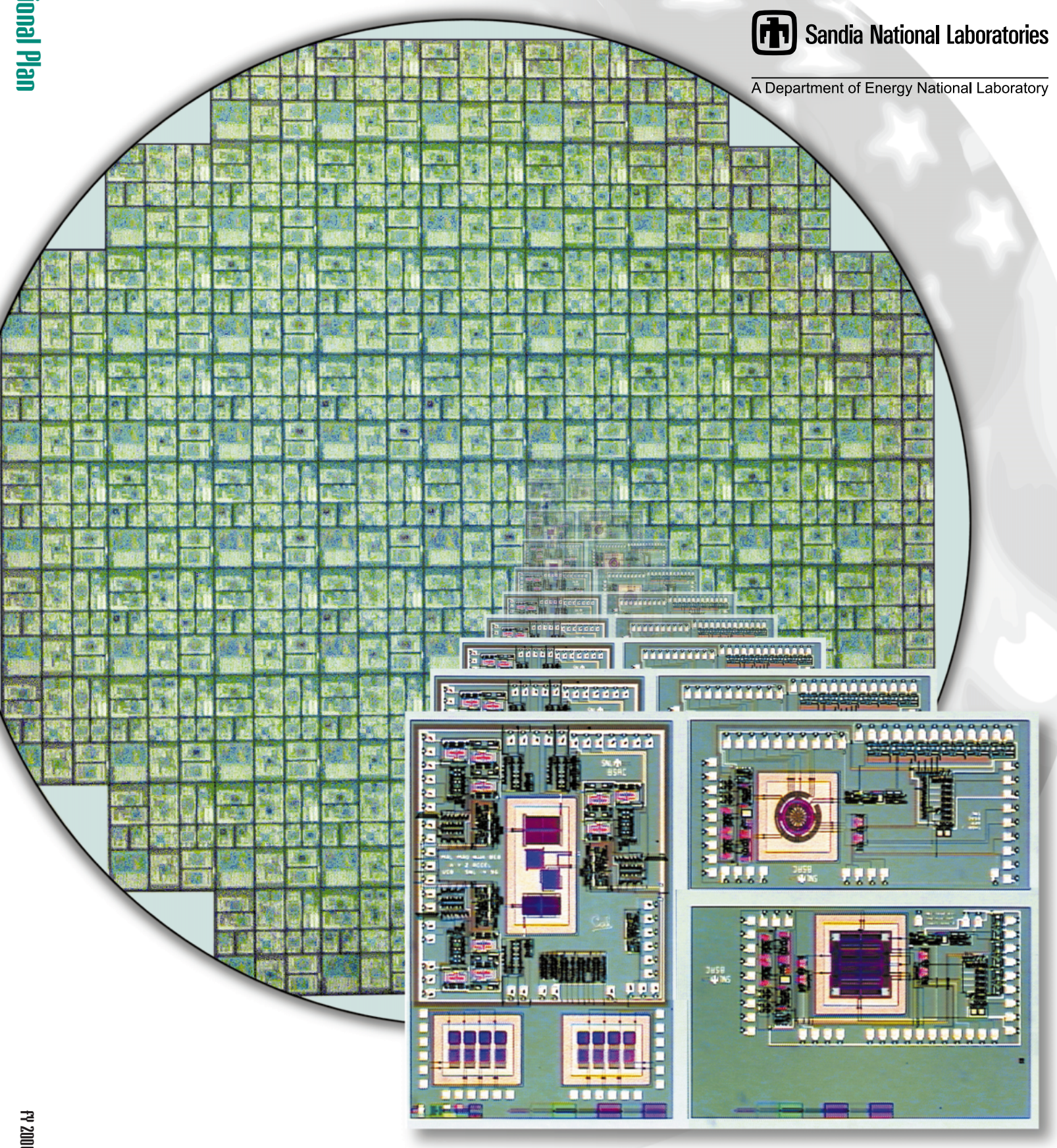
FY 2000–2005

Institutional Plan

Sandia National Laboratories

A Department of Energy National Laboratory



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

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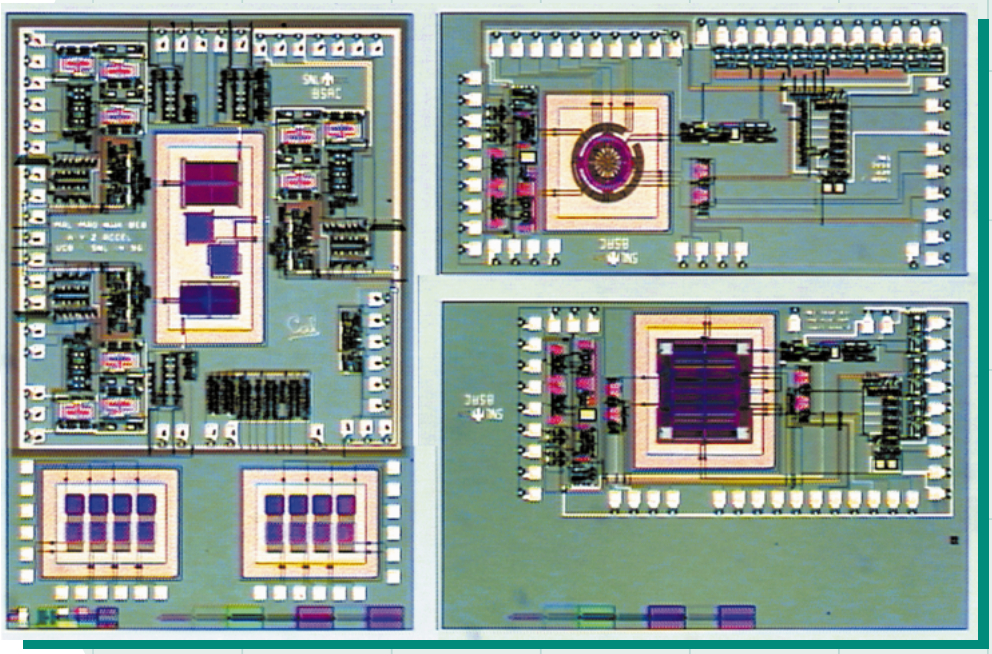
About the cover

The 6-inch-diameter green silicon wafer in the background is composed of four-component chips shown in the exploded view. Each chip measures 5 by 10 millimeters and the components include surface micromachined gyroscopes, accelerometers, and control electronics. At the upper left is the world's first monolithic, surface-micromachined, three-axis accelerometer, designed at the University of California at Berkeley and fabricated at the Microelectronics Development Laboratory using Sandia's modular monolithic microelectromechanical system (M^3S) surface micromachining technology. At the upper right is an x- and y-axis vibratory rate gyroscope and at the lower right is a z-axis vibratory rate gyroscope. The gyroscopes and the three-axis accelerometer form the critical building blocks of an inertial measurement unit. At the lower left is a pair of Sandia-designed accelerometers for sensing acceleration in high G-force environments. The silicon batch fabrication of these four-component chips demonstrates the feasibility of manufacturing incredibly small and inexpensive inertial measurement units using surface micromachine technology. The devices and technology have a wide range of applications, including weapons systems.



These chips are early examples of integrated microsystems. In order to continue improving the surety (i.e., safety, security, and reliability) of the nuclear weapon deterrent, increasingly smaller and more powerful new microsystems will be designed and fabricated in Sandia's Microsystems and Engineering Sciences Applications (MESA) Complex. The MESA Complex will support a safe, secure, reliable, certifiable, and affordable stockpile by housing weapons specialists, computation experts, and microsystems technologists in a single facility that gives them access to the world's most advanced, computationally enabled microsystems including a state-of-the-art microsystems clean room. The MESA Complex's revolutionary computation and simulation capabilities will allow weapons specialists to "see" their designs before they are built, and to understand how they will perform in the intended environments.

