INSTITUTIONAL PLAN

FY 1998 - FY 2003

SCIENCE SERVING SOCIETY

Front and Back Cover: The Accelerated Strategic Computing Initiative is playing a vital role in the Laboratory's central mission, Reducing the Global Nuclear Danger (shown in the illustration on the front cover). A major thrust in the ASCI Program is the understanding of turbulent flows in complex systems. The image on the front and back cover shows the late-time material densities (blue to red corresponding to low to high) for a radiation-hydrodynamics simulation of a NOVA laser high-energy-density physics experiment. In this experiment, researchers are investigating turbulent flows in a shock tube driven by a cylindrical hohlraum that reaches temperatures of about 2.5 million degrees Celsius. It was the inclusion of various 2-D approximations of the hohlraum in these calculations that led to a better understanding of the shock-tube results. Because the late-time hydro evolution is driven by the initial 3-D geometry, 3-D calculations on the ASCI Blue Mountain supercomputer (shown on the back cover) at Los Alamos are anticipated.

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**INSTITUTIONAL PLAN
FY 1998 - FY 2003**

SCIENCE SERVING SOCIETY

Los Alamos **MASTER**
NATIONAL LABORATORY

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PREFACE

The Institutional Plan has been rearranged this year as a reflection of new Department of Energy (DOE) guidelines and to better illustrate the Laboratory's mission-oriented focus.

In Section I of this plan, we set forth our vision, mission, core competencies, strategic view, and related material. This section illustrates integration with the vision, mission, priorities, and core businesses of DOE. We define strategies, tactics, and guidelines and describe how we measure progress.

In Section II, we have elaborated on how we plan to address the Laboratory's mission, describing programs and activities in the context of their role in this mission. Section III contains information on our approach to managing our business and operations. First we address our most critical issue—safety. In this section, we confirm that Los Alamos is addressing the DOE critical success factors and describe the initiatives and plans that make our mission successful and lead us toward our vision. Section IV contains details of our resource projections.

This is the last Institutional Plan produced under the present Laboratory Director, Dr. Siegfried S. Hecker. Dr. Hecker has announced his intention to step down as Director of the Laboratory on October 1, 1997. The University of California's intentions are to have the sixth Director in place by the first of October.

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DIRECTOR'S STATEMENT

As I prepare to turn the leadership of this Laboratory over to my successor, it is appropriate that I reflect on the changes that have occurred at the Laboratory and in the world in which we do our work. The last 12 years have certainly not been without drama and change; indeed, revolution is not too strong a term. When I accepted responsibility for this Laboratory, we were in the midst of a major weapon buildup, including design and testing of several new nuclear weapon systems. Within 5 years, the Soviet Union, the entity that had driven so much of our work for the past 40 years, was no more. Today, we are committed to the idea that nuclear testing is a thing of the past. We are working to ensure the orderly reduction of nuclear weapon systems in the world, and we are working with our former adversaries in Russia to help them do the same.

This period has seen two other dramatic changes that have profoundly affected the Laboratory. The 1980s saw a revolution—the quality revolution—in the way business does business. While we were late in realizing the effect this revolution would have on our operations, we finally saw the light, and we are working to incorporate quality concepts into everything we do. We are moving forward by learning from the best the business world has to offer, such as Motorola, AT&T, and Milliken. However, we are not a business in the strictest sense; we are a government operation, and we must adapt quality principles from a business to a government setting. We continue to work to improve the quality and productivity of our Laboratory. We have no choice but to do this if we are to continue to serve the nation as we have in the past.

The 1980s also saw a revolution in the way the public perceives the operations of government. In 1984, a court decision held that the Oak Ridge National Laboratory was subject to the Resource Conservation and Recovery Act and enforcement by EPA and the states. In the wake of this decision, a number of states challenged the Department of Energy's assertion of sovereign immunity, and over time, all major environmental statutes have been amended to explicitly require compliance by federal agencies and their contractors, including the Laboratory. The public now expects us to abide by all environment, safety, and health legislation. Indeed, because of the nature of our work, we are held by many to an even higher standard. The Department of Energy and the Laboratory can no longer respond that our work is so important to national security that it is beyond public scrutiny. As a public institution, we must ensure that we merit the public's trust.

The end of the Cold War and its associated arms race, more than anything else, has changed the Laboratory. Where we once worked with a massive production complex to design and develop new nuclear weapons, we are now the core of the nuclear weapons program, even taking on some of those production responsibilities. The immediate demand from the American people was for a "peace dividend," a reduction in the military budgets that had fueled the arms race. It was largely through the efforts of the University of California that we were able to absorb budget cuts through early retirement incentives without the disruptions that large-scale reductions in force would have produced. In another way, the Laboratory's traditions and the university's emphasis on excellence in science also helped us weather the reductions. We knew that whatever national priorities emerged, quality science

would have a role that would allow us to serve the nation's changing needs.

In response to the inquiries of the Galvin Task Force and the evolving mission of the nuclear weapons program, we focused our attention on just what our Laboratory had to offer the nation as we looked to the future. We knew that whatever changes were coming in the long term, we still had to provide for the continued safety, security, and effectiveness of the weapons that remained, including an adequate supply of tritium for the remaining warheads. In collaboration with the weapon laboratories, DOE has responded well to the changing national security situation. The resulting stockpile stewardship and management plan is a coherent and focused view of the nation's needs with respect to the nuclear weapon stockpile. We are working closely with DOE to successfully implement the stockpile stewardship and management plan. The directors of the three nuclear weapon laboratories have the awesome responsibility (by Presidential Directive) of certifying annually that the weapons remaining in the stockpile are safe and reliable; the President of the United States depends on our judgment. While the challenge of certifying the nation's nuclear weapon stockpile to be safe and reliable is daunting, it has helped to rejuvenate the scientific underpinnings of the Laboratory.

We also had to help ensure that the proliferation of weapons of mass destruction, still a very real threat, can be detected and, if necessary, countered. In particular, we must work with our former adversaries in Russia to ensure that the weapons, the specialized knowledge, and the materials that both nations worked so hard to produce do not fall into the wrong hands. We must ensure that the long-term disposition of nuclear materials is consistent with environmental preservation and nonproliferation goals, and we must clean up the legacy of the 50-year development history of the nuclear weapon complex. These tasks form the core of our mission—Reducing the Global Nuclear Danger.

We cannot perform this mission unless we remain a scientific institution of the first rank. For the nation and, indeed, the world to have confidence that our stockpile is safe, secure, and reliable, particularly in the absence of the nuclear testing that provided tangible evidence of our expertise, we must continue to contribute to national needs using our more transparent scientific and technical capabilities. By participating in the nation's broader scientific enterprise, we can contribute to the solution of national problems and underpin our national security role at the same time. Work in support of conventional defense and civilian national goals in energy and the environment, health care, space, and national infrastructure contributes to our reputation for

Siegfried S. Hecker

excellence in science and technology, and thereby increases our confidence in our ability to carry out our national security responsibilities.

Our mission is supported by eight core competencies: nuclear science, plasmas, and beams; nuclear and advanced materials; nuclear weapon science and technology; analysis and assessment; complex experimentation and measurements; theory, modeling, and high-performance computing; bioscience and biotechnology; and earth and environmental systems. These core competencies, in turn, provide the basis for our selective participation in civilian national missions, conventional defense research and development, and industrial partnerships. Work in these areas serves other important national needs while providing critical support to our core mission by strengthening and maintaining our core competencies. Thus, Reducing the Global Nuclear Danger is an effective shorthand for our mission, but it requires an understanding of the competencies needed to fulfill that mission and of how they will be supported.

