources planning and evaluation processes are a continuous cycle in which feedback from internal and external sources is used to monitor progress. Techniques used include analysis of industry best practices, external and internal surveys (many of them web-based), focus groups, self-assessment work force teams, town meetings, and 360-degree feedback for managers. In FY 1999 Sandia will implement the electronic delivery of an employee opinion survey, and feedback will be compared to employee opinion surveys conducted in 1991, 1993, and 1996. Plans will be developed to enhance our work force's ability to excel.

Six performance measures negotiated with the DOE provide the basis for an annual audit of human resource functions. Human Resources received an "outstanding" in the 1997 Business Management Oversight Review. The measures covered progress in the following areas: line ownership of diversity, cost savings and cycle time improvement in the staff augmentation process, implementation of the integrated job structure, demonstration of line of sight through completion of performance management forms, successful union negotiations, and utilization of feedback to improve customer satisfaction.

The Strategic Human Resources Planning Council is a group of Sandia directors commissioned by the Vice President of Human Resources to develop strategies that will prepare Sandia for future personnel requirements. In FY 1999 this council will focus on the requirements for Sandia becoming an employer of choice. A systematic approach will assess Sandia's current status and forecast its desired future, using internal information sources and principal national efforts. The council will benchmark companies considered employers of choice.

8.1.3 Awards and Recognition

Sandia fosters an environment of open communication and appreciation to increase opportunities for employee recognition. An interim compensation program is available throughout the year for team celebrations or to acknowledge exemplary individual contributions. Town meetings, newsletters, and web-based communications are also used to acknowledge achievements. Within specific organizations, a variety of monetary and other recognitions are used.

At the corporate level, four Sandia-wide awards programs are available. The President's Quality Award recognizes teams that have made exceptional contributions by applying quality processes. The Employee Recognition Award honors individuals and teams that have made outstanding contributions to Sandia's technical excellence, exceptional service, and leadership. Honoring Professional Excellence recognizes Sandia employees who have received national or international awards. A service awards program acknowledges employees for every five years of service.

8.1.4 Human Resource Programs

Sandia's human resources programs provide cost-effective services as close as possible to the customer. We apply best business practices in a dynamic environment while complying with the terms of the management and operating contract.

8.1.4.1 Staffing

Sandia's work force is its most valuable asset. We manage the work force by strategic planning that includes analysis of current skills, projection of future skills, and development of strategies to assure that future needs are met. We attract people with the needed skills, retain them and enhance their skills, and inspire them to perform to their full potential through a multiyear management plan.

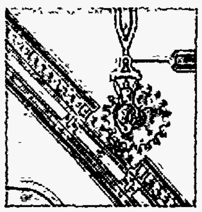
A skills profile data base provides an internal inventory of employee skills. This data base serves as a tool for defining corporate capabilities and matrixing Sandia employees to support new initiatives. The Employee Development Center provides a centralized resource for employees to market their skills for internal reassignment, determine career goals, and make personal development plans. The center sponsors seminars and training programs to help employees prepare resumes and learn interview techniques that will boost employee career growth at Sandia.

Various mechanisms for internal movement keep the work force agile. A post-and-bid system allows regular employees to nominate themselves or be nominated for internal job openings. Web-based applications have streamlined this system. During FY 1997, 1,420 employees changed jobs or organizations via Sandia's internal-movement mechanisms. Sandia has centralized its contracting responsibilities for staff augmentation. Thus, job openings can be matched with Sandians seeking reassignment before filling openings with contractors. Sandia hired 551 contract associates through this process in FY 1997.

External staffing agility maintains our capability to hire world-class talent for critical skill areas. During FY 1997 Sandia hired 143 regular and 96 temporary employees. Sandia has a recruitment and university relations program to attract top-level talent for regular and temporary employment. A variety of student intern programs provides qualified students with an opportunity to expand their career horizons through temporary work-related experience. These programs are a mechanism for Sandia to identify candidates for future regular employment. More than 450 students were hired through these programs in FY 1997.

8.1.4.2 University Relations

Nationwide recruiting efforts focus on leading institutions and their candidates from the physical sciences and engineering disciplines. Each recruiter receives training before visiting campuses to ensure that Sandia is properly represented and that a diverse pool of candidates will be interviewed. All recruiters hold other regular job assignments and recruit on a part-time basis only.



Sandia's existing university relations and campus recruiting programs have been greatly expanded by creation of the Campus Executive Program, which provides enhanced contacts with twenty-five of the top engineering and science schools. Program objectives include establishing high-level relationships with top university officials, linking Sandia's collaborative research with recruiting activities on select campuses, and focusing research collaborations on Sandia's long-term directions. In its first year, Sandia executives are concentrating on establishing relationships with university officials who lead their schools' research and engineering programs.

The Campus Executive Program supports an on-campus recruiting effort to hire persons who will prepare Sandia for the future.

8.1.4.3 Labor Relations

Three labor organizations represent approximately 16 percent of the employees at the New Mexico site. This figure is down 2 percent from 1997, representing a reduction of approximately 130 bargaining unit jobs. The Office and Professional Employees International Union (Local 251, AFL/CIO) represents 470 office and clerical employees. The Atomic Projects and Production Workers Metal Trades Council (AFL/CIO) represents approximately 460 trades employees, operatives, and custodians. The Security Police Association (AFL/CIO) represents approximately 117 uniformed security personnel.

Sandia seeks to balance the interests of the bargaining units and their members with the needs of the business. New labor contracts will be negotiated with the Office and Professional Employees International Union and the Atomic Projects and Production Workers Metal Trades Council in the first half of 1999. The negotiations planning process is well under way and will produce a well-balanced and fair set of proposals to take to the bargaining table.

8.1.4.4 Performance Management

To create a stronger link between employee performance and Sandia goals, we moved from appraising performance to managing performance in 1995. The performance management system establishes measurable goals connecting our strategic plan with business plans and individual jobs. At the beginning of the annual review cycle, negotiations between employees and managers establish and document these goals. Open communication is encouraged through ongoing feedback and a midcycle review that disseminates performance objectives from top management through all levels of the organization, defines and discusses each employee's contribution, solicits feedback from customers and stakeholders, and establishes the context for making compensation and other reward decisions.

In late 1996 the performance management process was modified to incorporate value of contribution and to increase management flexibility. These changes eliminated the need for managers to go through what was previously a separate, organization-specific process to determine an individual's value of contribution. Also in 1996 a performance improvement process was implemented to provide a means for individual employees to improve their value of contribution.

8.1.4.5 Compensation

Sandia's compensation system, which uses the elements of performance management, the structure of work at Sandia, and robust benchmarks with outstanding research and development firms, directly links individual compensation decisions to the value of an employee's contribution. Introduction of the integrated job structure, with its associated job classifications and occupation descriptions, enables more refined comparison to similar positions in the private sector job market. The integrated system allows Sandia to use compensation as an attraction and retention tool, rewards individual contributions that support strategic business objectives, and provides competitive compensation for the skills and knowledge required for Sandia's mission success.

8.1.4.6 Corporate Training and Development

Corporate training, development, and education programs maintain and increase Sandia's technical and business capability; meet mandated and compliance-related training, development, and education requirements; and assist Sandians in preparing themselves for future technological advances.

These programs include a range of products and services that give Sandians job-related training and development opportunities. Courses emphasize business skills and knowledge, software engineering, project management, and compliance-related topics such as Lockheed Martin's ethics training. Employees can access a variety of self-study, computer-based training courses.

To assure mission success, Sandia's future leaders must have a strong foundation of management skills. A four-step business and leadership management development process uses a portfolio of development options, including assessment, planning, implementation, and reevaluation. All candidates for management positions must complete a pre-management curriculum prior to promotion. The New Manager curriculum must be completed within the first appraisal year following promotion. A corporate-wide mentoring program is offered for all employees wishing to establish supportive and learning relationships. A number of Sandia divisions provide mentoring programs under the umbrella of the corporate program. As of March 1998 over three hundred Sandians had participated in the program.

In addition to more than two hundred in-house courses, Sandia offers these degree-related programs:

- the Tuition Assistance Program, which pays tuition for employees enrolled in university continuing education courses;
- the Doctoral Study Program, which pays expenses and stipends for full-time study toward the PhD;
- the One-Year-On-Campus Program, which pays expenses and provides stipends for new employees with bachelor's degrees to study full time for master's degrees; and
- the Distance Learning Program, which provides seminars and full-semester courses via video links to Sandia sites from universities or other locations.

8.1.4.7 Benefits and Medical Services

Sandia's integrated approach to employee well-being provides employee benefits, health care, occupational medicine, emergency medical response, medical surveillance, health promotion, and employee assistance. These services are balanced with careful stewardship of DOE funds and compliance with laws, regulations, and DOE orders. The result is a competitive and cost-effective employee benefits package.

Most of Sandia's health plans are self-funded and administered by vendors selected through a competitive procurement process. Benefits packages are benchmarked against private-sector research and development companies and other DOE management and operating contractors. Employees have a choice of health care options and may purchase increased coverage for dental, long-term disability, and long-term care.

To enhance employee productivity and well-being, Sandia offers an onsite child care resource and referral service, an eldercare resource and referral service, a compressed work week option, an updated leave and part-time work policy, and telecommuting. An employee health promotion program provides assessments, seminars, classes, and special speakers.

Mission-related technical and administrative initiatives include

- an international travel clinic that provides necessary immunizations and destination-specific health information to Sandians traveling abroad;

- a medical emergency response team that provides onsite emergency care for employees and standby capabilities for hazardous projects;
- computerized data files for medical surveillance and a cancer registry to study cancer incidence and mortality;
- a multidisciplinary team of health care providers to enhance the continuity and quality of care given to employees diagnosed with chronic diseases and terminal illnesses;
- medical oversight for the proposed extraction of technetium 99m, a medical radioisotope for use in therapeutic and diagnostic medical procedures;
- a systematic and comprehensive program for protection of human research subjects; and
- a new vacation donation plan that enables Sandians to help colleagues during family emergencies.

8.1.4.8 Diversity Leadership

Sandia's accomplishments in diversity have distinguished us as a leader in the DOE complex, Lockheed Martin Corporation, and the Albuquerque community. Within the last two years Sandia has received national recognition from the American Society for Training and Development and the Lockheed Martin Corporation Human Resources Division. Sandia earned the DOE's 1997 Roadrunner Award for Progress in Diversity.

8.1.4.8.1 External

Over the past five years Sandia has led a series of biannual community forums that brought together 120 community leaders to discuss diversity-related issues. Initially sponsored by the DOE, Lockheed Martin Corporation, and Sandia, this initiative is now led by the Diversity Leadership Council, a group of twenty Albuquerque-area executives representing business, government, education, and the community. The council has produced an online catalog of resources for diversity, a seventeen-minute awareness video, and a quarterly newsletter. The council plans to establish a diversity institute and to continue providing guidance to businesses.

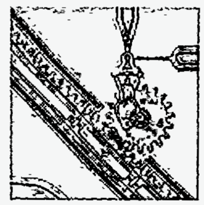
8.1.4.8.2 Internal

Long-term work force diversity strategies within Sandia have involved more than four hundred employees working in three key areas. A corporate diversity team helps develop and implement corporate diversity initiatives, fourteen division diversity councils plan and facilitate programs and events to encourage an inclusive work environment, and diversity champions help accelerate the process of change related to diversity throughout Sandia.

Managing diversity, one of the key competencies included on managers' annual performance management forms, is integral to the targeted development program for managers. Diversity progress reports are distributed to all managers and presented quarterly to the Laboratories Leadership Team. Work force diversity accomplishments for FY 1997 include

- initial planning to transfer ownership and accountability for diversity objectives from the Diversity Planning Department to line organizations;
- design and implementation of Diversity 102, a workshop featuring tools to support high performance and inclusive teaming;
- piloting the managing diversity progress index, which established baselines in two centers and one division; and
- developing a project for managing diversity.

Ownership and accountability for diversity will be transferred to line organizations in 1998 by



- providing strategic leadership from the Corporate Diversity Team;
- coordinating action plan and local awareness events by the division diversity councils;
- expanding diversity awareness training;
- utilizing the managing diversity progress index across the corporation;
- facilitating managerial growth in managing diversity competencies;
- establishing corporate and DOE diversity performance metrics; and
- continuing our community outreach efforts.

8.1.4.9 Equal Employment Opportunity and Affirmative Action

Sandia is committed to achieving an inclusive, high-performing work force that ensures all employees are treated fairly and equitably regardless of race, religion, gender, age, national origin, veteran status, sexual orientation, or disability. This commitment applies to recruiting and hiring; promotion; transfer; compensation and benefits; Sandia-sponsored training, education, and tuition assistance; layoff and return from layoff; and social and recreational programs.

Commitment to nondiscrimination in employment is supported by a complaint process that provides a fair and objective investigation of employee allegations of discrimination. Employees are encouraged to address concerns to management, human resource representatives, Equal Employment Opportunity and Affirmative Action staff analysts, or the Ethics Office. Sandia exceeds the letter of the law by providing additional employee services such as dispute resolution and mediation. Since 1993 the services for resolving certain disputes have been available to all employees through the Corporate Ombuds Office.

Sandia's Affirmative Action Programs create a balanced work force from a broad pool of highly qualified, talented people. Hiring and promotion practices reflect our commitment to improve employment opportunities for minorities, women, individuals with disabilities, disabled veterans, and Vietnam-era veterans. The percentages of minorities and women in the employee population are reviewed and analyzed annually. Goals are set for hiring and promoting qualified minorities and women in areas where they are underrepresented.

Sandia's Affirmative Action Program is implemented by the president, executive vice president, vice presidents, directors, and managers. Each vice president is accountable for actions in support of the Affirmative Action Program. The Laboratories Leadership Team monitors progress through a quarterly review.

Sandia supports affirmative action outreach/inreach committees and Equal Employment Opportunity networking groups. Sandia's six outreach/inreach committees include the American Indian, Asian, Black, Hispanic, Women's Program, and Disabilities Awareness committees. Each committee has twelve to twenty members representing various job classifications and organizations. Committees support women, minorities, and disabled employees in career development and growth and raise Sandians' awareness of cultural, gender-related, and disability issues. Committees ensure that key issues affecting women, minorities, and disabled employees are brought to the attention of management, and they also establish and maintain relationships between community leaders and Sandia. Committee activities include career fairs, conferences, tours, lectures, cultural celebrations, and advisory sessions.

Sandia's 1998 Affirmative Action Program offers detailed profiles of Sandia's diverse work force and documents 1997 accomplishments and 1998 goals. An annual internal review analyzes each component of the Affirmative Action Program, including information relevant to employee compensation and formal charges of discrimination. These assessments identify obstacles to attaining affirmative action goals.

Recommendations from self-assessment reviews are incorporated in operational planning activities, ensuring Sandia's continued commitment to equal employment opportunity and affirmative action.

8.1.5 Education Outreach

Sandia's education outreach programs use our scientific resources to strengthen math, science, and technology education and to enhance public science literacy and work force diversity. Our outreach programs use Sandia's unique scientific expertise and facilities to foster collaborations with local and national academic, government, and industry partners. The major purposes of our education outreach programs are to assist Sandia operations by improving the understanding of technical issues and problems through the education system and to facilitate an understanding of scientific concepts and their relevance to everyday life. These programs support mission success by stimulating students to pursue technical careers in order to maintain our qualified and diverse technical work force, by improving public scientific literacy, and by providing the community with access to unique Sandia resources. A reduction in funding and strategic focus has decreased the quantity of educational initiatives, although the quality remains exceptional.