SAND99-2096

FY 2000–2005

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Institutional Plan

December 1999
Albuquerque, New Mexico
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Table 3.1. Alignment of Sandia and DOE Strategic Plans (continued)

Sandia Strategic Objectives[a]	DOE Headquarters Strategic Plan Business Lines[b]
Nonproliferation and Materials Control: "Reduce the vulnerability of our nation to threats of proliferation and use of weapons of mass destruction, nuclear incidents, and environmental damage" (page 6).	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" (pages 9 & 10).
Infrastructure: "Create an infrastructure that operates as a system and is a differentiating advantage for our strategic missions" (page 9). People: "Apply excellence as our standard for attracting people to join and remain at Sandia and for measuring the performance of teams and individuals" (page 8). Business Results: ". . . achieve business results that represent critical measures of our achieving mission success and providing exceptional service in the national interest" (page 29).	Corporate Management: • "Environment, Safety, and Health; • Communication and Trust; and • Management Practices" (page 10).

[a] *Strategic Plan 1999: Sandia National Laboratories*. SAND99-0412. Albuquerque, NM: Sandia National Laboratories.

[b] *U.S. Department of Energy Strategic Plan*. 1997. Electronic (pdf) file available at http://www.doe.gov/policy/doeplan.htm. Citations refer to page numbers in the hard copy and pdf versions rather than to page numbers assigned by the browser.

Because Sandia's customers include some non-DOE federal agencies, our plans include some non-DOE goals and objectives that are consistent with our DOE mission assignments and technology base. Because Sandia is an extremely diverse multiprogram laboratory, our strategic objectives, intermediate goals, and fiscal year milestones represent major efforts rather than individual programs.

The following sections identify the strategic objective and intermediate goals for each of our eight strategic areas. The first four sections (3.1 through 3.4) correspond to our strategic business units, which address what we will accomplish. Crosswalks are included to match these sections with the program descriptions in chapter 6.

3.1 Nuclear Weapons: Our Primary Mission

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

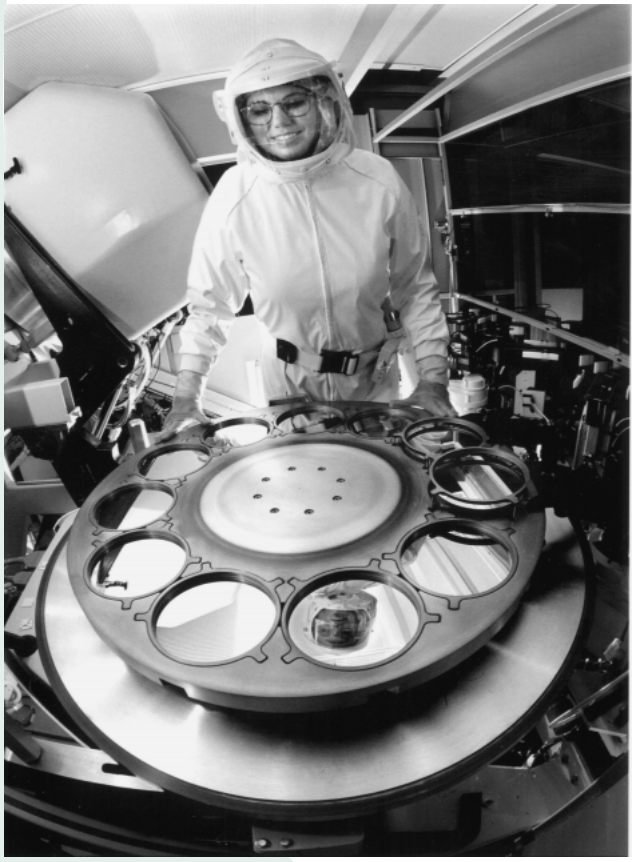
Together with Los Alamos and Lawrence Livermore national laboratories, Sandia is accountable for two critical elements of nuclear deterrence: the nuclear weapons stockpile and the expertise that ensures the stockpile remains safe, secure, and reliable.