Much of this work will be done in partnership with other entities. Basic and applied research will involve collaborations with the university community, demonstrating to all that we are as good as the best in the nation. In this, we benefit substantially from our association with the University of California, the premier research institution in the nation, both in direct collaborations and in the visibility that association gives us within the university community. Other work, including a substantial portion of our national defense activities, will be done in partnership with industry. As we take on a limited manufacturing role in nuclear weapons for the nation, we must ensure that we learn from the best in industry how to conduct those operations. These collaborations assist us directly by providing the know-how to accomplish our mission and indirectly by helping us recruit the best talent the nation has to offer, so that we can continue our traditions of excellence.

In the safety arena, we have had a tough 6 years since the Tiger Team, first struggling with rapidly changing DOE orders and directives, rules, and checkers, and now focusing on what we should have started with: an integrated safety management system that puts the emphasis where it should be—on the safe behavior of our staff, both on the job and at home. We are confident that this is the right road to travel and that, coupled with a quality approach, it will take the Laboratory to our destination of an injury-free workplace.

In dealing with the environmental legacy of our past operations and with our activities in environmental stewardship, the future is less clear. We became completely open about our past activities, particularly with respect to human experimentation with plutonium, and we are committed to public scrutiny and participation so that we can earn the public's trust. We are not yet where we would like to be in having earned this public trust, but we have taken steps to point us in the right direction. At the same time, we are beginning to develop a strong working relationship with the four neighboring Indian tribes. By working together on issues of mutual concern, particularly environmental issues, we can begin to earn the trust of the tribes.

With the help of the University of California, corporate citizenship is another area where great progress has been made. The opening of the University's Northern New Mexico office was a good step, and we have established the Los Alamos Foundation to enable the Laboratory to have a philanthropic presence in northern New Mexico. We will concentrate the work of this foundation on education and community development—efforts that will support the Laboratory in the long run as well as the individuals and communities that will benefit directly. We have also added new features to our subcontracting activities, requiring major subcontractors to bring new business, not related to the Laboratory, to northern New Mexico. These actions will do much to foster economic development in the region and to help diversify the economy.

So, we are making progress in improving our relationship with the communities that depend on the Laboratory. I am sure that our efforts in regional economic development and diversity, an enhanced corporate presence by the University, careful environmental stewardship, and a safe workplace will eventually lead to greater public confidence in everything we do.

Keeping our Laboratory first rate and making it attractive to the best talent presents a challenge today. However, we cannot afford to take chances; the consequences of failure are too great. I firmly believe that we can attract the best talent only if we maintain our Laboratory as a first-rate scientific institution, with quality science and technology and quality operations, and with a responsiveness to our communities that exemplifies the best of corporate citizenship. A renewed partnership between the government and the University of California, founded in trust and public service, is essential for success.

As I leave my tenure as director, I can look back on great accomplishments by a great Laboratory, based on the collective excellence of our staff. At the same time, I leave some works in progress. Science-based stockpile stewardship is still unproved, but we must achieve its ends. The quality journey is not yet finished, and we do not yet have the position of public trust our mission deserves and requires. Nevertheless, we have served the nation well in these 12 years, and I have confidence that the future is bright for continued public service to the nation.

LABORATORY OVERVIEW

I. LABORATORY OVERVIEW

In this section of the Institutional Plan, we outline our vision, mission, technical core competencies, and strategies, and we illustrate their alignment with the goals and priorities of the Department of Energy and the nation. Our relationship with the University of California is integral to our success, and thus is incorporated in this section. In developing strategies for fulfilling our mission, the Laboratory builds in flexibility and competency development that allows us to address rapidly occurring national scientific and technical needs. The section entitled Strategic View, describes the decisions and products that result from our strategic planning process. We also include an outline of our Tactical Plan, which provides goals, objectives, and measures for our progress over the next 1 to 2 years. Measuring Our Progress, explains how we evaluate progress toward our vision while we support our mission.

A. VISION

The vision of Los Alamos National Laboratory is that of a national laboratory in which science serves society to enhance global security, preserve the earth, and improve the quality of life through innovations in science and technology and through the management of its business and operations at a world-class level.

In daily usage, we prefer the following short form of this vision: *A customer-focused, unified laboratory where science serves society.*

The strength of Los Alamos lies in its ability to address complex national problems that require integration of an array of disciplines and a variety of capabilities with specialized and even unique facilities. This ability, in conjunction with operational expertise accumulated from the years of addressing our mission, will allow us to attain our vision of enhancing global security, preserving the earth, and improving the quality of life through innovations in science and technology. We strive for scientific, programmatic, operational, and management excellence. We intend to conduct business and operations in a manner that

- secures a safe and healthy workplace;
- protects the environment;
- honors commitments to our workforce and the public;
- provides responsive, comprehensive, integrated solutions to our customers' problems; and
- enhances our scientific and technological capabilities.

We draw on the breadth and depth of our science, technology, and other professions for the common purpose of delivering the best science and technology to our customers.

Embedded in our vision is our contribution to the Department of Energy's (DOE's) vision, which is recorded in the Performance Agreement Between the President and the Secretary of Energy, Fiscal Year 1996 (see Appendix D for Web site address), as follows.

The Department of Energy through its leadership in science and technology will advance U.S. economic, energy, environmental, and national security by being:

- A major partner in world-class science and technology, research centers, and university research.
- A vital contributor to reducing the global nuclear danger through its national security and nonproliferation activities.
- A world leader in environmental restoration, waste management, and pollution prevention.
- A key contributor in developing, applying, and exporting sustainable, clean, and economically competitive energy technologies.
- A key contributor in maintaining U.S. global competitiveness through leadership in environmentally conscious materials, technologies, and industrial processes.
- A safe and rewarding workplace that promotes excellence, nurtures creativity, rewards achievement, and is results-oriented and enjoyable.

B. MISSION

Last year, in the light of Senate ratification of the Strategic Arms Reduction Treaty in January 1996 and the signing of the Comprehensive Test-Ban Treaty by the leaders of many nations, including the five declared nuclear weapons states, the U.S. Government took significant steps toward pursuing a post-Cold War

national security strategy. DOE has, in turn, developed its plans for the future of the nuclear weapons program, which has served to reinforce the importance of the Laboratory's central mission of Reducing the Nuclear Danger (see Figure 1).

Figure 1. The Laboratory's central mission of Reducing the Global Nuclear Danger supports core competencies that enable the Laboratory to contribute to defense, civilian, and industrial needs. In turn, the intellectual challenges of civilian and industrial problems strengthen and help support the core competencies required for the national security mission. Our ability to do great science underpins all of our applied work.

The mission of the Laboratory is depicted as three concentric circles in Figure 1. As shown in the center, our central mission is Reducing the Global Nuclear Danger. Reducing the Nuclear Danger is made up of five areas.

- Stockpile Stewardship ensures that the U.S. has safe, secure, and reliable nuclear weapons.
- Stockpile Management provides capabilities ranging from dismantling to remanufacturing of the enduring stockpile.
- Nuclear Materials Management ensures the availability and safe disposition of plutonium, highly enriched uranium, and tritium.
- Nonproliferation and Counterproliferation help to deter, detect, and respond to the proliferation of weapons of mass destruction.
- Environmental Stewardship provides for the remediation and reduction of wastes from the nuclear weapons complex.