Our education outreach focus on kindergarten through twelfth grade is recognized throughout the DOE complex. The DOE Defense Programs Critical Issues projects include two professional enhancement initiatives: Science Understanding Promotes Environmental Responsibility, and the Leadership Academy for Science Education Reform. Both initiatives enable kindergarten through twelfth-grade teachers to learn about issues related to DOE Defense Programs challenges. On the Laguna Pueblo in New Mexico, DOE Defense Programs supports the Four Directions Challenge Grant, which integrates a heritage-based culture with kindergarten through twelfth-grade courses that prepare students for a technological future. Sandia has taken the lead in introducing total quality management principles and the Malcolm Baldridge National Quality Award criteria into the New Mexico school system through the Strengthening Quality in Schools Program. To date this program involves twenty-three school districts and more than seven hundred superintendents, principals, teachers, and parents.

At the postsecondary level, Sandia has worked with the University of New Mexico to develop and implement new science curricula for elementary and middle-school teachers. Based on the success of these efforts, Sandia is eager to expand the approach and curricula to other academic institutions. In addition, university student and faculty programs assist Sandia in research activities and provide a valuable resource. At present we focus on three programs: the Student Internship Program; the Scholars in Technology Program; and the University Research Semester Program. These programs have become excellent employment pipelines for Sandia, the DOE, and Lockheed Martin. Because of our wide range of applied engineering and scientific capabilities, Sandia has become a technical internship employer of choice.

Institutional development has become a cornerstone for Sandia's long-term relationships. In the broad area of institutional development, Sandia supports four major projects. The National Security Technologies Collaboration facilitates DOE Defense Programs-related research and development between Sandia and minority universities. After the Oklahoma City bombing, the Architectural Surety Education Collaboration was created to improve the surety of architecture in the event of future terrorist acts. The University Pre-Service Program was created at the University of New Mexico to improve the science and mathematics preparation of kindergarten through eighth-grade teachers. The Advanced Manufacturing for Education Program was established as a collaboration among Sandia, Albuquerque's West Mesa High School, and the Albuquerque Technical Vocational Institute to prepare qualified technicians for Sandia's advanced manufacturing programs.

Reduced fiscal resources have limited our educational initiatives, which now require streamlined operations with greater leveraging through partnerships. However, these outreach programs continue to apply our unique capabilities and resources to enhance Sandia's and the DOE's capabilities.

8.1.6 Community Involvement

To ensure that community leaders and organizations continue to regard Sandia as a responsible, caring, and involved corporate citizen and partner, our community involvement principles are to

- respect the values, culture, and quality of life of our community;
- remember that we and our families are part of the community fabric;
- listen and respond to the needs of our community;
- be participants in realizing the vision of a vital and sustainable community;
- foster mutual understanding and trust through communication and cooperation;
- build effective partnerships with our community; and
- meet present needs without compromising the welfare of future generations.

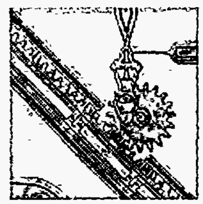
Sandia is actively involved with city and county governments and neighboring communities. Sandia's strategy integrates our people, resources, and technology to improve the quality of life for our employees and our fellow citizens. Sandians are members of many local committees, boards, and organizations. Sandia also maintains working relationships with various city, county, regional, and state agencies.

Sandia operates the congressionally chartered National Atomic Museum for the DOE. The museum, located in Albuquerque, preserves and exhibits the history of the nuclear age. Exhibits focus on nuclear defense but include peacetime uses of nuclear energy and nuclear science. The museum also maintains a library and photographic archives. Approximately 130,000 persons, including 23,000 local students, tour the museum annually.

Sandia's involvement with businesses, educational institutions, community associations, elected officials, and city, county, and state agencies is based on effective communication, cooperation, and mutual trust. This network enables us to identify emerging issues, analyze them for potential opportunities or impacts on Sandia, and determine the best course of action. When appropriate, Sandia's specific applicable technology is linked to these issues.

The Sandia Volunteers Program places Sandia volunteers (current or retired employees and family members) in activities that benefit surrounding communities and support Sandia objectives. Contributions by Lockheed Martin Corporation are strategically allocated to nonprofit organizations and activities that complement Sandia's overall objectives in education; health and human services; and civic, volunteer, and cultural areas. Some contributions emphasize education in mathematics, science, and technology. Others aid specific philanthropic activities (e.g., Shoes for Kids). Education outreach activities involve Albuquerque Public Schools Foundation, Strengthening Quality in Schools, Character Counts, Junior Achievement, and science and math programs designed to mentor Hispanic, Native American, and African-American students. The Public Involvement Program fosters open, honest, and timely communications with the public to build cooperation and trust.

Sandia's Supplier Partnerships Program matches Sandia's needs for products and services with suppliers who can provide high-quality products and services that are timely and cost-effective. The Supplier Partnerships Program works with the business community to facilitate access to Sandia.



Sandia/California's community outreach work supports community programs that help develop relationships specific to the Livermore community and that fit Sandia's strategic intent. Each year California volunteers participate in the United Way Week of Caring and the Holiday Spirit Drive. The California site uses its portion of the Lockheed Martin corporate contribution to support projects like Crayons to Computers and the Multicultural Festival. California works with local school districts in the areas of math and science by conducting a Science Bowl, participating in science fairs, upgrading and networking classrooms, and giving classroom presentations and demonstrations.

Students from Livermore High School participate in a Sandia-sponsored education conference.

8.2 Designated Capabilities, Technology Deployment Centers, and User Facilities

8.2.1 Designated Capabilities

When industry wants Sandia to provide services covered by a designated capability statement of work, we can place a work agreement in one to three weeks, depending on negotiations with the sponsoring partner. Even though use of preapproved DOE statements of work is restricted to industry, federal agencies may access Sandia's designated capabilities through the DOE Work for Others Program. DOE-approved Sandia designated capabilities are listed below.

8.2.1.1 Advanced Batteries Research, Engineering, and Evaluation

This capability provides technical assistance in the design and development of advanced energy storage devices and materials, testing and evaluation of battery cells and systems, and fabrication of prototype batteries.

8.2.1.2 Archimedes: Computer-Aided Geometric-Based Assembly Optimization

Archimedes, a planning and visualization software tool, streamlines an assembly process by taking data from computer-aided design programs and quickly generating visual output of the most efficient assembly sequence. Output can be in the form of a video loop or graphic display on a workstation screen or videotape. The sponsor defines assembly process constraints or quality metrics, and Archimedes automatically determines alternative assembly sequences satisfying those specifications.

8.2.1.3 Assembly Test Chips

This capability provides training, documentation of chip design, and test chips. Sandia will provide test chips in the requested chip configuration and train sponsor staff to gather and interpret test chip data.

8.2.1.4 Center for System Reliability

This capability provides access to a proven systems approach to reliability, including design-for-reliability; reliability modeling and analysis; training and optimization techniques; predictive maintenance; infrastructure reliability modeling and analysis; network reliability improvement; and independent assessment and qualification.

8.2.1.5 Class in CTH

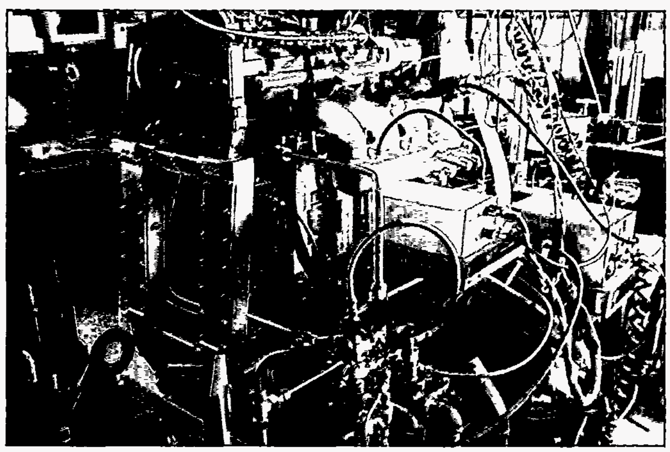
This is a three-day class on the capabilities and use of CTH, the Sandia-developed high-strain-rate and large-deformation continuum mechanics software package. Instruction includes a series of lectures on the use of CTH and hands-on assistance in applying CTH to problems of interest.

8.2.1.6 Design, Evaluation, and Test Technology

This capability provides full test engineering and analysis support for component and system testing. Available environments range from normal use to extreme accident conditions. Diagnostics include nondestructive testing, photometrics and optics, and electronic data acquisition. Tests range from characterization of circuit board solder connection strength to full-scale impact testing of transport vehicles.

8.2.1.7 Engine Combustion Issues

This capability supports tasks related to engine combustion efficiency and emission formation in the following areas: port fuel injection gasoline engines; direct injection gasoline engines; heavy-duty diesel engines; high-speed, direct-injection diesel engines; diagnostic development; and fuels evaluation.



Sandia's Port Fuel Injection Research Engine is designed for optical studies of port fuel injection and combustion processes.

8.2.1.8 Geo Center Flow Visualization Laboratory

This capability is used to investigate basic and applied experimental designs and numerical simulations of fluid flow and transport in natural or manufactured porous and/or fractured media in a variety of scales from laboratory to field experiments.

8.2.1.9 Geomechanics Research, Development, and Applications

This capability provides expertise, facilities, and equipment in geomechanics research, development, and applications to identify and model deformation and failure processes in rocks and other related porous, pressure-sensitive materials (such as ceramics and composite materials). Sandia also offers characterization, measurement, and modeling of thermal, thermal-mechanical, and transport processes in competent rock strata, natural fractures, and other related materials, including studies of coupled effects.

8.2.1.10 National Solar Thermal Testing

This capability is used to develop and test solar thermal components and systems, conduct thermal testing under intense heat flux, and perform optical experiments for astronomy and laser applications for sponsors in the commercial sector.

8.2.1.11 Photovoltaic Systems Support

Support includes technical assistance, development, fabrication, testing, evaluation, and modeling of photovoltaic systems and components to support industrial implementation of the technology.

8.2.1.12 Physical and Chemical Sciences

Capabilities in this area span the fields of semiconductor physics, electronic materials, nanostructures, surface physics and chemistry, plasma and chemical processing, lasers and optics, pattern recognition, remote sensing, ion/solid interactions and effects physics, and advanced materials sciences. In this area Sandia employs a wide range of multidisciplinary capabilities based on the physical and chemical sciences, from first principles modeling and atomic-scale measurement to remote laser sensing and new approaches to pattern recognition.

8.2.1.13 Plasma Materials Testing

This capability provides high-heat-flux testing and evaluation of fusion components and advanced modeling of plasma/material interactions using high-power electron beams to generate high-heat fluxes that simulate fusion reactor environments.

8.2.1.14 Primary Standards Laboratory Work

This capability includes the development and evaluation of measurement standards, systems, techniques, and procedures; certification of standards; measurement assurance programs; technical assessments; measurement uncertainty analyses; technical consultation; and training of metrologists.

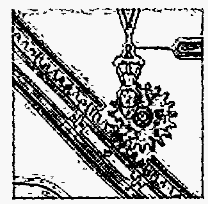
8.2.1.15 Pulsed Power Reactor Testing

Capabilities include neutron and gamma irradiation of various electronic devices from government weapons programs, documentation of radiation-damage effects, and evaluation of irradiated devices to determine degradation in performance.

8.2.1.16 Pulsed Reactor Capabilities

Various electronic devices may be irradiated at the Sandia Pulsed Reactor Facility, the Low-Dose Gamma Irradiation Facility, and the Gamma Irradiation Facility. The effects of these irradiations are then documented by the Radiation Metrology Laboratory.

8.2.1.17 Subsurface Environment



This capability evaluates environmental problems that relate to contamination of the subsurface and thus may threaten the long-term integrity of water resources. Present tasks include technology development and testing, with field-scale and pilot testing at real sites.

8.2.1.18 Switch Tube Technology

This capability provides product and process design using our product family of arc-discharge vacuum switch products, including the Poco Sprytron design. Two laboratories are dedicated to the development and applied research of arc-discharge switching device technology and will perform high-rigor and other fabrication and test work.

8.2.1.19 Underground Storage Technology

This capability provides advice and assistance for underground storage technology, including extremely large structural analysis simulations of storage cavern arrays, analysis of the complex dissolution kinetics of cavern creation, and design analysis of plugs and seals for long-term performance.

8.2.1.20 Unique Sandia Systems Applicable to Specific Environmental Problems

This capability addresses global problems in environmental remediation. Tasks include systems sensitivity analysis methodology, integration of technical and public policy concerns, physical modeling and simulation, and risk assessment methodology.

8.2.2 Technology Deployment Centers / User Facilities

Technology deployment centers/user facilities are a unique set of scientific research capabilities and resources primarily intended to satisfy DOE programmatic needs but which are accessible to private sector users through reimbursable user-facility agreements. Even though user-facility agreements are restricted to industry, federal agencies may access them through DOE Work for Others agreements. Sandia's technology deployment centers/user facilities are listed below.

8.2.2.1 Advanced Batteries Engineering Facility

This New Mexico facility designs, prototypes, tests, and evaluates energy storage systems.

8.2.2.2 Center for Security Systems Evaluation

This New Mexico center designs, tests, analyzes, and evaluates security equipment and related systems.

8.2.2.3 Combustion Research Facility

This California facility studies combustion processes ranging from those inside internal combustion engines to combustion-generated pollutants in the environment.

8.2.2.4 Component Modeling and Characterization Laboratory

This New Mexico laboratory models and characterizes electronic and electromechanical components.

8.2.2.5 Design, Evaluation, and Test Technology Facility

This New Mexico facility uses numerous specialized technologies to design, document, evaluate, and test the response of items ranging from components to full-scale systems in simulated use or abnormal environments.

8.2.2.6 Electronics Technology Facility (Microelectronics Development Laboratory)

This New Mexico facility develops, evaluates, and fabricates various microelectronics applications in a Class I clean room.

8.2.2.7 Electronics Quality/Reliability Center

This New Mexico center is used for reliability and failure analysis of electronic components ranging from cables and connectors to high-speed integrated circuits.

8.2.2.8 Engineering Sciences Experimental Facility

This New Mexico facility contains numerous specialized facilities, including laboratories for thermal/fluid science experiments and diagnostics, high-bay work areas for large-scale experiments, aerosciences facilities, and the Sandia parachute laboratory.

8.2.2.9 Explosives Components Facility

This New Mexico complex has a full range of specialized facilities to study energetic materials and components. The Shock Technology and Applied Research Facility is part of this complex.

Sandian Marc Hagan points to an explosion mark in a blast chamber at the Explosives Components Facility during "take our daughters to work day."

8.2.2.10 Facility for Acceptance Calibration and Testing

This New Mexico facility, operated by Sandia's Monitoring Technologies Department, tests and calibrates seismic verification systems and sensors. The facility is located in a remote area of Kirtland Air Force Base where users can operate without disturbance to other programs. The site was recently upgraded and will be supported by DOE/NN-20 programs in future fiscal years.