Our intermediate goals for this strategic objective are to

- develop surety technology for the stockpile that eliminates existing nuclear safety exceptions and upgrades capabilities in time for scheduled weapon refurbishments;
- ensure that the Stockpile Stewardship Program is integrated within Sandia and throughout the nuclear weapons complex;
- ensure that all existing and new products can be certified to meet their requirements in normal, abnormal, and hostile environments;
- provide a safe, secure, reliable, and affordable nuclear weapons stockpile by developing the Microsystems and Engineering Sciences Applications (MESA) Complex to integrate advanced component and subsystems design and stewardship, computational simulation and engineering, and twenty-first century microsystems development and production;
- create an environment for the stockpile that supports engineering organizations across the complex in

- complete the necessary actions (Critical Decision 1 and Critical Decision 2) to assure that the Microsystems and Engineering Sciences Applications (MESA) Complex is started and completed on time so that the necessary surety solutions are delivered to meet the Stockpile Life Extension Program schedule; and
- define a need-to-know security system and implement it to provide access to classified and nonclassified information within Sandia and then across the nuclear weapons complex.

The DOE will review a subset of Sandia's nuclear weapons programs during FY 2000. Areas scheduled for review include dismantlement, the Stockpile Life Extension Program, refurbishments, enhanced surveillance, field engineering and training, stockpile evaluation, production, surety assessment, stockpile support, and the Advanced Design and Production Technologies (ADaPT) Initiative. The DOE review will be based on any of the following criteria that apply to these programs: 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 of major research facilities.



Sandia technician Stephanie Reel is shown with one of the metal deposition systems in the Microelectronics Development Laboratory, an existing facility that will be part of the proposed Microsystems and Engineering Sciences Applications (MESA) Complex. Metal deposition systems are used for radiation-hardened microelectronics processing.

4.1.2 Nonproliferation and Materials Control

Our strategic objective goal is to reduce the vulnerability of the United States to threats of proliferation and use of weapons of mass destruction, nuclear incidents, and environmental damage. To achieve this goal in FY 2000 we will

- design an integrated system of nanosatellites and small mobile ground sensors to characterize deeply buried targets;
- conduct one international workshop and three major experiments to explore and develop options for the global management of special nuclear material;
- develop the overall strategy and system architecture for protecting vital facilities against chemical and biological attack; and
- generate a portfolio of twelve non-DOD partnerships to develop a constituency for Sandia's capabilities in physical security for "homeland defense."

The DOE will review a subset of Sandia's nonproliferation and materials control programs during FY 2000. Areas scheduled for review include treaty verification, nonproliferation technology in the chemical and biological areas, and the waste legacy. The DOE review will be based on any of the following criteria that apply to these programs: 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 of major research facilities.

4.1.3 Energy and Critical Infrastructures

Our strategic objective goal is to enhance the surety (safety, security, and reliability) of energy and other critical infrastructures. To achieve this goal in FY 2000 we will

- develop partnerships to further the interest in nuclear power;
- formalize external partnerships with industries and academic institutions that focus on "transparent Earth" technology development;
- develop and test distributed supervisory control and data acquisition systems for critical infrastructures;
- complete the performance assessment required for the Yucca Mountain site recommendation report; and
- increase partnering with the Science and Technology Strategic Management Unit and increase non-Basic Energy Sciences business by 10 percent in areas supported by Science and Technology organizations.

The DOE will review a subset of Sandia's energy programs during FY 2000. Areas scheduled for review include the Energy Research, Energy Efficiency, and Transportation programs. The DOE review will be based

on any of the following criteria that apply to these programs: 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 of major research facilities.

4.1.4 Emerging National Security Threats

Our strategic objective goal is to develop high-impact responses to emerging national security threats. To achieve this goal in FY 2000 we will

- successfully carry out target activities for the National Missile Defense Program integrated flight tests;
- develop and pilot a new approach to business development that focuses on understanding and satisfying our customer's needs (e.g., developing "capture plans");
- obtain Defense Advanced Research Projects Agency funding for at least one key new technology program (e.g., defeat of hardened, deeply buried targets; swarms of collectively intelligent robots); and
- coordinate a Sandia effort on "homeland defense" with the Nonproliferation and Materials Control and Energy and Critical Infrastructures strategic business units to develop and execute an integrated plan for obtaining business from the DOD, National Guard, Federal Bureau of Investigation, and other relevant federal entities.