How we address these five areas is described in this plan in Section II.A. Reducing the Nuclear Danger.

As illustrated in the outer portion of Figure 1, we also apply our expertise to key conventional defense and civilian issues that are synergistic with the central mission and with our capabilities. Our focus is on scientific and operational excellence, and we partner with universities and industry to accomplish our mission while addressing the needs of the nation. Our involvement in civilian national missions, conventional defense, and industrial partnerships is essential to our long-term vitality and excellence. Section II.B. Civilian National Missions, Conventional Defense, and Industrial Partnerships of this plan describes how we address these areas of our mission.

The dynamic relationship among these mission elements, the competencies, and the central mission—as described in the caption accompanying Figure 1—is essential to managing our strategic direction.

The Laboratory's mission is aligned with and incorporated in DOE's missions. Our mission supports DOE's mission for its laboratories, which is recorded in DOE Laboratory Operations Board's Strategic Laboratory Missions Plan, July 1996 (see Appendix D for Web site address), as follows:

...to deliver science- and technology-based solutions that serve the Department's national security, energy resources, environmental quality, and science missions. The laboratories develop, maintain, and apply unique, world-leading science and technological facilities and capabilities, and collaborate with industry, universities, and other Federal laboratories to pursue the Department's missions, and make their capabilities available to others in the national interest.

In addition, the Laboratory's mission supports the Secretary of Energy's four top priorities, which are as follows:

- Enhancing energy security and developing and deploying clean energy.
- Ensuring a safe and reliable nuclear weapons stockpile and reducing the global nuclear danger.
- Cleaning up former nuclear weapons sites and finding a more effective and timely path forward for disposing of nuclear waste.
- Leveraging science and technology to advance fundamental knowledge and our country's economic competitiveness with a stronger partnership with the private sector.

The policy of operation at Los Alamos is that in achieving our mission, safety is the first priority. A program of Integrated Safety Management (ISM) is in process to promote a culture of concern for safety at all levels of activity. For more information on ISM and ESH support at the Laboratory, see Section III.A. Safety First. An important component of this safety management program is that each employee applies the five-step process for working safely in all activities. The five steps are as follows: (1) define work, (2) analyze hazards, (3) develop controls, (4) perform work, and (5) ensure performance (see Figure 2). The Laboratory continues to work with DOE and the Defense Nuclear Facilities Safety Board to define both the appropriate standards for work and the safety authorization basis for the facilities. The Laboratory implements a Facilities Management model for all facilities. We are developing a "reward" system to go with the disciplinary actions outlined in the safety accountability matrix. We also are planning to incorporate environmental management with the overall ISM approach.

Figure 2. The five-step process for performing work safely at the Laboratory.

C. TECHNICAL CORE COMPETENCIES

The ability to solve complex problems that require the integration of scientific and technical expertise—an array of disciplines and diverse capabilities—with specialized facilities and operations expertise is a distinguishing characteristic not easily duplicated by other organizations.

The Laboratory's technical core competencies have grown out of its historical mission to develop and maintain the nation's nuclear deterrent. They are key to meeting the challenges of our present central mission to reduce the global nuclear danger. The core competencies contribute to and are sustained by carefully selected conventional defense and civilian programs. Academic collaborations and industrial partnerships are essential to their vitality.

The identification and subsequent strategic nurturing of core competencies allows us to respond to a diversified customer base and to respond rapidly to changing national issues. The core competencies provide a vehicle for strategic investment and estab-

lish a framework for managing change through evolution of the competencies.

The Laboratory has identified eight core competencies. The first three competencies listed emphasize a scientific approach; the last five focus on scientific content.

Scientific Approach

Theory, Modeling, and High-Performance Computing

Los Alamos, building on 50 years of learning and experience, has the special ability to formulate and solve some of the nation's most difficult and complex technical challenges by combining fundamental theory and numerical solution methods with the power of high-performance computing to model a broad range of physical, chemical, and biological processes. This specialized expertise complements our experimental programs with numerical approaches to solving complex, nonlinear problems. These capabilities and the underlying theory, modeling, and high-performance computing contribute to all other core competencies.

Complex Experimentation and Measurements

We are able to field complex experiments involving one or more of the following:

- novel sources such as accelerators, high-power lasers, high explosives, and pulsed-power systems;
- measurements employing multidisciplinary suites of diagnostics or one-of-a-kind measurement systems for a wide range of physical conditions; and
- applications and special research and development facilities for handling radioactive, explosive, and hazardous materials and processes.

Analysis and Assessment

The distinguishing characteristics of our competency in analysis and assessment are the abilities to integrate basic theory and experimental data across multiple disciplines into realistic simulation models; to validate the models through comparison with experiments and other expert information; and to integrate the models into computer programs for independent and unbiased assessment of complex systems. Examples of the latter include weapons performance and surety, energy systems, military systems, transportation, atmosphere and ocean environments, manufacturing and materials processes, nuclear facility performance and safety, and health systems.

Scientific Content

Nuclear and Advanced Materials

The breadth of materials expertise and the specialized facilities at Los Alamos make the Laboratory a national resource for the synthesis, processing, and application of nuclear and advanced materials. The Laboratory has extensive capabilities in metals, ceramics, polymers, and electronic materials of many types in both bulk and thin-film forms. It also has the ability to cast, forge, extrude, draw, form, and machine such materials into complex shapes over a range of sizes from microscopic to massive.

Nuclear Weapons Science and Technology

For 50 years, Los Alamos has provided scientific and engineering leadership in support of the U.S. nuclear deterrent. Our competency in this area is underpinned by a number of capabilities, including

- the science of nuclear weapons design and assessment;
- large-scale calculations of weapons behavior;
- engineering design, specifications, and integration of weapons components;
- the science and technology of weapons materials, with special emphasis on energetic, nuclear, and specialized organic and inorganic materials; and
- experimental measurement, testing, and diagnostics.

Earth and Environmental Systems

The Laboratory integrates strong discipline-oriented knowledge in the earth, environmental, space, chemical, biological, physical, and engineering sciences with skills in theory, modeling, and measurement. The intent is to further strengthen our ability to provide new scientific information and to create new technologies that will help solve the vast array of environmental, energy, and national security problems facing DOE and other agencies.

Bioscience and Biotechnology

The Laboratory's competency in bioscience and biotechnology integrates capabilities in molecular and cellular biology, cytology, structural biology, theoretical biology, spectroscopy, biochemistry, biophysics, and biomedical engineering for the study of life processes, living organisms, and human health. The strength of this competency rests on a close collaboration between experimentalists and theorists; strong interdisciplinary interactions between the physical sciences, life sciences, and engineering; outstanding computer facilities and expertise; and unique facilities that support biotechnology research and development at Los Alamos for the biomedical community at-large.

Nuclear Science, Plasmas, and Beams

Laboratory research in this competency encompasses nuclear and particle physics, astrophysics, nuclear chemistry, plasma physics, accelerator technology, laser science, and beam physics, as well as a wide range of applications such as neutron scattering, transmutation technologies, plasma processing, radiography, microlithography, inertial fusion, and defense applications. The strength of this competency lies in the integration of capabilities ranging from the origin of the beam to its ultimate end use—for example, developing particle accelerators based on a knowledge of the underlying beam physics, understanding how the beam interacts with fields and matter, advancing basic nuclear and plasma sciences based upon these interactions, and developing a wide variety of applications using beams and their interactions.