8.2.2.11 Geomechanics Laboratory

This New Mexico laboratory characterizes pressure-sensitive materials, rocks, and concrete.

8.2.2.12 Intelligent Systems and Robotics Center

This New Mexico center applies intelligent systems and robotics technologies to areas such as manufacturing, environmental cleanup, weapons production and dismantlement, and biomedicine.

8.2.2.13 Ion Beam Materials Research Laboratory

This New Mexico laboratory uses ion-beam analysis to examine a wide spectrum of materials from semiconductors to metals and ceramics.

8.2.2.14 LAZAP (Laser Applications)

This New Mexico facility includes a large Cassegrain beam director/telescope and several high-power lasers along with control, tracking, and safety equipment. The telescope can track satellites from low-earth to geosynchronous orbits and can also perform fixed-pointing and sidereal-rate tracking.

8.2.2.15 Manufacturing Technologies Center

This New Mexico center provides analysis tools for research and development of manufacturing sciences and processes.

8.2.2.16 Mechanical Test and Evaluation Facility

This California facility supports material, structural, and climactic testing; agile manufacturing; nonlinear constitutive thermomechanical modeling; and a wide range of test and evaluation laboratories.

8.2.2.17 National Solar Thermal Test Facility and Design Assistance Center

This New Mexico facility conducts tests requiring intense heat by collecting light using large-scale optics. Specific high-thermal-flux applications include investigating the thermophysical properties of materials and testing various solar applications. The Solar Central Receiver Test Facility is part of this center.

8.2.2.18 Photovoltaic Sciences Facility

This New Mexico facility offers advanced measurement, test, design engineering, evaluation, and production of photovoltaic components and systems.

8.2.2.19 Plasma Materials Test Facility

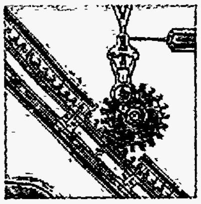
This New Mexico facility provides high-heat-flux testing and design and evaluation of plasma-facing and other high-heat-flux components.

8.2.2.20 Primary Standards Laboratory

This laboratory for calibration standards, devices, and facilities has elements in both California and New Mexico.

8.2.2.21 Pulsed Power and System Validation Diagnostics Facility

This New Mexico facility offers pulsed power accelerators, laboratories, lasers, remote sensing, advanced computation, and diagnostics suited to hostile environments.



8.2.2.22 Nuclear Spectroscopic Testing Facility

This California facility offers comprehensive, sophisticated detector-array and imaging system characterization. Capabilities include specialized analysis of detector-grade crystals and x-ray detector response. The Radiation Detector Test Facility is part of this facility.

8.2.2.23 Sandia Orpheus Site

This New Mexico test site and mobile geothermal research laboratory is used to develop and evaluate methods for employing acoustic waves in deep wells.

8.2.2.24 TIE-IN Scientific and Engineering Applications

This New Mexico facility offers direct remote computer access to Sandia's software, data bases, rapid prototyping equipment, and test and diagnostic equipment.

8.2.2.25 Virtual Laboratory Testbed

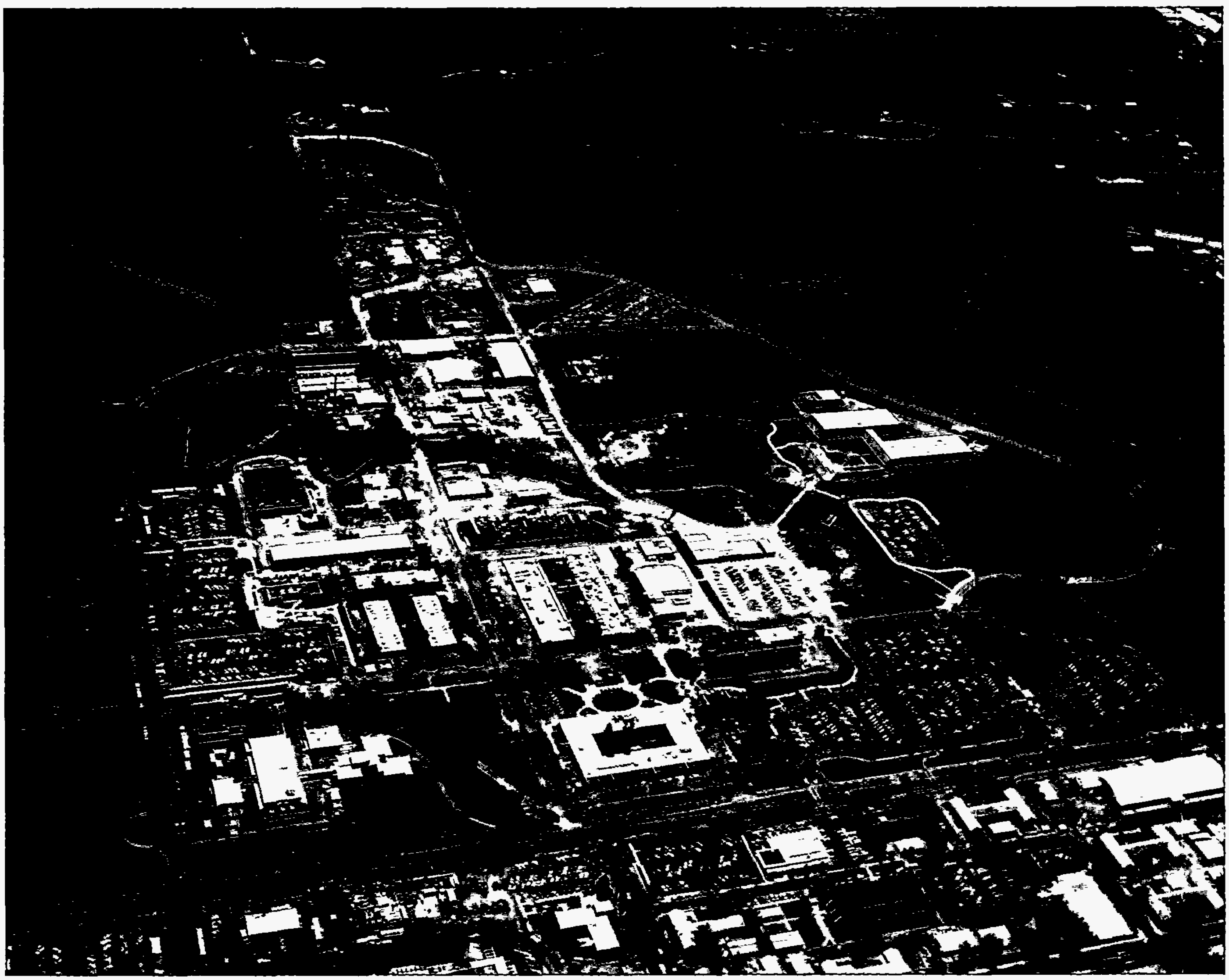
This California facility is shared by Los Alamos, Lawrence Livermore, and Sandia national laboratories. The virtual laboratory provides advanced information and computing resources that directly support the national information infrastructure and offer access to performance and interoperability testbeds.

8.3 Sites, Facilities, and Infrastructure

Sandia's facilities are an integral part of our capabilities. Our executive management offices and larger laboratory complex are located on Kirtland Air Force Base in Albuquerque, New Mexico. This 17,832-acre site is composed of five technical areas and an outdoor testing field. The site benefits from its proximity to other major defense laboratories and testing facilities, universities, and high-technology industry. The Sandia complex in Livermore, California covers 413 acres. This site benefits from its proximity to world-class research universities and the high-technology environment of the region.

In most cases, Sandia's facilities are multipurpose, which further enhances our ability to perform program work efficiently and cost effectively. Our facilities meet environment, safety, and health requirements to such an extent that planning and performing work are greatly simplified.

Sandia has a variety of special-purpose test facilities that are used for a range of defense and nondefense research and development activities. Our computing facilities support concurrent research, development, and engineering activities and the simulation and modeling of complex phenomena. A network and communications infrastructure provides ready access to Sandia's supercomputers and storage servers from both the California and New Mexico locations and from their distributed networks. Robotics laboratories are used to develop prototype advanced



Sandia National Laboratories, Livermore, California.

systems with application to DOE weapons production efforts. These applications include nuclear weapons dismantlement mandated by the Strategic Arms Reduction Treaty and retrieval and repackaging of radioactive wastes. Sandia's unique environmental testing facilities are used to subject components and systems to a wide range of extreme environments. Nuclear reactor facilities are used to simulate internal environments of power reactors and to evaluate the effects of nuclear weapons on components.

Sandia also has the largest pulsed power complex in the world. This complex provides energy concentrations for testing the nuclear vulnerability of weapons, conducting inertial confinement fusion studies, and studying atomic physics in the x-ray region.

Dedicated facilities and test equipment at the DOE's Pantex plant in Amarillo, Texas are used for quality assurance and stockpile evaluation operations.

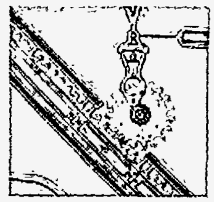
Some activities involve partnerships with universities, industries, and other laboratories in developing technologies of mutual interest that also have national security applications. Support for these partnerships may be provided in unclassified Sandia facilities or in facilities developed by land use planning with city, county, state, and other agencies. Sandia continues to enhance site accessibility while protecting classified information.

Site utilization will be enhanced by the environmental restoration efforts at Sandia's New Mexico and California sites. At the current budget and on the current schedule, Sandia's New Mexico site will be clean by the end of FY 2002; that is, site characterization will have been completed (sites either will require no further action or will have been cleaned). This process has already been completed at Sandia's California site.

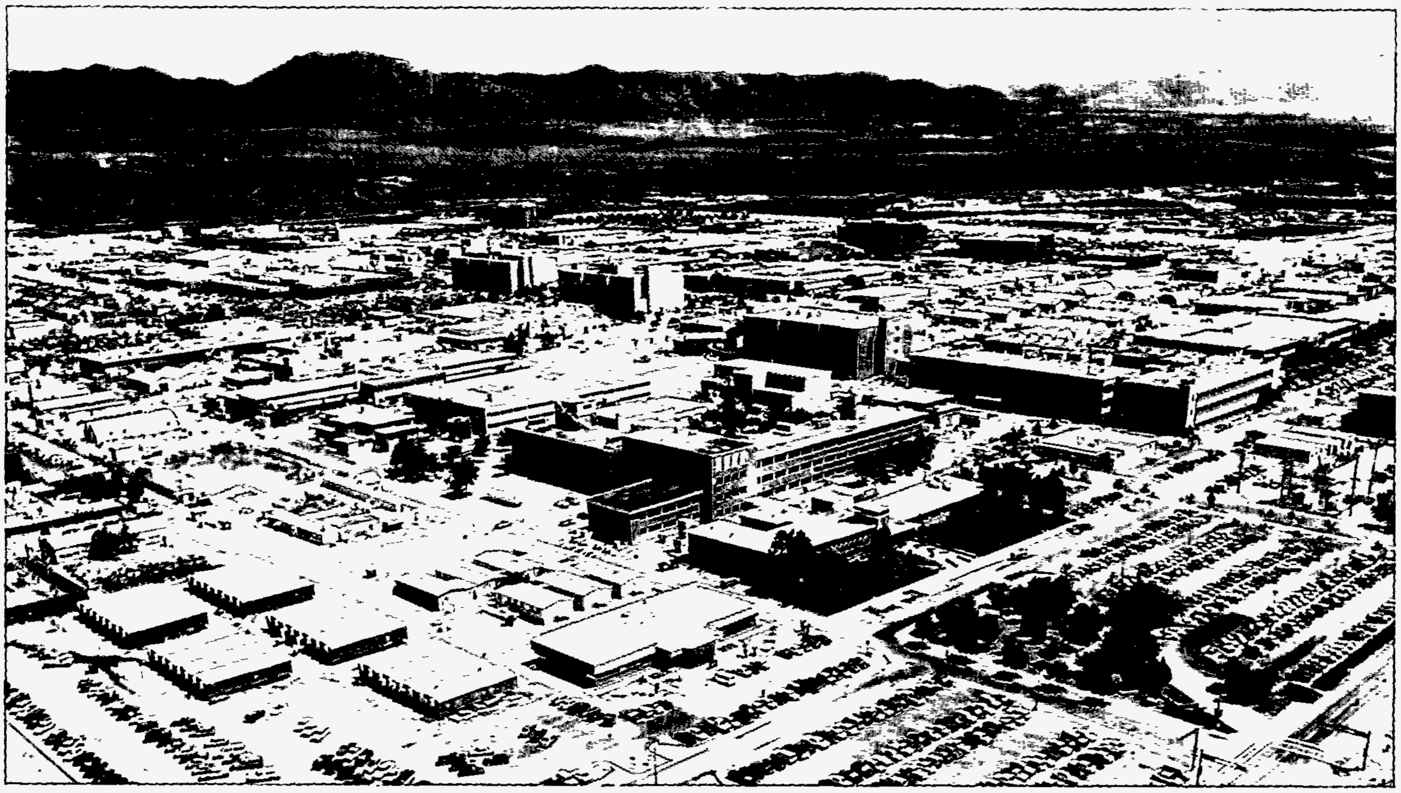
8.3.1 Facilities Plans and Options

8.3.1.1 Site Stewardship

Sandia's sites and facilities are a strategic asset of the United States, and we are responsible for the taxpayer dollars entrusted to us. Therefore, our first priority is to assess issues that could impact critical programs while we minimize environmental and economic impacts. Sandia's comprehensive planning will provide efficient and cost-effective transitions through anticipated and unanticipated events.



The Corporate Sites Planning Council is a corporate-level working group tasked with integrating a ten-year vision of mission- and support-specific strategies into proposed projects that will improve capability and capacity. The council also enacts other strategic objectives. This council supports both tactical and strategic planning for site and physical assets in support of planning mission requirements. Through this



Sandia National Laboratories, Albuquerque, New Mexico.

process, Sandia's requirements are prioritized more effectively and limited resources are applied to highest priority needs. The recommendations of the Corporate Sites Planning Council are reviewed by Sandia's Capability/Capacity Council for endorsement before project development begins.

Sandia will develop and sustain its facilities as strategic assets to ensure that they are managed cost effectively to support Sandia's strategic missions. The Facilities Business Unit, responsible for facilities management, defines its stewardship role as preserving existing capabilities and maintaining Sandia's assets for the long term. The sites, facilities, and infrastructure will be maintained in fit-for-use condition to support programmatic goals and objectives. Responsible stewardship is achieved by soliciting input from the sectors and programs concurrently with the customary life-cycle asset management process.

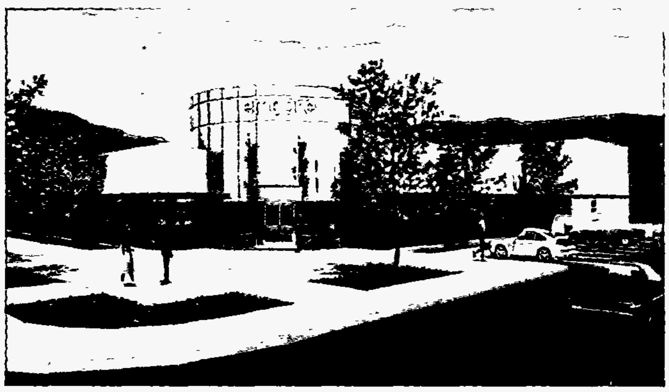
Three major processes have been adopted for facilities management: sustaining existing space, managing strategic space, and maintaining and operating the utilities and infrastructure to support the buildings and programmatic operations for the corporation. Sustaining existing space entails integrating work processes necessary to operate, maintain, and modify facilities to reflect present and projected near-term use (as bounded by strategic space plans and as required for corporate needs). Managing strategic space entails integrating work processes that plan for, retrieve, assign, modify, dispose, acquire, and deliver space according to corporate and organizational needs. Providing and maintaining safe and efficient sites, utilities, and infrastructure completes the facilities management element.