The DOE will review a subset of Sandia's emerging threats programs during FY 2000. Areas scheduled for review include programs in combating terrorism, counterproliferation, demilitarization, distributed information-rich systems, and chemical/biological weapons defense. The DOE review will be based on any of the following criteria that apply to these programs: 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 of major research facilities.

4.1.5 People

Our strategic objective goal is to inspire employees to achieve excellence in their contribution to Sandia's mission. To achieve this goal in FY 2000 we will

- develop a "total rewards strategy" that positions Sandia among comparable research-and-development companies to attract and retain employees;
- restructure the student intern program to align with programmatic needs in order to increase hiring rates of talented students as Sandia employees (determine a baseline rate and increase it by 10 percent); and
- implement corporate plans to address the three key findings of the 1999 Employee Attitude Survey (dealing with poor performers, making Sandia's post-and-bid system more accessible, and fostering people management skills).

4.1.6 Science and Technology

Our strategic objective goal is to pursue "science with the mission in mind" to provide solutions and options for our customers. To achieve this goal in FY 2000 we will

- gather "grand challenge" ideas from key staff and external sources, create a thirty-year vision as part of Science and Technology's Business Plan, and begin developing major science and technology thrusts needed in FY 2030 (e.g., a program with impact similar to that envisioned for the Microsystems and Engineering Sciences Applications Complex);
- demonstrate a robust microchemlab module for detection of trace chemical warfare agent simulants;
- apply high-fidelity scientific calculations to develop preliminary designs for the MC4300 neutron generator tube; and
- identify relevant physics for a model-based process to certify microsystems technology for nuclear weapons and other complex systems.

The DOE will review a subset of Sandia's science and technology programs and capabilities during FY 2000. Areas scheduled for review include the Computational and Information Sciences, Pulsed Power, and Laboratory Directed Research and Development programs. The DOE review will be based on any of the following criteria that apply to these programs: 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 of major research facilities.

4.1.7 Infrastructure

Our strategic objective goal is to create an infrastructure (including information, physical plant, and centralized support and services) that operates as a system and is a differentiating advantage for our strategic missions. To achieve this goal in FY 2000 we will

- integrate infrastructure planning and support for the Microsystems and Engineering Sciences Applications (MESA) Complex to facilitate this essential mission project and achieve minimal out-year operational costs;
- identify the ten most burdensome DOE requirements and work with the DOE and the other Defense Programs laboratories to significantly decrease the burden;

- implement Sandia's Major Renovation Master Plan in accordance with available funding;
- meet all Safeguards and Security milestones (including counterintelligence and cyber security) and ensure that the programmatic foundations are in place to continue meeting these milestones; and
- successfully negotiate the year 2000 computer transition.

We will also meet special Lockheed Martin Corporation Energy and Environment Sector and Sandia Corporation Objectives by demonstrating

- progress toward zero environmental noncompliances, notice of violations, and associated fines and penalties;
- progress toward zero Price Anderson Amendments Act violations and associated fines and penalties;
- progress toward zero reportable safety incidents; and
- compliance with Sandia's DOE-approved Integrated Safety Management System.

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

Our strategic objective goal is to maximize beneficial strategic partnerships. We commercialize our taxpayer-supported research and development by forming long-term, cost-shared strategic partnerships with industries that have similar technology development needs. The revenue from these partners and their "in-kind" technical contributions often directly offsets government funding that would be needed to meet our mission requirements.

To achieve our strategic objective goal in FY 2000 we will

- ensure that each strategic business unit and strategic management unit increases partnership revenues;
- follow up the Conference on the Southwest as a Region of Innovation with a Sandia-sponsored Conference on the Microsystems and Engineering Sciences Applications (MESA) Complex;
- support responsible new opportunities in international research and development, achieving increased funding with strategically important international allies; and
- support Technology Ventures Corporation in creating a master plan for Sandia's Science and Technology Park.