Core Competency Teams

Associated with each core competency is a team of technical staff members. Among other responsibilities, these teams provide advice to Laboratory management on building and developing Laboratory capabilities and assist in identifying scientific direc-

tions that position the Laboratory to capitalize on future opportunities. The teams help to assess the quality, strength, and breadth of the Laboratory's skills and capabilities.

These core competency teams play an important role in providing input to the investment strategy for our Laboratory-Directed Research and Development (LDRD) funds. Early in the LDRD planning cycle, the teams work with the technical divisions to develop guidance for the areas of skills and capabilities in which the Laboratory may be investing. The teams also participate in the scientific evaluation of the LDRD thrust proposals, which are, typically, large, multidisciplinary initiatives intended to meet the Laboratory's tactical and strategic goals.

In the development of the current Tactical Plan, a number of core competency teams played vital roles in establishing the tactical goals of The Genome and Beyond; Reducing the Threat of Nuclear, Biological, and Chemical Proliferation and Terrorism; and Integrated Environmental Science.

D. UNIVERSITY OF CALIFORNIA MANAGEMENT OF THE LABORATORY

Our ability to develop and maintain technical excellence in our core competencies and programs is strengthened by University of California (UC) management. Los Alamos National Laboratory is owned by DOE and is operated by UC under contract to DOE. This 54-year-old relationship between UC and the federal government has been of great benefit to the nation and represents a major public service by UC.

Enhanced interactions and collaborations among regional institutions, the Laboratory, the UC Office of the President (UCOP), and DOE are being explored and a number of positive steps have already been taken. The UC Northern New Mexico Office was established in July 1996 as a focal point for strengthening UC's relationship with regional communities and other entities within the state. The work of the office is diverse in nature and includes educational outreach to communities, economic development of the region, employee and retiree issues, and topics that enhance the corporate citizenship stature of UC and the Laboratory in the region.

Some of the steps that have been taken are focused on diversifying the regional economy and reducing its dependence on federal expenditures. For example, the Northern New Mexico Procurement Advisory Council was formed with members from regional Chambers of Commerce, the Eight Northern Indian Pueblos Council, and the university. The UCOP and Los Alamos have also initiated a New Mexico University Research Council to foster collaborations between New Mexico universities and the Laboratory. As part of this initiative, the New Mexico Universities Collaborative Research Program supports competitively selected joint-research projects using University of California Directed Research and Development (UCDRD) funds.

The future of these enhanced interactions, in addition to the economic and educational benefits that the Laboratory brings to the region, are dependent on the Laboratory's continued strength in an increasingly competitive research environment. UC has proven to be a significant ingredient in ensuring the quality of the personnel and research capabilities that are essential for the Laboratory to remain competitive in the rapidly changing research marketplace. Some of the ways that UC strengthens the Laboratory, thereby benefiting DOE and the region, are the following:

- world-class standards of excellence for scientific research and enhanced interactions with the top levels of the international scientific community, including the highest-quality independent peer review;
- a large pool of technical capability that is used to meet the objectives of the Laboratory and DOE;
- institutes and scientific centers that foster collaborative research;
- collaborative research involving students and postdoctoral research appointees that provides a recruiting pool of outstanding new scientists for the Laboratory;
- outstanding faculty with institutional expertise (e.g., political science, policy, and sociology) that is important for finding good solutions to complex interdisciplinary problems;
- unique educational and administrative services for Laboratory employees and their families that act as a magnet for retaining and attracting the highest-quality scientists and engineers; and
- standards of openness and integrity for scientific inquiry and reporting that provide Laboratory scientists with an atmosphere that is relatively free of political pressure and constraints from proprietary or profit-making motives.

UC recognizes the value of increasing the level of synergistic interactions among the nine campuses and three laboratories in the UC system, and they are committed to strengthening those ties. The UC Coordination Team at Los Alamos works with the UCOP and the UC system to coordinate programs that foster collaborations. For example, the Complementary and Beneficial Activities funds, which derive from the fee paid for managing the laboratories, are being used by the UCOP to support the Institute for Geophysics and Planetary Physics as well as the competitively selected Campus-Laboratory Collaborations (CLC). Los Alamos is participating in a number of these CLC projects, which include multidisciplinary research topics ranging from nuclear materials management to water resource issues.

Other funds that derive from the fee are returned to the Laboratory Director for research or research-related activities. The Laboratory's UC Coordination Team is using these UCDRD funds to strengthen strategic Laboratory capabilities and to enhance collaborative interactions with the UC campuses and New Mexico universities. These initiatives foster enhanced integration and use of the UC system's unique capabilities. The result will be an even more effective interaction among the Laboratory, the rest of the UC system, New Mexico universities, and DOE that will provide even greater value to the government and the public.

E. GOVERNMENT RELATIONS, CORPORATE CITIZENSHIP, AND PUBLIC AFFAIRS

To facilitate essential areas of communication, both internal and external, the Laboratory maintains three offices: the Government Relations Office, the Community Involvement and Outreach Office (CIO), and the Public Affairs Office, all of which are part of the Laboratory Director's Office.

Government Relations

The Laboratory Government Relations Office provides guidance and support to Laboratory leadership in developing and pre-

senting a coherent view of Laboratory activities, plans, and capabilities to all levels of government. The office provides Laboratory leadership with information about and analyses of governmental and public activities and priorities.

Community Involvement and Outreach

The Laboratory's ability to demonstrate respect for and appreciation of its neighbors will be an increasingly significant factor in determining the long-term viability of the Laboratory and, consequently, in its ability to contribute to the well-being of the region. The Laboratory maintains the CIO, whose mission is to form and strengthen mutually beneficial relationships between the Laboratory and its neighbors. This office handles all involvement and outreach activities; runs the Bradbury Science Museum; is responsible for overseeing the Laboratory's tactical goal on Corporate Citizenship; and ensures that the Laboratory meets the UC prime contract provisions in this area. It maintains a close partnership with the Laboratory Public Affairs Office (described in the next section) to coordinate efforts.

Community outreach efforts focus on face-to-face interactions with community stakeholders. Public involvement programs involve the public in the Laboratory's decision-making process. Information-sharing activities inform stakeholders about Laboratory operations and activities. Key customers for these activities are local, state, and tribal governments, regional businesses, community organizations (such as civic groups and nonprofit economic development institutions), local educational institutions, the general public, special interest groups, and Laboratory division and program offices.

In March 1996, the Laboratory created a new position in the Director's Office to address institutional development. It began an initiative to improve the outreach processes. A key component of this initiative was the formation of an executive team to ensure effective coordination and integration of the Laboratory's wide variety of outreach programs. The team, known as the Outreach Coordination Council, identifies key customers, performs assessments of community needs, and allocates resources to optimize outreach efforts. In May 1997, the Regional Economic Development Team merged with CIO as part of the improvement initiative.

The Laboratory intends to continue to improve efficiency in the area of community relations. An assessment of community stakeholder needs is being conducted through the Outreach Coordination Council. This assessment is expected to lead to a more coordinated and consolidated program of appropriate outreach activities.

Public Affairs

The Laboratory Director's Office prioritizes public affairs activities at Los Alamos. The Public Affairs Office, whose mission is to provide the best in communication programs to support the scientific activities of Los Alamos National Laboratory, implements the programs. This office is staffed by public affairs professionals with capabilities that include media relations, employee communications, strategic public affairs planning, radio work, science and technology story development, conference and visit management, and public affairs counsel. The Public Affairs Office comprises three groups: Public Information, which includes me-

dia relations and employee communications teams; Plans, Issues and Programs; and Conference and Visit Management.