The three major goals of facilities management are to maximize customer satisfaction, minimize life-cycle costs, and reduce overall costs for operation and maintenance of facilities and infrastructure. To achieve these goals a facilities subsite management process will provide a single point of contact for line customers. Internal lease agreements will document operational dependencies on specific facilities and provide the business unit with a better understanding of customer needs. The level of service required is determined through these agreements. To reduce overall operation and maintenance costs, the facilities will no longer be serviced uniformly across the complex. The level of service will depend on the priority of the program and the relative dependence of the program on the supporting facilities and utilities infrastructure.

Another process being implemented to reduce overall utilities operation and maintenance costs is consolidation of the work force into underutilized space that is in good or better condition. Organizations doing potentially synergistic work will be located together. This process will reduce reliance on temporary, substandard, and offsite leased space.

Because of Sandia's work with hazardous and radioactive materials, all space in structures returned to the indirect program inventory is assumed to be contaminated until sampling proves otherwise. Contaminated buildings will undergo decontamination and asbestos abatement under the direction of program and project managers who coordinate facilities planning and construction through the Corporate Sites Planning Council. An oversight committee of environment, safety, and health personnel will monitor, review, and approve the decontamination process. At the Sandia/New Mexico site, this work has focused on the north part of Area I and all of Area II. Planners are reviewing the California site for future decontamination and demolition projects.

The availability of land for expansion is a concern at both the New Mexico and California sites. Kirtland Air Force Base surrounds much of the New Mexico site, and we proactively manage the relationship with the US Air Force to maintain strategic and operational alliances and capabilities. Sandia representatives have increased their involvement with the planning, development, and use of adjoining properties to assure that Sandia's interests concerning space for partnership development and buffer areas are addressed.



The EMCORE building is the first resident of the Sandia Science and Technology Park located on land adjoining Kirtland Air Force Base.

Sandia will effectively manage risk using a graded approach rather than the traditional zero-risk approach. Linking the Sites Comprehensive Plan with the Enterprise Information Plan, the Integrated Safety Management System, and the Site-Wide Environmental Impact Statement will provide an integrated infrastructure planning tool for safe and efficient asset management at reduced cost.

8.3.1.2 Future Use Planning

A DOE directive requires that all DOE land and facilities be managed as valuable national resources. In response to the directive, a working group was established for the Kirtland federal complex. The group includes representatives from the DOE and its affiliates, Kirtland Air Force Base, the New Mexico Environment Department, the US Environmental Protection Agency, the US Forest Service, and a neutral facilitator. The working group prepared summary information on the sites to support the Citizens Advisory Board formed for the purpose of identifying and recommending future use options to DOE Headquarters, A site summary was provided to the Future Use Project Office at DOE Headquarters, and input to the Citizens Advisory Board continues.

8.3.1.3 Facilities Maintenance

Sandia provides a Maintenance Program for all DOE real property used by Sandia. The services are provided in a cost-effective manner so that facilities are managed in a manner that supports programmatic missions and promotes operational safety, worker health, environmental protection, and property preservation. In addition, operation and maintenance strategies include a system of preventive and predictive maintenance and the use of life-cycle costing in all programmatic project decisions.

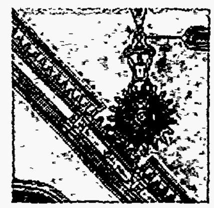
Sandia's utilities operations and maintenance costs are customarily related to replacement plant value. The usual cost of operation and maintenance ranges from 2 to 4 percent of the replacement plant value.

Mike Hessheimer and Vincent Luk, from Sandia's Nuclear Energy Technology Center, examine a scale model of a nuclear reactor containment vessel before a high-pressure test.

In FY 1997 Sandia's operating and maintenance costs were 3 percent of the replacement plant value; however, the backlog of essential maintenance was above desirable levels. As a result, maintenance is being managed to stabilize the backlog rate.

The Sandia/New Mexico Nuclear Facility Maintenance Implementation Plan was written in response to the requirements of DOE Order 4330.4B, "Maintenance Management Program," and is an annex to the Sandia/New Mexico Site Action Plan. The objective of the implementation plan is to achieve a balanced combination of written guidance, personnel skills, and supervision to establish and maintain a quality maintenance program that optimizes critical system and equipment performance. This plan addresses the responsibilities of Sandia organizations to the maintenance program.

The Nuclear Facility Maintenance Implementation Plan establishes responsibilities for nuclear facility maintenance activities relating to the Operations and Engineering Center and the Nuclear Energy Technology Center. Processes for real property maintenance activities are established to meet the intent of this plan. The maintenance of programmatic property and equipment is part of each organization's operating responsibilities and is assigned to the line organizations.



8.3.1.4 Energy Management

Sandia's formal Energy Management Program ensures efficient management of energy and utility costs. The program is managed by the Maintenance Planning Department of the Facilities Management Center.

The Energy Management Program implements performance-based management activities to meet the requirements and goals set forth in DOE Order 430.2, which was accepted into the Sandia Directives baseline in December 1996. Among these goals is a reduction of energy use per gross square foot of facilities space against an FY 1985 baseline. This goal is incorporated in the appraisal agreement between Sandia and the DOE and is evaluated annually to help Sandia better manage its operating costs. Sandia's Energy Management Program also

- implements and updates our short- and long-range Energy Management Plan,
- reports energy consumption for all fuels, aided by a new metering system,
- provides consultation on energy conservation reports for new facilities,
- provides technical support for utility billing and space charge-back,
- conducts energy awareness activities, and
- manages DOE-funded studies and retrofit projects.

8.3.1.5 Condition Assessment

The Sandia Condition Assessment Survey of critical and important facilities and systems began in FY 1993 using pilots developed by the DOE. Full condition assessment of real property capital assets began in FY 1995, and the inspections were completed in 1996. The results were incorporated in the Facilities Information Management System and the Sandia Sites Comprehensive Plan, making the information available to DOE Headquarters, field offices, and sites.

Because DOE Headquarters discontinued direct funding for condition assessment surveys, a graded approach is now used to estimate activity level. Results of the condition assessment surveys (with a yearly deterioration factor applied) will continue to be used to gauge the condition of Sandia facilities. Until the need for another full inspection is determined, systems engineers, building managers, operators, and mechanics will be relied on to provide input as part of the process for life-cycle asset management and meeting programmatic needs.

8.3.2 General Purpose Facilities Plans

8.3.2.1 General Purpose Plant Requirements

The funding of general plant projects is critical to the DOE's management of its facilities and to safe and reliable facility operations. In previous years, general purpose plant projects used capital funds, which were between 1.0 and 1.5 percent of total operating funds. General plant projects and capital equipment can now be merged with operating funding to expedite the allocation of resources for operating, maintenance, and other infrastructure activities and to ensure that Sandia operations are efficient and cost effective. This merger provides Sandia with flexibility to determine the amount of general plant project and capital equipment funding needed to maintain our infrastructure and to respond immediately to changes in requirements. The FY 1998 Defense Authorization Act increased the funding limit for general plant projects from $2 million to $5 million effective 18 November 1997.

In previous years, the limited amount of general plant projects funding and the need to maintain essential infrastructure systems led the National Security Sector to restrict use of those funds to infrastructure and infrastructure-like projects. Beginning in FY 1999, the sector is providing additional general plant projects funding in support of both the Stockpile Stewardship and Stockpile Management programs, and general plant projects will again reflect a balance between sector programmatic needs and site infrastructure needs. Even with the additional sector funding, not all general plant projects can be funded. However, organizations can reprogram operating funds to general plant projects to meet their programmatic requirements.

The process to identify, prioritize, and develop general plant projects includes brief project summaries in standard format for all submittals so that projects can be compared on an equal basis. A criteria-based scoring system for prioritizing submittals, developed to compare the merits of project proposals, uses these criteria:

- impact on our ability to meet Sandia and DOE missions if the project is not performed;
- a qualitative cost/benefit analysis; and
- potential effects of outstanding issues on cost, schedule, performance, or project viability (such as permitting requirements, environmental restoration issues, and National Environmental Policy Act issues).

8.3.2.2 General Purpose Equipment Requirements

General purpose equipment is used in laboratory administrative and management activities. Funding is provided by applying a surcharge of 10 percent on DOE capital equipment and 0.5 percent on non-DOE funding.

8.3.3 Inactive Surplus Facilities Plan

We have received no funding for the Surplus Facilities Inventory Assessment effort, and we expect none.

Sandia has inventoried its major buildings (those with more than three thousand net square feet) and primary programmatic occupants. We found that major buildings house multiple programs that change often. All buildings were inspected for condition of structure and major systems under the Condition Assessment Survey Program. Because many buildings are more than forty years old, those in the worst condition are being scheduled for demolition using the integrated planning effort described above. The remaining occupied buildings are being evaluated to determine the most cost-effective maintenance method.

Sandia is engaged in a consolidation effort to reduce total space and maximize use of existing space. However, instead of immediately consolidating programs and declaring vacant space surplus, we are examining the facility assets in conjunction with a sitewide effort to support present and anticipated missions. Facilities identified as having no further programmatic use will be taken out of service and removed from the laboratory inventory. In conjunction with the space consolidation initiative, substandard mobile and temporary facilities are being identified for cleanup and removal.

8.3.4 Facilities Resource Requirements

Although Sandia's goal is to achieve an overall net reduction in space, some test laboratories are being upgraded and new ones are being proposed. New construction projects will address missions that cannot be accommodated in existing or modified facilities. Other projects accommodate changing functions and requirements.

Environment, safety, and health concerns are actively addressed in planning for all facilities. Accordingly, the design features of all new buildings and major renovations are reviewed internally and by the DOE. In the area of environmental protection, the DOE now requires that contractors comply with the provisions of the National Environmental Policy Act and other relevant environmental laws. For each new facility and major renovation, Sandia prepares an environmental checklist/action description memorandum for the DOE. If the DOE requests further documentation, an environmental assessment or environmental impact statement is prepared and made available to the public.

Projects required to meet environmental laws, regulations, and DOE orders are included in Sandia's Five-Year Plan for Waste Management Operations and Environmental Restoration. The DOE also requires a safety review of new construction projects and major renovations.

8.3.5 Sandia Facilities Investment Strategy

The principal goals of Sandia's construction plan are to provide facilities needed to achieve programmatic objectives, eliminate substandard conditions, replace temporary space with permanent facilities, and eliminate space and facilities in excess of Sandia's mission needs. The compressed line-item process, a partnership initiative endorsed by the DOE Kirtland Area Office and the Albuquerque Operations Office, has been submitted to DOE Headquarters. If approved, this initiative will change the milestones for this process. Milestones and deliverable dates are subject to further negotiation between Sandia and the DOE.

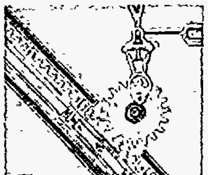
The Sandia Facilities Investment Strategy is proposed within the guidelines of an agreement among the three weapons laboratories, which results in an annual average DOE Defense Programs budget of $47 million over the planning time frame. This DOE Defense Programs budget consists of

- $30 million in Stockpile Stewardship and $5 million in Stockpile Management for line-item projects;
- $5 million in Stockpile Stewardship and $3 million in Stockpile Management for general plant projects; and
- $4 million in Stockpile Stewardship for demolition and renovation.

In addition to the budget above, we have an indirect corporate infrastructure budget of $8 million. This results in a total Sandia investment strategy of approximately $55 million a year over the planning time frame.

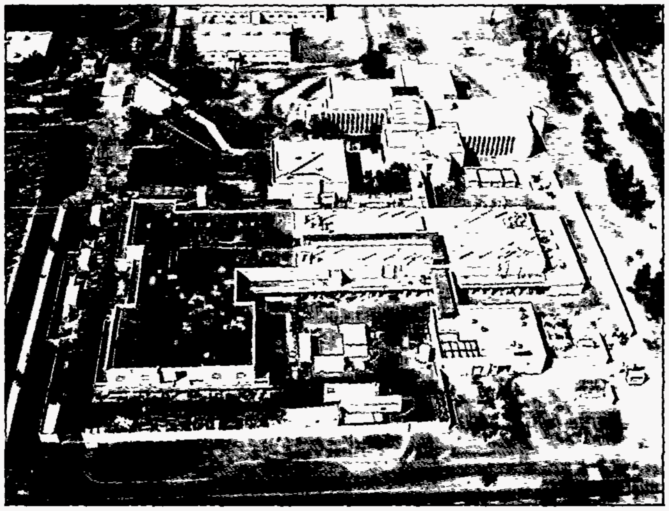
Major construction projects through FY 2004 are briefly discussed below; each includes the anticipated first year of funding and the funding source. The four non-Defense Programs projects are in addition to the budget given above. A number of major alteration projects with a price range of $150,000 to $4 million are being performed using expense funds.

8.3.5.1 Combustion Research Facility, Phase II (California)



This facility will provide specialized resources, including state-of-the-art laser diagnostic systems, to address combustion-related research needs for the next decade. In addition to enhancing basic research, the facility will enable research on new generation automotive engines and will advance industrial processes by improving energy efficiencies and minimizing air pollutants.

The first year of funding was FY 1997 and the funding sources are DOE Energy Research and Basic Energy Sciences.



Phase II construction is well under way at the Combustion Research Facility at Sandia/California.

8.3.5.2 Molybdenum 99 Facility (New Mexico)

The molybdenum 99 project will develop a second source for this radioactive isotope, which has widespread medical application. The facility will supplant the only operating plant in the western hemisphere (in Canada). The long-range viability of the Canadian plant is in question, and reactor shutdown is anticipated. The molybdenum 99 project will convert Sandia's Annular Core Research Reactor for production of the radioisotope. In addition, modifications to Sandia's Hot Cell Facility will be required to process irradiated targets as they are received from the Annular Core Research Reactor. Completion is projected for December 1999.

The first year of funding was FY 1998 and the funding source is nonfederal entities.

8.3.5.3 Storm Drain, Sanitary Sewer, and Domestic Water System Modernization (New Mexico)

This project will rehabilitate, expand, and improve sanitary sewers, storm drains, and domestic water systems. The improvements will prevent soil and groundwater contamination, increase flood protection, reduce the programmatic risks of systems failures, and minimize operating and maintenance costs.

The first year of funding was FY 1998 and the funding source is DOE Stockpile Stewardship.

The Storm Drain, Sanitary Sewer, and Domestic Water System Modernization Project will increase flood protection.