The DOE will review Sandia's Technology Commercialization Program during FY 2000. The DOE review will be based on any of the following criteria that apply to these programs: 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 of major research facilities.

4.2 Crosscutting Milestones

Some representative FY 2000 milestones do not fit neatly into a single strategic objective goal area. These milestones, which subsume all strategic areas and are reported to Lockheed Martin, are given below:

- achieve total Sandia FY 2000 operating and capital equipment revenue of $1,441 million (104 percent of our FY 1999 base line) and construction revenue of $42 million (based on our Site Development Plan);
- meet or exceed the fee commitment and the earnings before income tax commitment to Lockheed Martin; and
- conduct business according to the Lockheed Martin Ethics and Business Conduct Program.

4.3 Continuous Improvement

Sandia's strategic objectives and intermediate goals (see chapter 3) and representative FY 2000 milestones will change if funding or requirements change. During FY 2000, change control will document evolution of the statements that appear in chapters 3 and 4, and a current version will be placed on Sandia's internal web.

In addition, every spring Sandia reviews and modifies our planning elements, striving to align more closely with current customers and future national security needs. Every summer, we establish milestones for the following fiscal year and use "line-of-sight" mechanisms to communicate these milestones to all Sandians for their annual performance management. Every quarter, we review progress on fiscal year milestones and at the end of the year we report to Lockheed Martin and the DOE.

We continuously improve our planning process so that every Sandian can maximize mission success.

SEVEN

MAJOR PROGRAMMATIC INITIATIVES

This section presents proposals for consideration by the DOE. 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 nation. Project proposals respond to DOE needs and may introduce novel technologies with potential for new commercial applications. Consistent with good stewardship of public resources, all work will include collaboration with other federal laboratories, industry, and universities through cost-sharing arrangements. Sandia also will 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 Microsystems and Engineering Sciences Applications Complex

Microelectronic components have long been critical to almost every DOE Defense Programs mission, initiative, and program. These components have largely determined the reliability of weapon systems, the precision of weapon delivery to the target, and the operability of weapons in the severe environments encountered during delivery. Satellites that monitor compliance with international arms control agreements also require the special durability offered by the radiation-hardened microelectronics for which Sandia is the world leader.

Today, however, Sandia has pioneered a new and far more advanced form of microcomponent, the integrated microsystem. Microsystems are a new generation of integrated circuits, capable of thinking, sensing, acting, and communicating. These amazing devices are created by combining integrated circuit, microelectromechanical system, sensor, and photonic technologies on a single chip. Sandia is already exploring a component that would combine radiation-hardened microelectronics, chemical and mechanical sensors, and a wide array of miniaturized electromechanical micromachines to open the doors to new kinds of strong links, inertial sensors, trajectory sensing safing systems, and weapon state-of-health monitors. Sandia's rapid progress and the advantages offered by these new types of integrated components are so compelling that the United States must make every effort to integrate them into planned cycles of weapons component replacement and refurbishment as soon as possible.

The stockpile is aging, the components within existing weapons are aging, and we need to begin replacing some key components within the next decade. In many (if not most) cases, we cannot replace these components by building replicas of the original designs. In many cases, the supplier base, technology, materials, and design tools no longer exist to build the obsolete items in the stockpile today. In other cases, modern environmental regulations prevent the use of older materials and methods. In all cases, the cost to recreate obsolete technologies will be high.