Public Information customers include both external and internal audiences. External audiences—local, regional and national—learn about Laboratory programs through media relations activities. Last year, an aggressive media relations program reached more than 165 million readers. The Employee Communications Team targets the internal audience of the Laboratory by publishing a daily electronic newspaper and a monthly employee magazine, *Reflections*. These two publications serve also to inform Laboratory retirees of Laboratory activities.

The Plans, Issues, and Programs Group has numerous internal customers, as it interacts with public affairs liaison personnel in each Laboratory organization. The monthly on-line publication, *The Public Affairs Report*, provides information internally and generates feedback. A monthly magazine, *Dateline: Los Alamos*, targets external audiences and describes science and technology achievements and programs at the Laboratory. Radio outreach work targets local audiences from Albuquerque to the Colorado border. Radio outreach to the Hispanic community was implemented with Radio Lobo, one of the state's largest Hispanic radio stations. A second radio outreach program with veteran Ernie Mills, who does statewide legislative reports (Capitol Hill Report and *Dateline: Santa Fe*), was also implemented. In addition, the Plans, Issues, and Programs Group is the source of expertise for other Laboratory organizations in communication planning and in providing national platforms for Laboratory issues, projects, and speakers.

The Conference and Visit Management Group handled more than 690 conferences and visits last year. More than 10,000 external customers were exposed to Laboratory programs. This group assists Laboratory management in its outreach to external clients and audiences. The work of this group has an economic impact on Northern New Mexico; visits to the Laboratory generated more than \$3 million in room rentals. The Conference and Visit Management Group is also the executive agent for Laboratory colloquiums (last year there were 69).

Public Affairs is a management function reflecting the approach of the Laboratory Director, and it is guided by an external review committee. Regardless of changes in public affairs strategies, the office's mission remains constant.

F. STRATEGY

External Environment

Technical, political, social, and economic forces all affect the Laboratory's strategic direction. Although these forces have always been drivers for the Laboratory, today they are changing more rapidly than ever before and must be incorporated into the Laboratory's strategic thinking. In a changing world, national security threats now come from countries other than just the former Soviet Union, and the national security environment is, and will remain, complex and ambiguous.

During 1996, the United States took action on two major treaties directed at reducing the global nuclear danger. In January, the Strategic Arms Reduction Treaty (START) II was ratified by the Senate; the United States and Russia are on a clear path to the reduction of nuclear strategic systems. Following this success, the leaders of the five declared nuclear weapons states, among many

others, signed the Comprehensive Test Ban Treaty (CTBT) in New York in September. Acceptance of this treaty by the nuclear weapons states and the vast majority of the community of nations is a significant development. These events come on the heels of the indefinite extension by the United Nations of the Nonproliferation Treaty (NPT) last year.

The CTBT effects some constraint on new nuclear weapons development activities by the nuclear powers and strong inhibition to the acquisition of sophisticated nuclear weapons capability by nonnuclear weapons states. The NPT will help limit the spread of nuclear weapons and nuclear materials capabilities and help safeguard weapons-capable materials from diversion to clandestine weapons programs. Together with START I and II, these agreements form the cornerstones for a new, stable era in nuclear weapons. President Clinton has clearly reaffirmed the critical role of nuclear weapons to deter war and keep the peace:

The United States must and 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.

Moreover, in his call for negotiation of a zero-yield comprehensive test ban, the President stated, in August 1995, the following:

As a central part of this decision, I am establishing concrete, specific safeguards that define the conditions under which the United States will enter into a comprehensive test ban. These safeguards will strengthen our commitments in the areas of intelligence, monitoring and verification, stockpile stewardship, maintenance of our nuclear laboratories, and test readiness.

The DOE weapons laboratories are charged, then, with keeping those weapons deemed critical for national security safe and reliable in the following environment:

- there will be no nuclear testing;
- there is no new-design nuclear weapons production;
- core nuclear weapons funding is nearly 50% lower than in the late 1980s;
- the proliferation of weapons of mass destruction and materials with potential to produce such weapons is of increasing concern; and
- START and U.S. national security policy require a reduced stockpile along with continued nuclear deterrence, necessitating high confidence in the safety and reliability of the remaining inventory.

The U.S. plan to accomplish this task is science-based stockpile stewardship. Science-based stockpile stewardship will require enhanced surveillance so that we can understand the changes that will inevitably occur in the materials in weapons. It will require that we understand the fundamental science involved so that we can assess the effects those changes may have on weapons performance. It also will require that we do this with sufficient predictive capability so that we can respond, in a timely way, with remanufactured parts that will preserve the integrity of the stockpile. Stockpile Stewardship and Stockpile Management mission elements combine with other key components such as nonproliferation of weapons of mass destruction and the resolution of problems associated with 50 years of nuclear weapons production

to fulfill the Laboratory's mission of Reducing the Global Nuclear Danger.

Strategic Planning

Strategic planning is especially important during rapidly changing times. DOE weapons laboratories have experienced three strong driving forces over the past 10 years:

- the end of the Cold War,
- dramatically increased public concern and a stricter regulatory environment, and
- the quality and productivity revolution.

In 1992, we began a strategic thinking and planning process. This process took on an increased sense of urgency when the Secretary of Energy commissioned the 1994 Galvin task force to look at the future of the laboratories. We have concluded that it is crucial for our institution to strive for four things:

- a compelling national mission,
- great science,
- world-class operations, and
- good corporate citizenship.

Institutional planning at Los Alamos interconnects with DOE Strategic Planning. Our compelling national mission was developed in concert with the DOE Defense Programs' strategic planning and mission-focusing effort and was reinforced by our own planning process. Planning in this environment requires a process that builds in flexibility, allowing a quick response to an identified opportunity. Our planning process produces a continuous discussion concerning the Laboratory's future. From these discussions come strategic direction and from strategy comes action plans (see Figure 3) that move the Laboratory forward as the strategies and plans evolve.

There are currently three documents that represent the Laboratory's strategic planning efforts at the institutional level: (1) the Strategic Overview, in which we define our overall direction; (2) the Tactical Plan, in which we set short-term goals, targets, and measures for selected areas; and (3) the Institutional Plan, which describes our strategies and plans at a Laboratory-wide level, as well as the plans and activities of technical and operational elements of the Laboratory. Other planning activities such as those of facilities, Human Resources, the technical divisions, the program offices, and our major contractors, as well as Laboratory-wide processes such as the Capital Assets Management Process and the budgeting process are all guided by the products of our planning system.

In the Strategic Overview (see Appendix D for Web site address), we define a value basis for all Laboratory planning. We consider the long-term perspective (15 to 20 years) with our vision and mission statement. We have identified, at a high level, our core technical competencies and a set of strategies. The strategies guide our investments in programs and core competencies. They reflect the focus of our mission and guide us toward our vision. The strategies are as follows:

- maintain a strong, innovative, defense core with a nuclear focus;
- emphasize science and strengthen our core technical competencies within the defense core, teaming with universities as appropriate;

Figure 3. Strategy evolution at the institutional level.

- use our science and technology base to support both civilian and conventional defense programs that are critical to retaining the multiprogram nature of the Laboratory in areas that strengthen core competencies;
- while becoming more customer focused, continue to balance program (market) pull with technology push;
- manage our business and operations at a world-class level; and
- partner with industry when appropriate.