8.3.5.4 Rapid Reactivation (New Mexico)

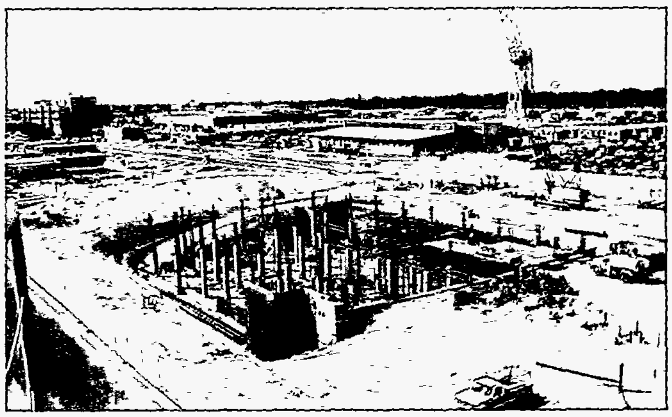
The nonnuclear reconfiguration project was initiated to downsize the nonnuclear manufacturing component of the nuclear weapons complex while maintaining production capacities at a certain level. This weapons stockpile management project is intended to support the increase in requirements at Sandia associated with the new DOE directive schedule that calls for component production rates that are considerably higher than the capacity designed under the Nonnuclear Reconfiguration Program.

The first year of funding is FY 1999 and the funding source is DOE Stockpile Management.

8.3.5.5 Process and Environmental Technologies Laboratory (New Mexico)

This construction item is part of the nuclear weapons research, development, and testing facilities revitalization project. The Process and Environmental Technologies Laboratory will be used for DOE Defense Programs research and development. The laboratory will include office space for personnel associated with transportation of hazardous materials, detoxification, site restoration, and burial of hazardous materials. These activities will directly support DOE nuclear weapons complex reconfiguration programs.

The first year of funding is FY 1999 and the funding source is DOE Stockpile Stewardship.



The Process and Environmental Technologies Laboratory will be used for DOE Defense Programs research and development.

8.3.5.6 Joint Computational Engineering Laboratory (New Mexico)

This laboratory will provide a state-of-the-art facility for research and development in leading-edge, high-performance computer and communications technologies. The facility will house supercomputers, computational research and development staff, and weapons design engineers. Activities in the facility will be conducted in partnership with other DOE laboratories, universities, and the private sector for the primary purpose of achieving science-based stewardship of the US nuclear weapons stockpile.

The first year of funding is FY 1999 and the funding source is DOE Stockpile Stewardship.

8.3.5.7 Model Validation and System Certification Test Center (New Mexico)

This proposed test center will be a state-of-the-art test command, control, and data acquisition facility in Technical Area III. The facility will monitor tests and routine activities via microwave and hard-wire communications and audiovisual-telemetry computer data. The test center will be linked to Technical Area V and remote test areas within the Coyote Test Field.

The first year of funding is FY 1999 and the funding source is DOE Stockpile Stewardship.

8.3.5.8 Distributed Information Systems Laboratory (California)

This facility is proposed to develop and implement distributed information systems for DOE Defense Programs, consolidating at one location activities to incorporate those systems into a virtual enterprise for stockpile stewardship. It will also provide a focus for the integration and validation of distributed information systems created from technologies developed and applied within the DOE, leveraging multiple programs in industry and academe.

The first year of funding is FY 2000 and the funding source is DOE Stockpile Stewardship.

8.3.5.9 Weapons Evaluations Testing Laboratory (New Mexico)

The project is a Stockpile Management initiative designed to provide new capability at the Pantex plant to perform additional weapons and component testing and evaluation, including maintenance, dismantlement, and retirement of weapons from the stockpile. The project will also support improved quality assurance and ongoing operations by addressing existing infrastructure gaps and implementing advanced diagnostic techniques through installation of upgraded equipment.

The first year of funding is FY 2001 and the funding source is DOE Stockpile Management.

8.3.5.10 Compound Semiconductor Research Laboratory (New Mexico)

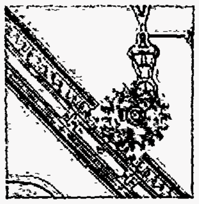
The Compound Semiconductor Research Laboratory is proposed as a replacement for an existing facility that is outmoded and nearing the end of its useful life. The Compound Semiconductor Research Laboratory will increase capability and capacity to support research, design, prototype fabrication, and production of hardened microelectronic and high-temperature devices and improve their reliability and survivability in hostile radiation environments.

The first year of funding is FY 2002 and the funding source is DOE Stockpile Stewardship.

8.3.5.11 Cooperative Monitoring Center (New Mexico)

The Cooperative Monitoring Center operates in a leased facility inadequate for this rapidly growing program. The proposed new facility will have demonstration display rooms, laboratory space, meeting and conference facilities, a reception area with a display lobby, and offices and support areas. The new facility will enable the Cooperative Monitoring Center to perform its mission of assisting political and technical experts around the world in acquiring the technology-based tools they need to respond to nonproliferation and other security measures.

The first year of funding is FY 2002 and the funding source is DOE Nonproliferation and National Security.



8.3.5.12 Nuclear Weapons Institute (New Mexico)

The Nuclear Weapons Institute, located with the Sandia Corporate Records Management group, will fill a void in the national laboratory system by preserving and broadening the knowledge base for future weapons production and ensuring stockpile surety via education and certification of both military and civilian weapons-handling personnel. Location adjacent to the DOD Nuclear Weapons School would maximize utilization of resources.

The first year of funding is FY 2004 and the funding source is DOE Stockpile Management.

8.4 Information

8.4.1 Information Resources Management

The Chief Information Officer develops and sustains the integrated information and distributed information system that enables twenty-first century engineering and dramatically reduces the time and cost of management and administrative tasks. The Chief Information Officer sponsors the Enterprise Information Plan, which identifies and details the specific Sandia-wide information initiatives, information infrastructure alignment projects, and operational plans that will fulfill Sandia's Strategic Plan objectives. The Chief Information Officer and Sandia's Integrated Information Services are contributing to the development of an integrated, mission-conscious infrastructure by aligning information capabilities and plans with the Infrastructure Strategic Plan.

Integrated Information Services operates the information utility and provides applications to support Sandia's strategic initiatives and corporate needs. These applications guide and unify the introduction of modern work flow technologies, procurement of commercial packages, and methods to reengineer Sandia's processes. To have a laboratory that works better and costs less, Integrated Information Services is creating an information infrastructure that has specific measurable goals, proven and effective approaches derived from "best in class" models, accountability and progress tracking, and no requirements that do not add value.

To achieve the corporate goals of location-independent engineering collaboration, product realization information reuse, and integrated information infrastructure, the Chief Information Officer and Integrated Information Services are aligning the information infrastructure and engineering information with revolutionized engineering and manufacturing processes. The classified Internal Secure Network is being renovated to meet the modeling and simulation needs of the nuclear weapons design community. An integrated design system and information infrastructure that provides nuclear weapon engineers with desktop access to product realization information is also being developed.

To enable completion of desktop management and administrative tasks, the Chief Information Officer and Integrated Information Services, in collaboration with administrative organizations, are converting a large number of dissimilar business information systems to standard commercial systems. The human resources conversion is complete. The financial conversion will be implemented in FY 1999. A companion activity that provides seamless integration of project management tools and work status and financial information will be deployed and operational in FY 1999.

8.4.2 Software Management

Sandia established the Software Management Program in accordance with the requirements of DOE Order 1330.1D. The program was implemented as a good business practice that identifies a single Sandia point of contact for software management reference; implements a uniform Sandia software management policy; establishes guidelines derived from internal organizations and industry best practices; and encourages development of organization-specific, results-oriented software management plans that incorporate the precepts of software quality assurance and software quality control.

The Software Management Program Quality Improvement Team is the software technical advisor to Sandia's vice presidents. The corporate-level focus is on developing policy guidance and general software management methods based on known best practices. The organization-level focus is on identifying application-specific life-cycle models and methodologies consistent with corporate policy and processes. The team has identified and completed several tasks: revision of the implementation plan, establishment of a software management policy, surveys of software engineering practices within Sandia, establishment of a software home page on the internal web, and linkage with other corporate software-related initiatives. Links within the Albuquerque community and the nuclear weapons complex have been established, and software process assessments and improvements are under way within Sandia organizations having significant software engineering activity. Ongoing tasks include helping to coordinate Sandia's response to computer problems that will result from the date change in 2000 (the Y2K problem). The team is also developing action plans in response to the conclusions and recommendations of the most recent software engineering survey results.

The Software Management Program policy was formalized in April 1993 as "Sandia Laboratories Policy 1011: Software Management." This policy remains in place as CRP 400.2.4. Each organization identifies software for which it is responsible, defines applicable software management practices, and identifies applicable software plans, methodologies, and environments. Preferred practices for development and maintenance of software are given in the following publications:

- *Sandia Software Guidelines. Volume 1: Software Quality Planning.* SAND85-2344. Albuquerque, NM: Sandia National Laboratories. 1987.
- *Sandia Software Guidelines. Volume 2: Documentation.* SAND85-2345. Albuquerque, NM: Sandia National Laboratories. 1995.
- *Sandia Software Guidelines. Volume 3: Standards, Practices, and Conventions.* SAND85-2346. Albuquerque, NM: Sandia National Laboratories. 1986.
- *Sandia Software Guidelines. Volume 4: Configuration Management.* SAND85-2347. Albuquerque, NM: Sandia National Laboratories. 1992.
- *Sandia Software Guidelines. Volume 5: Tools, Techniques, and Method.* SAND85-2348. Albuquerque, NM: Sandia National Laboratories. 1989.

To assert copyright for any Sandia-developed software, support documentation must be forwarded to the DOE's centralized software distribution center (currently the Energy Science and Technology Software Center) when permission to assert is given. Assistance in this process is available through Sandia's Technical Partnerships and Commercialization Center or Patent and Licensing Center.

8.4.3 Computational Facilities

8.4.3.1 Scientific Computing Resources

Our scientific computing center provides resources to integrate various facets of technical computing into a Sandia-wide distributed environment. Our computing resources range from desktop systems to supercomputers. Supercomputers are essential to modeling three-dimensional effects, performing high-resolution approximations, and simulating complex chemical and physical phenomena. To accommodate the computational demands of its missions, Sandia's desktop computers and workstations are linked with specialized dedicated department servers and with central high-performance systems. Asynchronous transfer mode switches and synchronous optical network technologies are the basis of Sandia's network. The network separates secure (classified) and restricted (unclassified) computing resources. Individual computer systems reside in one of these domains. The secure domain processes secret restricted data. The restricted domain may be accessed by industry partners and other DOE laboratories from the Internet through restrictive security gateways. Unique systems (such as Sandia's massively parallel computer systems) are designed to be switched between these two domains. The secure domain is linked to similar secure domains at other DOE laboratories via special-purpose encrypted communication.

Sandia's central supercomputer systems are located at the New Mexico site and include both vector architecture machines and massively parallel systems. These resources are available to users at Sandia/California.

Computing acquisitions to FY 2000 are intended to increase computational power and simulation capability dramatically and to improve the performance of support servers both at the central facility and within distributed local-area networks.

Sandia has demonstrated high-speed connectivity of supercomputing equipment among multiple DOE laboratories. We continue to provide leadership in this endeavor. Ultimately it will be possible for a customer to log on to a network and have access to a single-system image of resources on local- and wide-area networks.

8.4.3.2 Computer-Aided Engineering

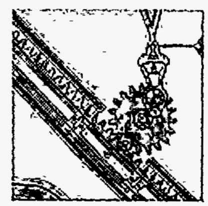
Sandia's computer-aided engineering capability supports the design, analysis, definition, manufacture, and acceptance of a product (including product life-cycle information) through shortened product development phases. Computer-aided engineering information is created via the NIRVANA and ACCORD projects. Both projects involve participation by a number of departments at Sandia, at AlliedSignal's Federal Manufacturing and Technologies Division, and at the DOE's Pantex plant.

The NIRVANA project, based on the concept of a standard design environment using a common set of tools and processes, enables delivery of advanced prototype hardware in days instead of weeks. The ACCORD project objective was to select the next-generation system supporting mechanical design for use within the weapons complex. The system is based on a parametric feature-based solid modeler that is the foundation for the various processes.

Sandia produces a wide range of information from many sources. This information exists in a variety of formats and is often located on different computer systems and networks. Because creating information and sharing it in a common electronic environment are important goals, Sandia has a Product Data Management Project to investigate and implement a modern information management system.

8.4.3.3 Administrative Information Systems

Centralized information business systems now reside primarily on an IBM 9672-R24, the Laboratory Information System. Applications on the system include finance systems, property, and procurement. These applications run under the multiple virtual storage operating system and an IBM data base management product. In addition, the Integrated Information Services group has implemented several distributed client/server applications to bring information to every Sandian's desktop in an intuitive, user-friendly format. These applications can be accessed by the three main desktop configurations at Sandia (Windows, Macintosh, and UNIX), and the data services will be provided by UNIX servers and the Sybase and Oracle data base management products. In early FY 1998 the Laboratory Information System human resources, benefits, and payroll applications were replaced by the PeopleSoft client/server commercial software. This software operates in a UNIX-based environment on an HP/K460 under an Oracle data base management system.



Current plans are to replace the remaining systems on the mainframe with commercial software from Oracle Corporation in October 1999. This will solve the Y2K problem as well as serving as a conduit for simplifying laboratory administrative processes.

Production-related activities for centralized information services (such as scheduling and data administration) are provided through indirect funds rather than on a charge-back basis. This arrangement allows equitable costs to be allocated to all customers. The Information Systems Utility ensures that all enterprise computers and networks operate around the clock, seven days a week.

Classified applications residing on the Classified Information System were converted to a client/server production environment and now reside on an IBM RX6000. Applications that support the technical library have been converted to a commercial software package called Horizon.

One of the goals of Administrative Information Systems is to provide economical and efficient service from enterprise servers to customer desktops. We anticipated customer needs via two initiatives. First, the Gartner Group benchmarked the Laboratory Information System Data Center and applications. The results showed that Sandia provides high-quality service to customers at a lower cost than the Gartner Group average corporation. Metrics are in place to make sure that we continue to provide service at this low cost. The second initiative is to create an enterprise client/server production environment to provide our customers with reliable and easy access to data from their desktops. The second phase of the initiative will be completed in FY 1999.

8.4.4 Telecommunications

8.4.4.1 Data Communications

The data communications network that serves Sandia has been enhanced by extensive rewiring of the Sandia complex and introduction of new data communications technologies. These new technologies have improved data communications bandwidth and capabilities, providing Sandia with a strategic advantage for supporting mission-critical projects such as the Accelerated Strategic Computing Initiative. Network management software and routers have been upgraded. The Internal Secure Network was redesigned and modernized using asynchronous transfer mode technology to accommodate the changing requirements of Sandia's user community. Simple network management protocol agents, coupled with the installation of monitoring and analysis tools, allow thorough network monitoring and management, rapid problem diagnosis, and improved routine maintenance.

Video conference rooms have been established at several Sandia sites. Many organizations depend on this service to supplement face-to-face meetings and to enhance project management and coordination with outside agencies. A video distribution service will improve dissemination of information within the corporation.

8.4.4.2 Voice Communications

Since FY 1993 Sandia has been responsible for providing its own telecommunications service. Sandia expanded the AT&T 5ESS digital electronic switch to form the cornerstone of our voice telecommunication services. Although primarily used to provide customers with voice services, this switch also provides enhanced video and data services. Sandia's telephone system is augmented by a Motorola ten-channel radio trunking system with a user capacity of more than two thousand two-way radios. Radio networks on the trunking system include the motor pool, transportation and storage, plant maintenance operations, safety, emergency services, health physics, and security operations.