Microsystems are the answer to affordably refurbish the stockpile while simultaneously gaining critical advantages in recent and continuing changes in the global security environment. First, microsystems are so small that a single microsystem can replace dozens of much larger and heavier conventional components and still enable more functions (specifically safety and security) to be packed into a given space. This smaller size allows the use of deeply embedded, expanded coverage, and enhanced-fidelity joint test assembly functions in systems to diagnose and communicate their condition at all times. Second, because microsystems are small, they are rugged—extremely tolerant of shock and vibration. Microsystems have been taken to 100,000-gravity levels without failure. Third, microsystems are modular and inherently reconfigurable, enabling the development of an integrated component suite suitable for use in multiple weapon platforms. Fourth, microsystems are inexpensive because they are batch fabricated. For example, airbag deployment systems in cars using traditional technology cost about $1,200. Today, using microsystem technology pioneered at Sandia, this same function is performed for under five dollars. Because microsystem components will be lighter and smaller to carry, they can also reduce the cost of future delivery systems. Fifth, microsystems are reliable because they are batch fabricated using integrated circuit techniques; thus, the same levels of process control and reliability can be obtained.

In addition to the advantages that come from using modern technology in weapons, the exciting new technologies associated with microsystems will also help us to recruit and retain our share of the nation's top scientists and engineers. Refurbishing the stockpile is not easy and continues to require the best efforts of our brightest technical minds. To motivate such people to come to Sandia and to stay here, we must offer them stimulating and challenging work.

As noted by various external review groups, working at Sandia is stimulating and challenging because we are the world leader in microsystems. There is no comparable commercial capability, and even with technology transfer there will not be an adequate commercial capability to meet pressing stockpile needs. Thus, a capability at Sandia is likely to be the only means of meeting the long-term needs of stockpile stewardship through integrated microsystems.

Today, Sandia has only research, development, and demonstration capabilities in these amazing devices. We use the facilities of both our existing Compound Semiconductor Research Laboratory (which has aged to the point where it must be recapitalized) and our existing Microelectronics Development Laboratory (which is the nation's foundation for defense radiation-hardened microelectronics but also needs equipment recapitalization).

Although we can best meet critical stockpile needs using new microsystem technology, we cannot do so by forgetting other responsibilities. We must preserve 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 0.5 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; therefore, commercial 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 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 circumvention and code-storage applications. If remaining vendors are unable to supply stockpile needs for current or future

This artist's conception shows the proposed Microsystems and Engineering Sciences Applications (MESA) Complex.

technologies, the DOE would encounter a substantial delay without Sandia's microelectronics program. Such a delay could affect large portions of the stockpile.

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; however, Sandia must provide components with production volumes too small to interest the private sector. This focused program allows Sandia to sustain and develop radiation-hardening technologies for quick transfer to industry as needed and expedites the entry of new suppliers into this specialized market. 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 designated Sandia as the contingency development and fabrication facility for radiation-hardened microelectronics. We meet these responsibilities through the existing Microelectronics Development Laboratory by using facilities, equipment, and staff that the DOE has already assembled. The Microelectronics Development Laboratory is equipped to manufacture 0.5-micron semiconductors on six-inch wafers, but 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.

This artist's conception shows the proposed Deep Space 1 unmanned spacecraft. Such spacecraft will need the radiation-hardened chips Sandia is developing for use in satellites, space vehicles, and defense systems.

Thus, if we are to meet the need for microsystems in the stockpile, we must recapitalize both the Compound Semiconductor Research Laboratory and the Microelectronics Development Laboratory. In combination with the Microelectronics Development Laboratory, we also need another facility that will produce certified microsystems products for DOE Defense Programs systems. Moreover, to accomplish this goal in the time frame required to meet pressing stockpile refurbishment schedules, we must rely on and incorporate the most advanced elements of our integrated product and process design capabilities. For example, we must make the most advanced use of concurrent engineering techniques and computational modeling and simulation technologies to develop modular design tools that will enable weapon component designers to design, develop, engineer, test, and certify microsystem replacements on a greatly accelerated schedule.

To meet this objective, we must develop a Microsystems and Engineering Sciences Applications (MESA) Complex to integrate the recapitalization of the Compound Semiconductor Research Laboratory and Microelectronics Development Laboratory and to develop new capabilities required to fulfill pressing stockpile refurbishment needs.