The Strategic Overview describes the strategic management of our programs and capabilities as follows:

As national issues evolve, the Laboratory draws from its capabilities to develop new programs that respond to customer requirements. These programs involve advancing our capabilities into new frontiers, often leading to the creation of new capabilities. New capabilities allow us to enhance existing programs and to respond to new national issues. (See Figure 4.)

Figure 4. We manage our capabilities, our programs, and the interaction between them.

We consciously manage, nurture, and build capabilities to respond to future national needs, while focused, integrated program-development allows us to tackle new, complex issues. Laboratory entrepreneurs provide the seeds for developing new technologies and applying current capabilities in ways that will spawn new, emerging capabilities. Not only is there cycling among the mission areas and among large and small projects, but

there is also cycling between programs and associated capabilities.

Our strength as a Laboratory lies in our ability to adjust to new conditions by managing this cycle well. As we move into an uncertain future, our ability to invest wisely in both capabilities and programs will be a key to our success and will allow us to be responsive to our customers. While our investments will be increasingly aligned with our vision and mission, our process for making these investments will require increased flexibility for responding to unpredictable circumstances.

Of particular importance to supporting the strategic and tactical plan, and to stretching the Laboratory's capabilities, is the Laboratory-Directed Research and Development (LDRD) Program. The program funds basic and applied research and development (R&D) focusing on early exploration and exploitation of creative concepts selected at the discretion of the Laboratory Director. By encouraging multidisciplinary and multidivisional research, the LDRD Program helps to ensure a strong science and technology base and to retain the Laboratory's intellectual vitality.

In the Strategic Overview, we define a set of guiding principles that direct our behavior and interactions with our customers, stakeholders, workforce, and neighbors. They are as follows:

- We identify and meet customer needs.
 - We monitor external events to anticipate and respond to national issues as appropriate.
- We select, develop, and nurture our capabilities to respond to customer requirements and to build for the future.
 - We strategically select and nurture those technical competencies that will prepare us to anticipate and meet customer requirements.
 - We invest in technical competencies in which we are or intend to be world class.
- We develop and sustain a diverse, creative, and productive workforce.
 - We treat our coworkers, customers, and stakeholders with integrity, honesty, and respect.
 - We value our differences as a creative resource to generate competitive advantage.

- We form partnerships to increase the value of our products and services to our customers.
 - We evaluate programs and operations to determine which products and services should be obtained externally.
 - We partner with industry; academia; other Laboratories; federal, state, and local governments; and our neighbors to achieve excellence.
- Our products and services are of the highest quality and are produced safely, cost-effectively, and efficiently.
 - We protect the workforce, the public, and the environment by continually improving our operations.
 - We strive to attain the highest standards in our management of business and operations.
 - We encourage the free exchange of knowledge and information within the Laboratory and with the public.
 - We involve the workforce, customers, and stakeholders in decisions that affect the future of the Laboratory and its neighbors.
 - We strive to be cost-effective and productive in everything we do.
- We continually improve our work, our services, and our products.
 - We measure our performance.
 - We identify key performance measures and review our performance continuously to improve processes, products, and services.
 - We use criteria from the Malcolm Baldrige National Quality Award to measure our progress as an institution.

The Strategic Overview is based on information from customers, the stakeholder community, the workforce at all levels, university professors, and DOE managers, as well as market analysis, technology innovation analysis, and industry needs analysis. There is a strong link to the DOE mission statement and the Department's core values (see Appendix D for Web site address).

The Laboratory's Tactical Plan (see Appendix D for Web site address) is the basis for action planning that determines direction and addresses key institutional strategies. This plan sets specific near-term (1- to 3-year) goals. The current Tactical Plan was initiated in June of 1996. The plan and process used to develop the current Tactical Plan derive from the previous, our first, Tactical Plan. Improvements were built on results from the FY95 goals, DOE Award comments, customer comments, and the UC/DOE Contract Performance Assessment, as well as from feedback from the Laboratory management and workforce. Implemented improvements from 1995 include (1) increased use of programmatic and operational data, (2) a longer period to address the same goals, (3) data from focus groups being solicited and applied to the creation of new goals, and (4) results from the FY95 goals being collected and shared with the workforce and stakeholders.

The current Tactical Plan for FY96-98 includes 11 tactical goals—4 operational and 7 programmatic/technical—each with defined tactics, specific measures, and targets for performance. This plan emphasizes and embodies strategies and principles laid out in the Strategic Overview. The Laboratory's 11 tactical goals are as follows.

1. *Safety First!*—The Laboratory will perform all work safely and will strive to eliminate injuries and to reduce adverse environmental and health impacts. All Laboratory operations will meet applicable regulations, conserve natural re-

sources, and respond to the public's expectations for safety and for protection of the environment.

2. *Productivity and Strategic Business Development*—Improve the productivity of internal Laboratory processes. Increase the value to customers of our programs and competencies. Assess and develop opportunities for Laboratory work consistent with our national mission.
3. *Embrace Diversity*—Aggressively strive for improvement in three areas identified in the Diversity Strategic Plan: enhance workforce diversity in the technical staff member and official and manager categories, strengthen science education outreach programs, and increase the involvement of the surrounding communities in our diversity efforts.
4. *Corporate Citizenship*—Be valued as a good corporate citizen of New Mexico.
5. *Science-Based Stockpile Stewardship and Management*—Develop the ability to certify the safety, reliability, and performance of nuclear weapons that have changed because of age or remanufacture. Use all the Laboratory's technical capabilities, from basic research through process engineering, while concentrating this year on radiography, advanced computing, enhanced surveillance, and integrated manufacturing.
6. *The Neutron Laboratory*—Strengthen support and recognition for the Los Alamos Neutron Science Center and the Accelerator Production of Tritium through important contributions to the DOE Stockpile Stewardship and Management Program and by providing the basic and industrial research community with excellent research capabilities and reliable operations.
7. *The Plutonium Future*—Complete the Laboratory process to explore visions for dealing with the plutonium future. Develop and apply the Laboratory's capabilities to the management and control of plutonium arising from nuclear weapons dismantlement, downsizing of U.S. and Russian nuclear weapons production complexes, and nuclear power activities.
8. *Reducing the Threat of Nuclear, Biological, and Chemical (NBC) Proliferation and Terrorism*—Support establishing a national agenda for reducing the threat of NBC proliferation and terrorism, broaden the DOE's role to include the biological and chemical threat areas, and position Los Alamos as a major resource with DOE, DoD, the Intelligence Community, and other federal agencies.
9. *Integrated Environmental Science*—Develop a detailed approach that will allow the Laboratory to strengthen, coordinate, and apply all of the Laboratory's relevant competencies to better address the environmental legacy and operational issues of the DOE. Improve our understanding of environmental processes and develop technologies to address public- and private-sector environmental problems.
10. *Modeling, Simulation, and High-Performance Computing*—Build the Partnership for Advanced Computing to define the leading edge of computing and use it to enable science-based stockpile stewardship, global climate studies, and other grand scientific and technological challenges at the Laboratory and other institutions.
11. *The Genome and Beyond*—Strengthen and integrate genome, structural, and computational biology capabilities.

ties and apply them to key Laboratory programs in health, environment, national security, and industrial applications.

A report of results from implementation of these goals is available on the Tactical Goals web page referred to previously.

Program Development and Project Execution

The core processes that we call program development and project execution are the lifeblood of the Laboratory. In this context, the term "program development" refers to the effort to secure support for an activity as small as a single investigator project or as large as the Nuclear Weapons Program. During analysis of our processes some years ago, a number of problems with program development and project execution were identified.