8.4.5 Records Management

Records management focuses on the life-cycle of records and includes managing the creation, receipt, use, maintenance, preservation, and disposition of records. Records management provides the right record to the right person at the right time for the right cost.

Sandia's records management program supports core research and laboratory operations by improving management of information resources; fostering understanding of the importance of recorded information generated by Sandia employees and subcontractors; educating Sandians on their responsibility in the creation, use, maintenance, and disposition of records; and explaining the federal government's role in information management at Sandia. The records management program assists line organizations with information retrieval and cost- and mission-effective information management.

Records management and retention guidelines combine regulatory compliance requirements with good business practices. With certain exceptions, all records held by Sandia are government property and therefore are subject to our prime contract, requirements specific to Sandia projects, and federal statutes and regulations. Sandia's records management program reviews line organization information management procedures for adherence to good business practices and compliance with regulatory requirements. The program also provides leadership and partnering activities that

- integrate information services by teaming with other information providers;
- preserve and make available Sandia's corporate memory and evidence of Sandia's service in the national interest;
- work with nuclear weapons complex design and production agency engineers to ensure that records to support changing mission assignments during reconfiguration remain available to Sandia product and stockpile evaluation engineers; and
- assist the DOE in identifying, preserving, and improving retrievability of weapons data vital to the national defense.

The Technology Transfer Software Repository and the Technology Partnerships and Commercialization organizations hold Sandia-developed software waiting for marketing opportunities and license waiver from the DOE. Coordination of these activities allows Technology Partnerships and Commercialization to develop markets for Sandia's software and provides licensed packages to be submitted to the DOE's Energy and Science Technical Software Center in Oak Ridge, Tennessee.

Other partnerships exist within Sandia with the Classification and Sensitive Information Review Department (for records management activities in the large-scale review of classified information and submittal to OpenNet) and with the Nuclear Waste Management Program and Production Division (for dedicated records management support through matrixed positions). A new customer-funded partnership was created with the Environment, Safety, and Health Program when the records management program responsibilities were transferred to the Recorded Information Management Department.

Outreach is ongoing to familiarize Sandia employees with records management practices. In particular, file plan templates were established to institute standardized filing systems throughout Sandia, and implementation has begun. Additionally, our training program in records management continues to expand. This year we added training to the new hire and new managers classes. We added a files management module and specialized training for secretaries through professional development classes.

The Corporate Archives group assisted Environmental Restoration in avoiding significant expenditures by producing historical documents of Technical Area III activities. The Inactive Records data base was updated to a Windows environment.

The one-volume history of Sandia received the Best of Show award and the Talavai Award of Distinguished Technical Communication in Technical Publications from the Society for Technical Communication, New Mexico Kachina Chapter. The original printing of the book sold out. It has been reprinted and continues to be available through the National Atomic Museum Store. The history program has also teamed with cultural resources management to provide documentation for the DOE in compliance with the National Historic Preservation Act. A history of the buildings and activities in Technical Area II will appear in 1998. Similar documentation has begun for the older buildings in Technical Area I.

8.4.6 Management of Scientific and Technical Information

The Scientific and Technical Information Management Program was established to protect the public's interest in research performed at Sandia. Because our work is largely funded by government, the public has considerable investment in Sandia's operations. The public has legitimate concerns that

- technical staff manage scientific and engineering information to promote cost- and mission-effective operations;
- technical staff document their work to assure accountability and protect against fraud, waste, and abuse;
- research staff control the dissemination of information to protect national security interests; and
- results and progress on all scientific efforts are reported to the DOE and as appropriate made available to individuals in the research community.

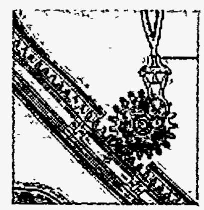
Sandia's Scientific and Technical Information Management Program follows life-cycle information practices to ensure that information is produced, processed, disseminated, and properly archived. The program develops policy and procedures that define staff roles in generating information needed to document research efforts and responsibilities as custodians of such documentation.

A task is under way to establish the federally mandated Standard Generalized Markup Language as a means of sharing scientific and technical information electronically with the DOE, industry, and the public. Full implementation is targeted for FY 2001. The task involves a cross section of critical Sandia line organization stakeholders working to identify technological solutions that will permit full electronic document exchange.

Sandia has a formal review and approval process for technical information prior to external release. The process includes DOE approvals as necessary.

8.4.7 Management of Personal Property

Sandia's Personal Property Management Program includes all our sites. The program encompasses all personal property owned, rented, borrowed, or leased by the government that is in the possession or under the control of Sandia, including property loaned to other entities. Personal property is defined as all tangible possessions except real property, nondurable goods (e.g., office supplies), records, and special source materials (e.g., special nuclear material).



The program has seven major processes: receipt and distribution, inventory and control, utilization, general storage, reutilization and disposal, precious metals, and motor fleet. The program provides Sandia line organizations with management, control, reapplication, and disposal services for approximately $1 billion of government-owned personal property.

In FY 1997 the Personal Property Management Program received a second consecutive "outstanding" rating from the DOE Business Management Oversight Review. The program has received system approval from the DOE Albuquerque Operations Office through 2001. In FY 1998 Sandia obtained DOE approval of a three-year inventory plan involving two physical inventories by statistical sample (FY 1998 and FY 2000) and one wall-to-wall inventory (FY 1999). The plan is expected to save Sandia more than $400,000 annually when compared to conducting complete inventories.

The program has four strategic objectives: reducing internal and external property management requirements, reducing the effort required of line organizations to manage property and meet requirements, increasing internal reuse of excess property and the dollar return on excess sales, and improving internal information systems. As part of reducing requirements and effort, Sandia negotiated the removal of cellular phones and items past their service lives with an acquisition cost of $5,000 or less. Eight thousand items (15 percent of controlled items) were removed from controlled inventory this fiscal year. Through its excess sales initiative, property management has returned over $250,000 in excess sale proceeds to the line organizations that generated the excess property. To improve its information systems, the program is converting its existing mainframe property management system to an Oracle Fixed Assets environment.

8.5 Protection

8.5.1 Security

8.5.1.1 Program Overview

The Safeguards and Security Program is responsible for protection of DOE assets at all Sandia sites in accordance with the requirements of the DOE (our primary customer), our Sandia customers, and other stakeholders. The major activities of the Safeguards and Security Program include

- program management,
- protection program operations,
- information security,
- personnel security, and
- nuclear material control and accountability.

The missions of both the DOE and Sandia have changed in response to global political changes. The security infrastructure employs automated access controls and technological improvements to cost-effectively address Safeguards and Security needs. Onsite employees and contractors use web-based resources to enhance communication, maintain awareness, and provide up-to-date Sandia business rules and security practices that implement administrative controls.

8.5.1.2 Protection Philosophy

The overall Safeguards and Security Program philosophy is to protect nuclear materials, classified matter, government property, and other security interests from unauthorized access, theft, diversion, sabotage, espionage, or other hostile acts that may cause risks to national security or the health and safety of DOE and contractor employees, the public, or the environment.

Levels of protection and other safeguards must be commensurate with the DOE's design basis threat guidance, locally identified risks, and other programmatic requirements. Our protection strategies are based on compliance and performance.

The Sandia program is based on risk management, which in this context means that higher risks require greater protection. The complexity of analysis, thoroughness of documentation, and levels of effort are commensurate with risk, consequences of loss or compromise, value of assets, cost of implementation, and other factors. This risk management approach eliminates unnecessary features or activities that add to costs of implementation.

All information created by Sandia is considered a Sandia asset. Sandia manages information as a corporate asset by ensuring appropriate dissemination and protection throughout the information life cycle. Sandia's information assets are made available at the user's desktop for legitimate business use, consistent with customer requirements.

8.5.1.3 Evolving Site Security Needs

During the last decade the nature of work at Sandia has changed dramatically. Much of the laboratory expertise and technical base is being transferred to nonweapon areas such as environment, energy, and computer and materials science—all of which have dual-use applications. A substantial portion of Sandia's work now involves law enforcement, treaty monitoring and verification, nuclear weapon reduction and dismantlement, nuclear material protection, nonproliferation, and other security interests that involve interaction with a large number of foreign nationals. Changes in the customer mix, increased cyber-communications and interactions, staff requirements to publish in technical journals and give presentations at international conferences, all tend to increase this interaction.

As a result, the targeting of technology by foreign interests at Sandia has also increased. Any technology that is considered important either militarily or economically could potentially be targeted by foreign intelligence groups. Therefore, counterintelligence programs will continue to expand to protect information from the threat of foreign intelligence gathering as well as potential insider threat. A major part of the protection strategy is a well-informed and knowledgeable Sandia staff.

Sandia's protection systems are driven by DOE security requirements, technological developments, international security issues, and increased partnerships with private industry. Major initiatives require modification of protection systems. As a result, Sandia line organizations and customers participate in decisions about protection systems established for their programs and facilities. Sandia implements new security requirements through increased use of web-based information systems, restructured security areas, and increased employee accountability for security.

8.5.1.4 The Changing Face of Security

The new missions of the DOE and Sandia require changes in the security infrastructure. Information security processes will expand to address the evolution of electronic transmission capabilities. The networking environment at Sandia is being extended to all desktops by rapid deployment of Windows NT operating systems for both classified and unclassified computing. Initial deployment of NT began with the weapons engineering community and will be extended to the unclassified community over the next two to three years.

Sandians and contractors will receive frequent, comprehensive information about security threats as well as potential consequences based on loss of military and economic information. Safeguards and Security staff will partner with line organizations, their customers, and the DOE to implement cost-effective risk-based security strategies documented in customized security plans to achieve more efficient protection systems. Roles, responsibilities, and accountabilities will be simplified and clarified to address protection issues. Security technologies will be employed to address physical security needs. Extensive educational programs will be focused on foreign interactions, onsite visitor control, foreign travel, and export control issues. Protection changes will be monitored through performance management processes to ensure protection of DOE assets.

8.5.2 Environment, Safety, and Health

Sandia is committed to protecting the environment and preserving the health and safety of individuals and the community. We conduct a comprehensive program to ensure that operations conform to industry standards and DOE expectations and comply with all applicable laws and regulations on environment, safety, and health (ES&H).

8.5.2.1 Goals and Objectives

Sandia's Corporate Policy Statement 400.1 ("Environment, Safety and Health") articulates our commitment to safety and affirms our intent to comply with all applicable laws, regulations, and DOE directives and to adhere to the principles of integrated safety management.

Sandia's annual appraisal agreement with the DOE identifies four ES&H performance objectives:

- protect people,
- protect the environment,
- comply with regulations, and
- use good management practices.

Additionally, a Lockheed Martin corporate goal is to reduce the "days-away case rate" by the year 2000.

8.5.2.2 Line Operations: the Integrated Safety Management System

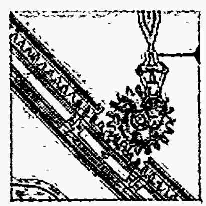
Sandia's Integrated Safety Management System is the primary vehicle for achieving our ES&H objectives. In accordance with DOE Safety Management System Policy 450.4, Sandia intends to "do work safely" by incorporating five safety management functions:

- define the scope of work,
- analyze and categorize hazards,
- develop and implement controls,
- do the work safely, and
- collect feedback to improve processes.

Safety is considered during every stage of Sandia's work. The person who directs day-to-day work is responsible for safety, reinforcing "line ownership." In matrixed situations involving direction from both project leaders and organization managers, the project leader must identify the person responsible for safety. The line support team assists workers and individuals who direct day-to-day work and suggests options for accomplishing mission goals while managing risks associated with the work. The line support team and the person responsible for safety must apply the five safety management functions discussed below.

8.5.2.2.1 Define the Scope of Work

The first safety management function translates the mission into work, sets ES&H expectations, prioritizes tasks, and allocates resources. To translate the mission into work at the corporate level, managers consult Sandia's strategic, institutional, division, and center plans to define work at department or project levels. To set ES&H expectations, the corporation annually negotiates an appraisal agreement with the DOE that defines objectives and measures. To prioritize tasks and allocate resources, line managers work with program managers to secure funds. Managers take into account the risk and hazards associated with the work. The documents and processes for prioritizing tasks and allocating resources vary with the source of funding and the organization. Regardless of the individual mechanism, priorities and resource requests eventually appear in the annual budgets that Sandia management submits to the DOE.



8.5.2.2.2 Analyze and Categorize Hazards

The second safety management function analyzes hazards and categorizes operations and facilities according to the hazard categories. The analysis is accomplished with Sandia's Integrated Safety Management System software. The software, which contains hazard-related regulatory requirements and is linked with the ES&H Manual, also collects operational and environmental information required by the National Environmental Policy Act.

For National Environmental Policy Act requirements, the software provides an environmental checklist/action description memorandum that Sandia submits to the DOE. The DOE then grants an exclusion from further analysis and categorization, or it requires Sandia to prepare an environmental assessment if an environmental impact statement is required.

For health and safety requirements, the software produces a primary hazard screen, which identifies hazards and the sections of the ES&H Manual dealing with those hazards. For office hazard and standard industrial hazard operations, the primary hazard screen and the documents to which it refers are sufficient to control the hazards associated with the work. For low-hazard operations, the software prompts for more information to produce a hazards analysis.

For nuclear, moderate-hazard nonnuclear operations, and accelerators the software prompts and records additional information useful for the safety assessment, safety analysis report, and safety assessment documents that these operations require as part of their authorization bases. However, the software does not produce complete safety assessments, safety analysis reports, or safety assessment documents.

8.5.2.2.3 Develop and Implement Controls

The third safety management function identifies standards and requirements, generates authorization basis documents and authorization agreements, identifies and establishes controls to prevent or mitigate hazards, and trains and qualifies personnel.

To identify standards and requirements and tailor them to specific operations, Sandia has formalized a directives flow to Sandia's ES&H Manual from the Legal Division (for laws and regulations), from the Contract Management Department (for DOE directives), and from the Laboratory Standards Department (for consensus standards). Subsequently, persons who direct day-to-day work and subject-matter experts consult to prepare work control documents (standard operating procedures and operating procedures).

Procedures vary with the hazard level of an operation. For operations involving office and standard industrial hazards, the primary hazard screen of the Integrated Safety Management System software completes the authorization basis document. The primary hazard screen, the approved integrated safety management system description, and the existing management and operating contract constitute the authorization agreement. Controls identified in the hazards analysis or the ES&H Manual are linked to work activities by work control documents. Most Sandia operations involve office, standard industrial, and low-level nonnuclear hazards.

For low-hazard nonnuclear operations, completing the primary hazard screen and hazards generate the authorization basis. After Sandia conducts a prestart readiness assessment, the primary hazard screen, the hazards analysis, the approved integrated safety management system description, and the existing management and operating contract constitute the authorization agreement.

Higher degrees of hazard require more extensive authorization basis documents, more careful review, and explicit authorization agreements on a case-by-case basis.