Table 7.1.1. Additional Funding Requirements for the Microsystems and Engineering Sciences Applications Complex (Dollars in Constant FY 1999 Millions; Personnel in FTEs)

	Year 1	Year 2	Year 3	Year 4
Operating	20.0	20.0	20.0	20.0
Construction	18.2	48.3	109.6	95.0
Total Cost	38.2	68.3	129.6	115.0
Direct Personnel	68	80	92	100

7.1.2 A Modernized and Expanded Cooperative Monitoring Center and Program

The end of the Cold War has produced a dynamic world characterized by rapid industrialization, regional rivalries, localized arms races, and competition for living space and resources—all at a time when the spread of advanced technology is increasing global military capabilities.

Within the last decade, military technologies have spread, including weapons of mass destruction and the means to

Institutional Plan Team

Executive Staff Director
D. Jerry Allen / Sandia

Department Chair
Lori Parrott / Sandia

Project Lead
Dan Garber / Sandia

Technical Writing / Editing
Tim Peterson / TRI

Technical Editing / Indexing
Sally Kmetz / TRI

Technical Editing
Mary Ann Cordova / TRI

Text Processing
Debbie Rivard / TRI

Concept, Design, and Production
Arnold Puentes / TRI

Design and Production
Rosanne Rohac / TRI

Sandia is a multiprogram engineering and science laboratory operated by Lockheed Martin Corporation for the United States Department of Energy. Sandia has major research and development responsibilities for nuclear weapons, arms control, energy, the environment, economic competitiveness, and other areas of importance to the nation. Sandia's principal mission is to support national defense policies by ensuring that the nuclear weapons stockpile meets the highest standards of safety, reliability, security, use control, and military performance.

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D. Jerry Allen • Stephen S. Baca • Sandra J. Barnes

Jon A. Bedingfield • Gary N. Beeler • Joy Bemesderfer • Larry D. Bertholf

Felton W. Bingham • Michael A. Blackledge • Thomas E. Blejwas • Paul E. Brewer Jr.

Richard J. Buss • William J. Camp • Julie C. Clausen • Donald L. Cook • David W. Corbett

Dona L. Crawford • John C. Cummings Jr. • William R. Dawes Jr. • Michael D. Dewitte • Sudip S. Dosanjh

Linda D. Duffy • Robert J. Eagan • Charles E. Emery • Melanie H. Florez • Robert J. T. Fraser • Corina E. Gallegos

Frank Gallegos • Polli H. Gerstle • Karen G. Gillings • Steven E. Grieco • Carlos T. Griego Jr. • Larry K. Grube

Lynda G. Hadley • Danny L. Hartley • Christian (Neil) Hartwigsen • Margaret A. Harvey • Edward L. Hathaway III

Thomas O. Hunter • Jay F. Jakubczak II • William L. Jenkins Jr. • Barbara J. Jones • M. Lynn Jones • Jeffrey W. Kallio

Berweida E. Learson • James R. Lee • Jannifer L. Levin • Theresa A. Lovato • William C. Lovejoy III • Gregory A. Mace

Christopher J. Madigan • Connie R. Martin • William J. Mclean • Paul J. McWhorter • Charles E. (Chuck) Meyers

Teresa A. Mills • Randy J. Montoya • Kevin D. Murphy • Melissa J. Murphy • David R. Myers • J. Alan Nichelason

Michael E. Norte • Anna W. Nusbaum • Lori K. Parrott • John P. Petronis • Samuel T. Picraux • Lynne A. Powell

Douglas G. Prout • Jeffrey P. Quintenz • Paul S. Raglin • Camille M. Reyes • C. Paul Robinson • Richard W. Rohde

Lourdes M. Romero • Alton D. Romig Jr. • John A. Sayre • Barry L. Schrader • Donald G. Schueler

Paul E. Shoemaker • Russell F. Smith • Rebecca A. Statler • Peggy L. Stevens • Amy S. Tapia

James A. Tegnelia • Joanne M. Trujillo • Frank P. Tully • Michael O. Vahle • Anne Van Arsdall

Samuel G. Varnado • John Vitko Jr. • Douglas L. Weaver • Charline A. Wells

Henry R. Westrich • Kenneth L. Wilson • James B. Woodard

Joan B. Woodard

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