The need to improve program development and project execution was a strong motivator for reengineering and restructuring at the Laboratory. Management roles and responsibilities were designed to improve and clarify program development and project execution processes. The program development process is designed to provide the following:

- Flexibility to accommodate large and small programs and to respond quickly.
- An opportunity for any employee to champion an idea.
- Clearly defined roles and responsibilities for project development decisions.
- Thorough concept analysis (appropriate to program size).
- Evaluation of project opportunities relative to the Laboratory strategic plan.
- An optimized customer interaction, as follows:
 - a well-coordinated Laboratory interaction with each customer;
 - effective teaming between champion and program offices;
 - good understanding of customer needs and opportunities; and
 - effective proposals.

The project execution process is designed to provide the following:

- Appointment of a project leader with authority commensurate with responsibility.
 - Appointment is based on nominations from "capability organizations," with selection by cognizant program manager or program director.
- Reconciliation of project commitments with project funding.
- Development of project execution plan.
- Formation of a project team that involves the best available resources.
- Allocations are done nonparochially.
- Balanced power of "capability managers" and project leaders in negotiating resource commitments. Commitments can include
 - people,
 - services, and
 - products.
- Written agreements ("contracts") between the project leader and other participants to clarify mutual commitments.

- Effective communication with the customer.
- Assessment of performance.
- Learning from project experience for future development.

Efforts to improve these processes and their connections to each other are ongoing and important. Current efforts are focusing on improving and making more consistent the channel between the program offices that develop the programs and the line organizations that implement the projects.

G. MEASURING OUR PROGRESS

At Los Alamos, we systematically analyze information and data about employees, processes, products, and customers. The criteria for developing measures and selecting data and information are provided by contract obligations, regulatory agency requirements, the Laboratory's core mission and Tactical Plan, quality-driven business practices, and operational performance improvement criteria. We measure our performance and use results to consolidate our strengths and remedy our weaknesses.

Our major criteria for measuring progress at a Laboratory-wide level are the Performance Assessment criteria of the DOE/UC contract and the Malcolm Baldrige National Quality Award/DOE Quality Award, which are discussed in this section. Other criteria include tactical planning measures, employee survey, customer feedback, external reviews, and performance appraisals.

DOE/UC Contract Performance Assessment

Los Alamos National Laboratory is operated under a contract between DOE (acting for the federal government) and UC. Five years ago, when the 1992 DOE/UC contract was adopted, DOE and UC pioneered performance-based contracting. Specific requirements for the use of objective standards of performance, self-assessment, and performance evaluation are discussed in the 1992 contract. Appendix F of this contract contains the performance measures that compose the performance management system. The new contract is expected to continue the requirement for application and improvement of this system.

The contract performance evaluation incorporates provisions to measure the Laboratory's performance in two specific areas: (1) science and technology and (2) administrative and operations systems, which includes items such as environmental, safety, and health (ES&H), business operations, facilities management, and human resources. UC uses the Science and Technology Assessment reports, prepared by the Laboratory's Science and Technology Base Program Office (STB), and the administrative and operations systems results, coordinated by the Laboratory's Quality and Planning Program Office, to prepare an overall report that it submits to DOE. DOE publishes an annual appraisal of the Laboratory's performance. (See U.S. Department of Energy, Albuquerque Operations Office FY1996 Performance Appraisal of the Los Alamos National Laboratory.)

Science and Technology Assessment

The Laboratory has a tradition of using external peer reviews to assess the quality of its science and technology. Such peer reviews have taken on added importance as a result of the most re-

cent contracts between UC and DOE for management of Lawrence Berkeley, Lawrence Livermore, and Los Alamos national laboratories. These DOE/UC contracts call for the laboratories to conduct annual Science and Technology Assessments. The Planning and Assessment Team at STB is responsible for ensuring that the Laboratory satisfies the assessment requirement. The principal input to the assessment is based on reviews conducted by 15 committees, one for each technical division. Our report along with the administrative systems results are submitted to the UCOP. The university evaluates the report and submits a report to DOE, which uses this information as part of its assessment of the Laboratory. This assessment process has also provided UC with a more in-depth view of the capabilities of the laboratories it manages. This process has helped to strengthen the existing ties between the university and the laboratories and is fostering new relationships as well.

STB develops the procedures for conducting these technical reviews, works with the 15 technical divisions to establish their division review committees (DRCs), coordinates the scheduling of the committee visits, and prepares and submits the assessment report to the UCOP. For more information on the role of the DRCs, see Appendix D for the Web site address.

Each DRC evaluates its division according to four broad criteria:

- quality of science and engineering,
- relevance to national needs and agency missions,
- performance in the construction and operation of major research facilities, and
- programmatic performance and planning.

The DRCs have already provided incisive and candid feedback and advice to Laboratory management regarding the quality of our science and technology and our programmatic contributions. They have helped us validate areas of excellence, noted areas requiring attention, and suggested directions representing future opportunities for the Laboratory. As we embark upon the 1997 review cycle, the UC-managed laboratories (Los Alamos, Lawrence Livermore, and Lawrence Berkeley) are working with UCOP and DOE to continue to refine and improve the assessment process.

Administrative and Operations Systems

Performance measures for the assessment of administrative and operations systems are listed in Appendix F of the DOE/UC contract and are renegotiated every year (for more information, see Appendix D for the Web site address). The Laboratory performance scores for FY96 are higher than those in FY95 and FY94. Working relationships among DOE and the Laboratory functional areas were better this year because this is the second year that all functional areas have reported quarterly to DOE. Working relationships were also enhanced by the business oversight process in the business areas and more frequent and structured meetings among the senior managers of the Laboratory, the DOE Los Alamos Operations Office, and the DOE Albuquerque Operations Office. During the most recent evaluation period, it was clear that communication had progressed, but the Laboratory, DOE, and UC will continue working to improve. The system for providing and exchanging requirements information is one important area that needs attention.

Figures 5–7 show a comparison of DOE ratings over time from FY93 to FY96. The administrative and operations area

shows the greatest rate of increase. The science and technology ratings have also increased but in smaller increments because of the relatively high starting point. These continued increases in ratings have been accomplished while decreasing the cost per research FTE, as shown in Figure 8.

The most recent assessment defines several objectives for improving the internal Appendix F process. The following are targeted improvement areas:

- accountability—to be accomplished by improving the Director's Accountability Scorecard,
- communications—by utilizing the Web,
- data gathering and presentation, and
- oversight by senior management.

The scorecard was used for the senior managers' performance appraisals and salary increase exercises. It will continue to be used this year, and for the following year it will be improved based on input from the senior managers. Performance measures are now available on the Web. The Web page allows access to summaries for each functional area and to the performance of divisions, when applicable.

A major process improvement, derived from a Laboratory-level CQI team, is the designation of a special subset of Appendix F measures as the "Critical Few" on which the Laboratory will focus through a quarterly self-assessment throughout the year. The measures in the most critical functional areas are sent through a screening process to determine which measures meet the criteria to be part of this "Critical Few." The screening process is depicted in Figure 9. For 1997, seven measures were selected from the ESH functional area, five from Facilities Management, and four from Safeguards and Security. From the 1998 criteria, the new ESH set will be entirely rescreened, and both Facilities Management and Safeguards and Security will be refined. In addition, a "Critical Few" will be selected from areas that will most enhance our mission.

The process has been reviewed by both DOE (ALOO and LAAO) and UC. Although it has been well received, there are still improvements to be made. We expect this effort to enhance the value of the overall assessment process and the specific measures.