For Sandia's nuclear facilities (all category 2 or 3), the list of applicable requirements, the safety analysis report, the technical safety requirements, and the unreviewed safety questions process constitute the authorization basis. The DOE reviews and approves the authorization basis documents by issuing a safety evaluation report that serves as the authorization agreement. After satisfactory completion of an operational readiness review to assure that controls identified in the authorization agreement are in place and effective, the DOE approval authority authorizes facility startup.

For moderate-hazard nonnuclear operations, the applicable list of standards and requirements, the safety assessment, and the operational safety requirements constitute the authorization basis. The DOE reviews and approves the authorization basis documents via a memorandum that serves as the authorization agreement.

For accelerator facilities, the applicable list of standards and requirements, the safety analysis document, and the unreviewed safety issues process constitute the authorization basis. After performing a readiness assessment, the DOE authorizes operation via a memorandum, which serves as the authorization agreement.

Managers ensure that all Sandia employees, onsite contractors, and visitors are trained in compliance with the ES&H Manual and the authorization basis documents applicable to their work.

8.5.2.2.4 Do the Work Safely

The fourth safety management function concerns readiness and safe performance. For less hazardous operations (office hazard, standard industrial hazard, and low hazard nonnuclear), Sandia conducts a readiness assessment and determines when to start or restart operations unless a DOE directive requires DOE involvement. For more hazardous operations (accelerator, moderate-hazard nonnuclear, or nuclear), the DOE participates in the readiness assessment. Reports of these assessments usually become part of the authorization basis or authorization agreement.

8.5.2.2.5 Collect Feedback to Improve Processes

The fifth safety management function involves collecting feedback to evaluate performance and identify improvements.

ES&H feedback includes such indicators as radiation exposures, reportable releases to the environment, and injury and illness rates. The corporation negotiates an annual performance agreement with the DOE and evaluates its performance every quarter. Line organizations conduct self-assessments of their operations and Lockheed Martin conducts corporate appraisals of ES&H, as do the DOE, Department of Transportation, California Environmental Protection Agency, and New Mexico Environment Department.

Additionally, several mechanisms provide ongoing feedback and identify improvement opportunities. Various ES&H councils and committees meet regularly to review and improve performance. DOE facility representatives provide daily, independent oversight of Sandia facilities. The ES&H concerns program allows any employee, onsite contractor, or visitor to report concerns or complaints. The occurrence management program captures both DOE-reportable and nonreportable occurrences, and the lessons learned program uses experience at Sandia and other DOE sites to improve Sandia's ES&H performance.

After analyzing the feedback, Sandia staff and management may correct minor problems immediately. For major findings, corrective action plans are developed and monitored.

8.5.2.3 Sandia-Wide Cleanup Operations

Sandia's Integrated Safety Management System focuses on individual line operations in support of current missions. In addition, we close out operations from past years. These include restoring sites, disposing of legacy waste, and decontaminating and decommissioning outdated facilities.

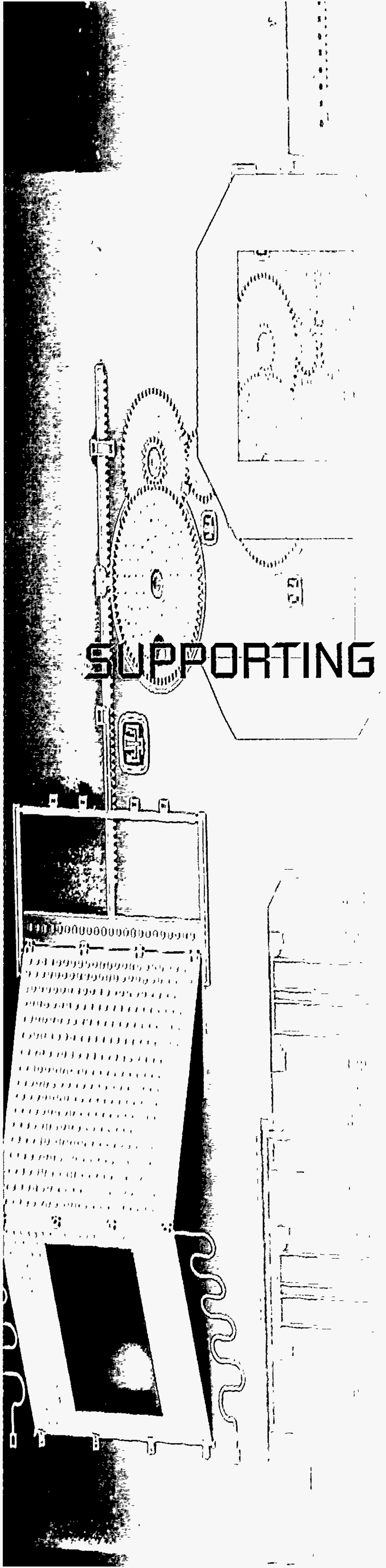
8.5.2.4 Site-Wide Environmental Impact Statement Support Project

The Sandia/New Mexico Site-Wide Environmental Impact Statement, a required DOE project to implement the National Environmental Policy Act, evaluates the environmental impacts of three future alternatives: continued operation of the laboratory at current facility levels, increased operation to the highest supportable levels, or reduced operations at minimal levels necessary to maintain capabilities to support DOE missions.

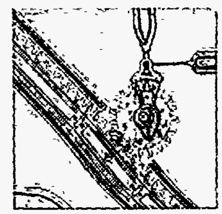
Sandia is a partner with the DOE and the DOE contractor that prepares the environmental impact statement. We are providing baseline information drawn from internal corporate and facility operations planning programs, environmental management programs, and safety and health programs. The environmental impact statement will evaluate the cumulative actions of Sandia, DOE facilities on Kirtland Air Force Base, and other contributors to environmental impacts. Minimally, the Site-Wide Environmental Impact Statement will inform the public, the DOE, and Sandia of the following:

- potential exposure of the public and workers to radiological and hazardous materials during normal operations and from postulated accidents, including aircraft crashes;
- potential effects on air and groundwater quality from normal operations and potential accidents;
- impacts on waste management practices and activities, including pollution prevention, waste minimization, and waste-stream characterization;
- potential impacts of noise levels to the ambient environment and sensitive receptors; and
- potential impacts on land use plans, policies, and controls.

The DOE formally began the Site-Wide Environmental Impact Statement on 30 May 1997. Completion is scheduled for 30 June 1999.



SUPPORTING DATA



This supporting data section includes Sandia's funding summary table, funding table by assistant secretarial office, funding tables by program within each secretarial office, funding table for work other than for the DOE, and personnel summary table by major sponsor.

The funding tables cover five years. Budget authority dollars are in millions; personnel are in annual average full-time equivalents (FTEs). Amounts for operating, capital equipment, and general plant projects in FY 1997 and FY 1998 are expressed in the actual dollars of their respective years. For FY 1999 and beyond, operating, capital equipment, and general plant project estimates are expressed in then-year dollars. Estimates for major construction projects are expressed in dollars of the year of project commencement. Estimates for FY 2001 assume a funding profile similar to that for FY 2000.

[illegible] Sandia Funding Summary

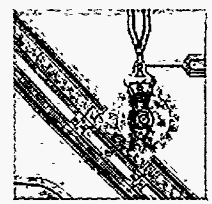
(Fiscal Year Budget Authority in Millions)

	1997	1998	1999	2000	2001
DOE Operating	929.0	979.6	1,025.0	1,006.9	1,006.9
Work for Others Operating	356.7	364.1	383.1	404.1	404.1
TOTAL OPERATING	1,285.7	1,343.7	1,408.1	1,411.0	1,411.0
DOE Capital Equipment	28.1	25.2	28.3	30.8	28.5
DOE General Plant Projects	4.9	8.6	11.5	8.2	8.2
DOE Line Item Construction	33.3	14.8	41.0	41.4	16.5
TOTAL FUNDING	1,352.0	1,392.3	1,488.9	1,491.4	1,464.2

9.2 Sandia Funding by Assistant Secretarial Office

(Fiscal Year Budget Authority in Millions)

	1997	1998	1999	2000	2001
Weapons and Waste Cleanup Programs					
Total Assistant Secretary for Defense Programs					
Operating	614.0	647.6	689.0	665.1	665.1
Capital Equipment	25.7	20.7	24.8	27.3	25.0
General Plant Projects	4.8	7.5	11.3	8.0	8.0
Major Construction	24.3	8.0	38.1	50.4	38.3
Total Funding	668.8	683.6	762.1	741.8	714.6
Total Office of Fissile Materials Disposition					
Operating	4.1	3.6	3.4	3.4	3.4
Total Office of Nonproliferation and National Security					
Operating	126.3	137.7	150.6	161.7	161.7
Capital Equipment	-0.9	0.7	1.5	1.5	1.5
Total Funding	125.4	138.4	152.1	163.2	163.2
Total Assistant Secretary for Environmental Management					
Operating	90.5	94.4	75.5	60.0	60.0
Capital Equipment	0.1	0.4	0.0	0.0	0.0
Total Funding	90.6	95.8	75.5	60.0	60.0
Energy Programs					
Total Assistant Secretary for Energy Efficiency and Renewable Energy					
Operating	42.9	42.7	47.0	48.5	48.5
Capital Equipment	0.4	0.3	0.0	0.0	0.0
Total Funding	43.3	43.0	47.0	48.5	48.5
Total Office of Civilian Radioactive Waste Management					
Operating	0.0	0.2	0.0	0.0	0.0
Total Office of Nuclear Energy					
Operating	11.2	12.9	15.3	21.0	21.0
Total Assistant Secretary for Fossil Energy					
Operating	7.3	6.6	6.6	6.5	6.5



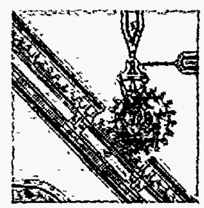
(Fiscal Year Budget Authority in Millions) (continued)

	1997	1998	1999	2000	2001
Science and Technology Programs					
Total Office of Energy Research					
Operating	32.7	33.8	37.5	40.7	40.7
Capital Equipment	2.8	2.3	2.0	2.0	2.0
General Plant Projects	0.1	0.1	0.2	0.2	0.2
Major Construction	9.0	7.0	4.0	0.0	0.0
Total Funding	44.6	43.2	43.7	42.9	42.9
Total DOE Programs					
Operating	929.0	979.6	1,025.0	1,006.9	1,006.9
Capital Equipment	28.1	25.2	28.3	30.8	28.5
General Plant Projects	4.9	8.6	11.5	8.2	8.2
Major Construction	33.3	14.8	41.0	41.4	16.5
Total Funding	995.3	1,028.2	1,105.8	1,087.3	1,060.1

9.3 Sandia Funding by Program within Each Secretarial Office

Assistant Secretary for Defense Programs
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
Programs and Initiatives (DP0101)					
Operating	168.0	163.0	206.0	192.7	192.7
Direct Personnel	523	555	634	559	559
Core Research and Advanced Technology (DP0102)					
Operating	185.7	199.7	190.3	178.0	178.0
Direct Personnel	572	524	492	434	434
Testing Capabilities and Readiness (DP0103)					
Operating	0.0	0.0	4.4	4.1	4.1
Direct Personnel	0	0	14	13	13
Infrastructure/Landlord Requirements (DP0105)					
Operating	0.0	9.0	0.0	0.0	0.0
Direct Personnel	0	2	0	0	0
Total Stockpile Stewardship (DP01)					
Operating	353.7	371.7	400.7	374.8	374.8
Capital Equipment	24.0	17.2	21.1	23.8	21.5
General Plant Projects	3.6	6.3	6.2	5.0	5.0
Major Construction	23.2	1.6	27.8	31.4	13.5
Direct Personnel	1,095	1,081	1,140	1,006	1,006
Inertial Confinement Fusion (DP02)					
Operating	25.9	23.8	31.0	30.7	30.7
Capital Equipment	0.4	0.4	0.7	0.0	0.0
General Plant Projects	0.0	0.2	2.2	0.0	0.0
Major Construction	4.8	6.4	3.6	0.0	0.0
Direct Personnel	58	41	48	48	48
Technology Transfer and Education (DP03)					
Operating	23.2	26.4	16.1	11.2	11.2
Direct Personnel	79	71	44	29	29

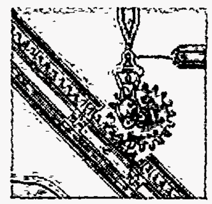


Assistant Secretary for Defense Programs
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs) (continued)

	1997	1998	1999	2000	2001
Weapons Stockpile Management (DP04)					
Operating	201.8	224.9	241.1	248.3	248.3
Capital Equipment	1.3	3.1	3.0	3.5	3.5
General Plant Projects	1.3	1.0	2.9	3.0	3.0
Major Construction	-3.7	-0.2	5.6	10.0	3.0
Direct Personnel	775	802	819	794	794
Program Direction (GB05/DP05)					
Operating	0.7	0.7	0.1	0.1	0.1
Direct Personnel	3	2	0	0	0
Worker and Community Transition Program (GG)					
Operating	8.4	0.1	0.0	0.0	0.0
New Production Reactors (NP)					
Operating	0.3	0.0	0.0	0.0	0.0
Direct Personnel	2	0	0	0	0
Total Assistant Secretary for Defense Programs					
Operating	614.0	647.6	689.0	665.1	665.1
Capital Equipment	25.7	20.7	24.8	27.3	25.0
General Plant Projects	4.8	7.5	11.3	8.0	8.0
Major Construction	24.3	7.8	37.0	41.4	16.5
Total Funding	668.8	683.6	762.1	741.8	714.6
Direct Personnel	2,012	1,997	2,051	1,877	1,877

Office of Nonproliferation and National Security
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
Nonproliferation and Verification Research and Development (GC)					
Operating	68.4	67.3	66.0	66.0	66.0
Capital Equipment	0.8	0.9	1.0	1.0	1.0
Direct Personnel	185	201	186	181	181
Nuclear Safeguards and Security (GD)					
Operating	8.6	9.5	9.0	9.0	9.0
Capital Equipment	0.7	0.0	0.5	0.5	0.5
Direct Personnel	31	33	32	31	31
Arms Control and Nonproliferation (GJ)					
Operating	44.5	56.0	70.1	81.2	81.2
Capital Equipment	-2.3	-0.2	0.0	0.0	0.0
Direct Personnel	86	89	107	116	116
Emergency Management/ Program Management (ND/NN)					
Operating	0.3	0.0	0.3	0.3	0.3
Capital Equipment	-0.1	0.0	0.0	0.0	0.0
Direct Personnel	1	0	1	1	1
Intelligence (NT)					
Operating	4.6	4.9	5.2	5.2	5.2
Direct Personnel	16	19	22	22	22
Total Office of Nonproliferation and National Security					
Operating	126.3	137.7	150.6	161.7	161.7
Capital Equipment	-0.9	0.7	1.5	1.5	1.5
Direct Personnel	319	342	348	351	351



Office of Fissile Materials Disposition
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

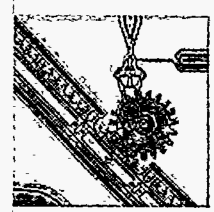
	1997	1998	1999	2000	2001
Fissile Materials Disposition (GA)					
Operating	4.1	3.6	3.4	3.4	3.4
Direct Personnel	11	11	11	11	11

Assistant Secretary for Environmental Management
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
Environmental Management - Defense (EW)					
Operating	90.4	94.2	75.5	60.0	60.0
Capital Equipment	0.1	0.4	0.0	0.0	0.0
General Plant Projects	0.0	1.0	0.0	0.0	0.0
Direct Personnel	249	216	181	147	147
Environmental Management - Nondefense (EX)					
Operating	0.2	0.2	0.0	0.0	0.0
Direct Personnel	1	1	0	0	0
Total Assistant Secretary for Environmental Management					
Operating	90.5	94.4	75.5	60.0	60.0
Capital Equipment	0.1	0.4	0.0	0.0	0.0
General Plant Projects	0.0	1.0	0.0	0.0	0.0
Direct Personnel	250	217	181	147	147

Assistant Secretary for Energy Efficiency and Renewable Energy
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
Solar Energy (EB)					
Operating	34.4	33.8	36.5	37.9	37.9
Capital Equipment	0.2	0.1	0.0	0.0	0.0
Direct Personnel	96	98	99	101	101
Energy Conservation (EC/ED/EE)					
Operating	8.5	8.9	10.5	10.6	10.6
Capital Equipment	0.2	0.2	0.0	0.0	0.0
Direct Personnel	21	25	29	28	28
Total Assistant Secretary for Energy Efficiency and Renewable Energy					
Operating	42.9	42.7	47.0	48.5	48.5
Capital Equipment	0.4	0.3	0.0	0.0	0.0
Direct Personnel	117	123	128	129	129



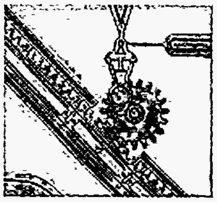
**Assistant Secretary for Fossil Energy
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)**

	1997	1998	1999	2000	2001
Coal (AA)					
Operating	1.6	1.3	1.5	1.5	1.5
Direct Personnel	8	5	5	5	5
Gas (AB)					
Operating	0.6	1.1	0.8	0.7	0.7
Direct Personnel	2	1	3	2	2
Petroleum (AC)					
Operating	2.1	1.6	1.8	1.8	1.8
Direct Personnel	6	6	5	5	5
Strategic Petroleum Reserve (SA)					
Operating	2.9	2.7	2.5	2.5	2.5
Direct Personnel	11	10	9	9	9
Total Assistant Secretary for Fossil Energy					
Operating	7.3	6.6	6.6	6.5	6.5
Direct Personnel	27	22	22	21	21

Office of Energy Research

Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
Magnetic Fusion Energy (AT)					
Operating	5.3	5.9	5.4	5.4	5.4
Direct Personnel	15	14	15	15	15
Basic Energy Sciences (KC)					
Operating	18.6	19.3	21.5	23.1	23.1
Capital Equipment	2.5	2.3	2.0	2.0	2.0
General Plant Projects	0.1	0.1	0.2	0.2	0.2
Major Construction	9.0	7.0	4.0	0.0	0.0
Direct Personnel	52	54	59	61	61
Computational and Technology Research (KJ)					
Operating	6.1	5.2	5.9	6.5	6.5
Capital Equipment	0.2	0.0	0.0	0.0	0.0
Direct Personnel	17	16	17	18	19
Biological and Environmental Research (KP)					
Operating	2.7	3.5	4.7	5.7	5.7
Capital Equipment	0.1	0.0	0.0	0.0	0.0
Direct Personnel	5	6	8	10	10
Total Office of Energy Research					
Operating	32.7	33.8	37.5	40.7	40.7
Capital Equipment	2.8	2.3	2.0	2.0	2.0
General Plant Projects	0.1	0.1	0.2	0.2	0.2
Major Construction	9.0	7.0	4.0	0.0	0.0
Direct Personnel	89	90	99	104	105



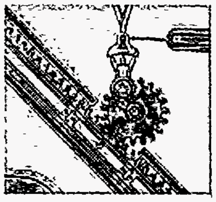
Office of Nuclear Energy
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
Nuclear Energy Research and Development (AF)					
Operating	2.3	0.6	5.0	5.0	5.0
Capital Equipment	0.0	0.8	0.0	0.0	0.0
Direct Personnel	6	2	12	12	12
Uranium Supply and Enrichment Activities (CD)					
Operating	1.2	1.4	2.1	2.1	2.1
Direct Personnel	3	3	4	4	4
Isotope Production and Distribution Program (ST)					
Operating	7.7	10.9	8.2	13.9	13.9
Direct Personnel	31	31	29	33	33
Total Office of Nuclear Energy					
Operating	11.2	12.9	15.3	21.0	21.0
Capital Equipment	0.0	0.8	0.0	0.0	0.0
Direct Personnel	40	36	45	49	49

Office of Science Education and Technical Information
Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

	1997	1998	1999	2000	2001
University and Science Education (KT/KV)					
Direct Personnel	1	1	0	0	0

9.4 Sandia Funding for Work for Other than the DOE



Resources by Major Program
(Fiscal Year Budget Authority in Millions; Personnel in FTEs)

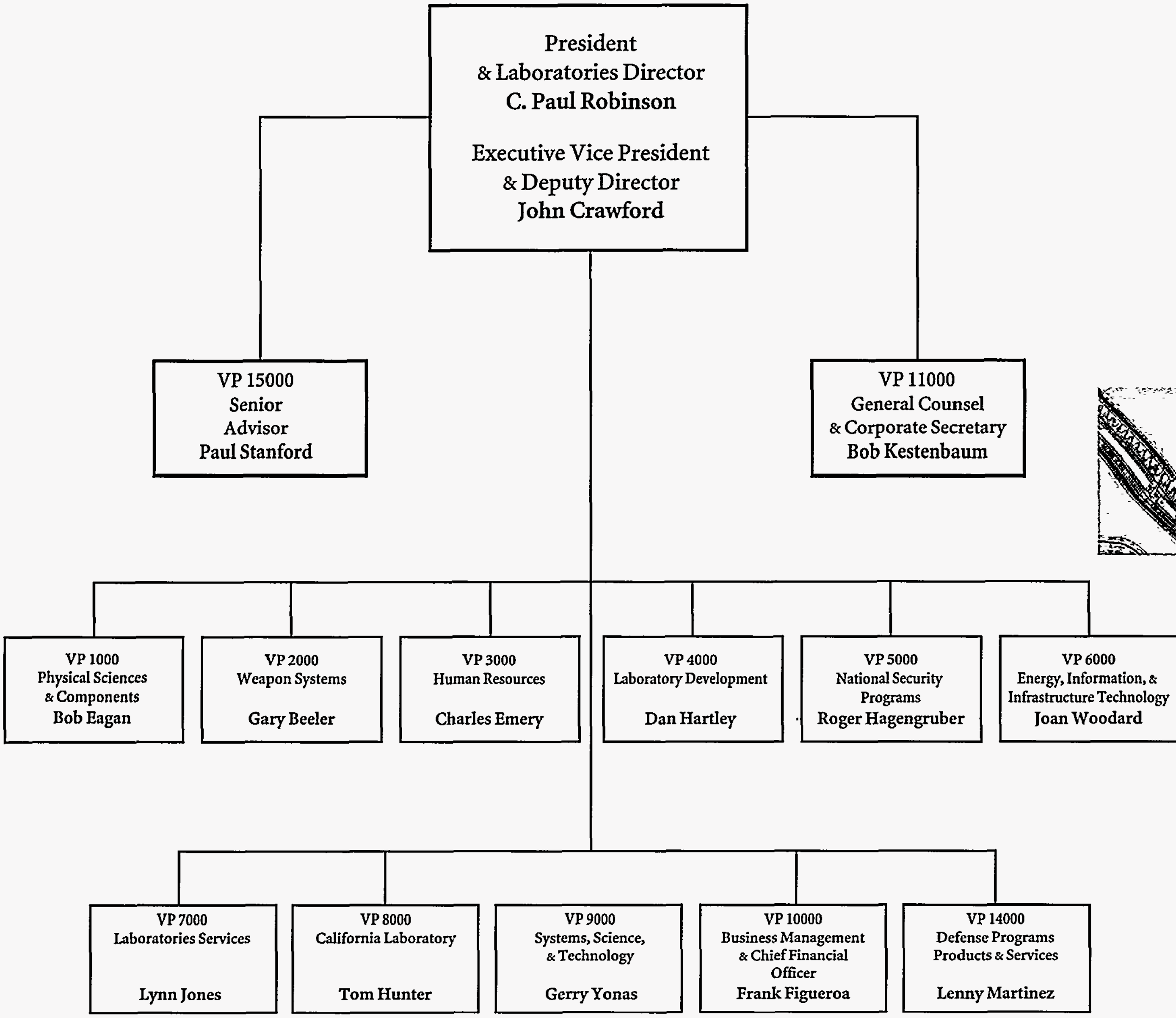
	1997	1998	1999	2000	2001
Department of Defense					
Operating	183.9	181.2	184.5	185.6	185.6
Direct Personnel	537	513	522	525	525
Nuclear Regulatory Commission					
Operating	10.4	8.8	8.8	8.0	8.0
Direct Personnel	43	34	34	31	31
All Other Federal Agencies					
Operating	45.8	52.7	53.7	54.0	54.0
Direct Personnel	129	134	137	137	137
Total Other Federal Agencies					
Operating	240.1	242.7	247.0	247.6	247.6
Direct Personnel	709	681	693	693	693
Nonfederal Entities					
Operating	19.7	22.8	28.2	36.3	36.3
Direct Personnel	70	72	89	115	115
CRADA Partners/Royalties and Licensing					
Operating	28.8	33.7	41.8	53.7	53.7
Direct Personnel	63	108	134	172	172
Other DOE Locations/ M&O Contractors					
Operating	68.1	64.9	66.1	66.5	66.5
Direct Personnel	206	203	206	209	209
Total Work for Other than the DOE					
Operating	356.7	364.1	383.1	404.1	404.1
Direct Personnel	1,048	1,064	1,122	1,189	1,189

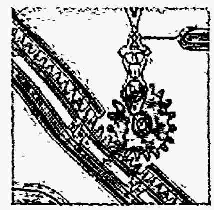
6.3 Personnel Summary by Major Sponsor

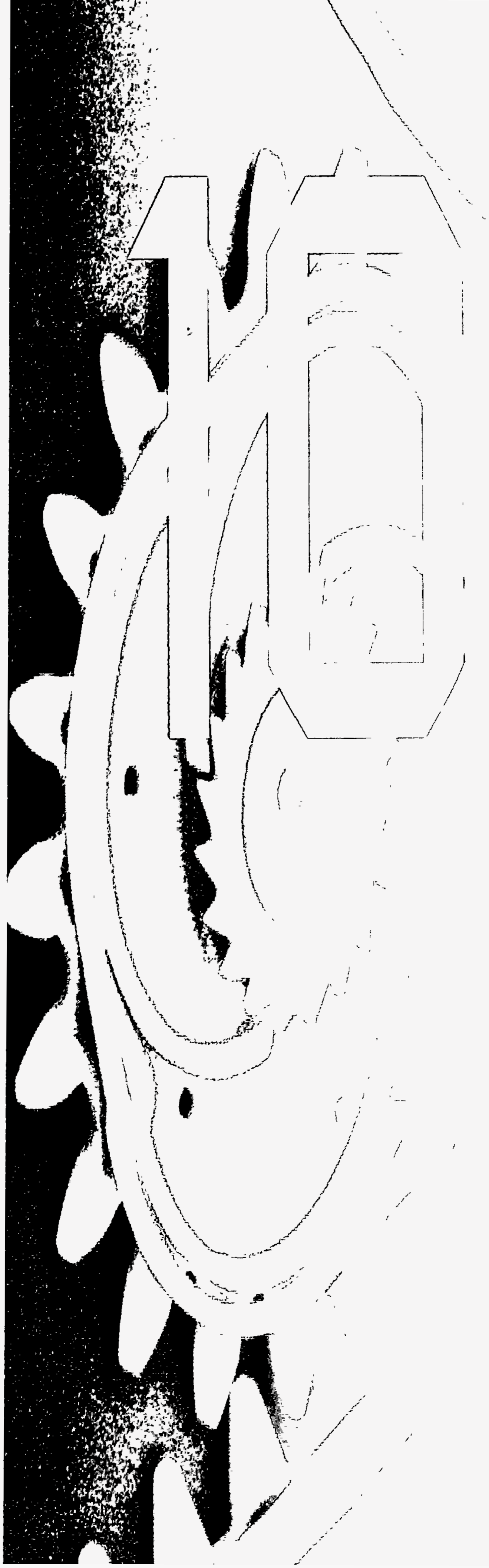
(FTEs)

	1997	1998	1999	2000	2001
DOE Programs					
Weapons and Waste Cleanup Programs					
Defense Programs	2,012	1,997	2,051	1,877	1,877
Nonproliferation and National Security	319	342	348	351	351
Fissile Materials Disposition	11	11	11	11	11
Environmental Management	250	217	181	147	147
Energy Programs					
Energy Efficiency and Renewable Energy	117	123	128	129	129
Fossil Energy	27	22	22	21	21
Nuclear Energy	40	36	45	49	49
Science and Technology Programs					
Energy Research	89	90	99	104	105
Science Education/Technical Information	1	1	0	0	0
Total DOE Programs	2,866	2,839	2,885	2,689	2,690
Programs Other than DOE					
Department of Defense	537	513	522	525	525
Nuclear Regulatory Commission	43	34	34	31	31
All Other Federal Agencies	129	134	137	137	137
Nonfederal Entities	70	72	89	115	115
CRADA Partners/Royalties and Licensing	63	108	134	172	172
Other DOE Locations/M&O Contractors	206	203	206	209	209
Total Work for Others	1,048	1,064	1,122	1,189	1,189
Total Direct Programs	3,914	3,903	4,077	3,878	3,879
Laboratory Directed Research and Development	270	277	288	295	295
Direct Support	1,749	1,647	1,600	1,612	1,611
Indirect Support	1,741	1,652	1,605	1,615	1,615
Total Laboratories	7,674	7,479	7,500	7,400	7,400

9.6 Sandia Organization Chart at the Vice Presidential Level







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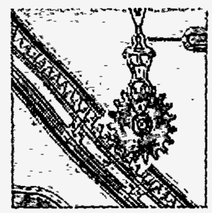

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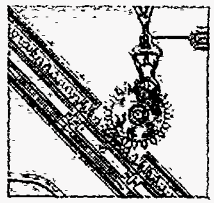

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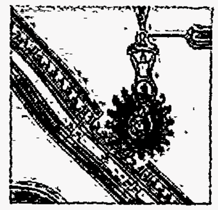

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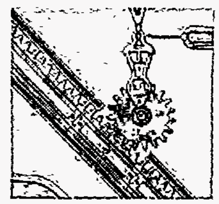

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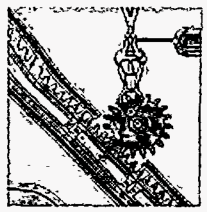

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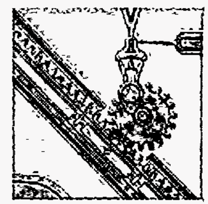

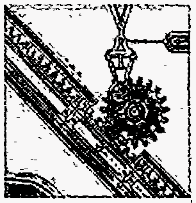

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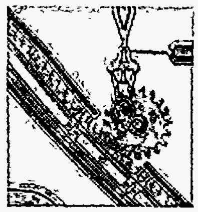

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