Figure 5. Administration and operations ratings from FY93 to FY96.

Figure 6. Science and technology ratings from FY93 to FY96.

Figure 7. FY96 DOE ratings by functional area.

Figure 8. Cost per research FTE.

* Cycle 3 will address Financial Management, Property Management, and Procurement.

** Already selected are 7 measures from ESH, 5 from Facilities Management, and 4 from Safeguards and Security.

Figure 9. Appendix F "Critical Few" selection process.

Baldrige Criteria and DOE Quality Award Program

In 1994, the Laboratory Leadership Council adopted the Malcolm Baldrige National Quality Award criteria as an institutional-level framework for the Laboratory's journey towards its vision of a customer-focused, unified laboratory where science serves society. The use of the Baldrige criteria was designed to allow integration, prioritization, measurement, and feedback of Laboratory quality. The Baldrige criteria are being widely adopted by government and educational institutions and afford both flexibility and the ability to benchmark against other organizations. The Baldrige scoring system allows the Laboratory to numerically assess itself or have others assess the Laboratory to give a macromasure of progress. These criteria also serve as the basis for the DOE Quality Award and the Quality New Mexico Award programs.

Conducting our 1994 Baldrige baseline self-assessment gave us a good starting point for many of our current quality improvement efforts. Conducting subsequent annual evaluations against the Baldrige criteria—in 1995 and 1996—has allowed us to judge where we have significant areas for improvement and where we are making progress. Three significant areas in which we are making progress are the following:

- *We are gaining self-knowledge.* Preparing the detailed applications for both the 1995 and 1996 DOE Awards programs has given us a much clearer picture of the Laboratory. In some cases, our applications gave us a better Laboratory-wide perspective on how our processes and initiatives were interwoven and deployed. We were also able to more sharply define our areas for improvement. Leaders are becoming personally involved in setting goals for customer satisfaction and quality improvement. Some are meeting with customers, chartering quality improvement teams, and reviewing improvement progress.
- *We are beginning to think systematically.* Using the Baldrige assessment process has allowed us, in many cases, to see more clearly some of the linkages and connections between components of our work. Rather than developing unique initiatives for every situation or for every part of the Laboratory, we have begun to concentrate on unified approaches. And we have then worked to make sure full deployment takes place. Most divisions and program offices have begun to integrate goals and plans with the overall goals and plans for running the Laboratory. Quality improvement teams are beginning to be cross-functional in nature to ensure that selected solutions are optimal for all affected organizations. Thinking systematically helps us ensure that we use cooperative efforts that build on each other.
- *We are improving our way of doing business.* The Baldrige criteria allow us to measure the effectiveness of what we do, and we are now beginning to apply quality principles and practices to how we manage our business.

Our Baldrige score has risen steadily for the past 2 years, an indication that we are on the right track. Although we must allow for some variation in examiners' findings, the feedback provides a clear message that we are moving in the right direction. We had set an informal goal of having in place by the year 2000 practices that would allow us to attain a score against the Baldrige criteria

comparable to that earned by Baldrige Award-winning organizations. Our three evaluations indicate that we are on track to reach that goal if we maintain our current rate of improvement.

Interest, commitment, and understanding have grown. However, we will not see strategic benefit of our progress until we systematically align all that we do at every level of the Laboratory—our customer focus, values, behaviors, processes, measurements, information systems, and daily work. In some ways, the progress we have made so far has been easy because we had such great room for improvement. What we do in coming years will truly require dedication, effort, and constancy of purpose. The following specific areas are those in which we need to strengthen efforts under way or develop new initiatives.

- *Leadership system.* We must clarify and clearly communicate the leadership structure and decision-making authority of the Laboratory. Key management processes such as tactical planning and performance management must be fully deployed into all divisions, and we must strengthen the linkages between Laboratory management processes and division operations.
- *Management information and results.* We must find ways to identify key management information, more effectively integrate that information, and provide timely, effective analysis. We must structure our data to support uniform and systematic management processes and improvement efforts. In short, we must begin to more effectively use data to manage our business.
- *Employee participation and development.* Although they frequently work effectively within functional areas, many Laboratory citizens still are unable to clearly see the "big picture" of the Laboratory's efforts. We have not structured work systems to allow employees to easily share information—including lessons learned and best practices—across organizations. Nor do we systematically encourage employees to use initiative to improve processes, especially those processes that lose efficiency when they cross organizational boundaries. We must also develop ways to improve employee morale, satisfaction, and motivation.
- *Process focus.* As a Laboratory, we need to develop a process mentality. We need to identify those processes key to our mission and continuing operation and then develop a uniform approach to process management and improvement.
- *Customer focus.* Although pockets of excellence exist at the Laboratory, we must establish a more comprehensive identification of all our customer segments and develop a uniform approach to customer interactions. We must also expand our data analysis efforts to more completely include "Voice of the Customer" information.

We still have a great deal of work ahead of us, but we have made a great deal of significant progress that will enable this institution to maintain its reputation as a premier research and development institution doing work of great value to our nation and to society. We can look with pride on many of our past accomplishments. And we can look forward with anticipation to the challenges that await us as we continue our quest for quality products and services.

SCIENCE AND TECHNOLOGY

SECTION II. SCIENCE AND TECHNOLOGY

Section II depicts the scientific and technological activities through which the Laboratory addresses its mission. The strength of the Laboratory lies in its ability to undertake complex problems requiring creative integration of disciplines, capabilities, and unique facilities. To illustrate the considerable synergy among programs as they address the mission, we have presented the material in this section by mission area.

In Section A., we describe activities that comprise our core mission, Reducing the Nuclear Danger. In Section B., we summarize activities that address the Civilian National Missions, Conventional Defense, and Industrial Partnership. Section C. contains plans of two important competency-related areas: (1) Laboratory-Directed Research and Development, which is an important part of our strategy to nourish and develop competencies, and (2) Theory, Modeling, and High-Performance Computing, which is a competency that spans our entire mission. Lastly, Section D. is a compilation of major new initiatives.

Data in funding tables represent the best budget projections at the time budget documents went to print. The projections are consistent with the data in the *FY1999 Annual Controller's Budget Book*. They may not represent DOE's current intentions, or the latest information. Figure 10 shows how FY96 actual expenditures on the total Laboratory operating budget were apportioned among the mission areas.

Figure 10. FY96 Laboratory budget.

A. REDUCING THE NUCLEAR DANGER

This section describes how the Laboratory is addressing its core mission, Reducing the Nuclear Danger. We divide the core mission into five areas: Stockpile Stewardship, Stockpile Management, Nuclear Materials Management, Nonproliferation and Counterproliferation, and Environmental Stewardship. Although the text is divided into these five areas, there is considerable overlap and synergy among programs addressing these areas. Figure 11 shows how FY96 actual expenditures on the core mission were apportioned among the five areas.

In addition, it is important to note that almost all our programs have a national security element, even though they are listed in the other mission areas described in Section II.B. Civilian National Missions, Conventional Defense, and Industrial Partnership.

Figure 11. FY96 actual expenditures on the core mission.

1. Stockpile Stewardship

Stockpile Stewardship activities mesh considerably with other core-mission elements such as Stockpile Management. This section describes the contributions of the Nuclear Weapons Technology (NWT) Program Office, the Accelerator Production of Tritium (APT) office, and the Los Alamos Neutron Science Center (LANSCE) to this core-mission element. The Department of Defense's (DoD's) interactions with NWT are described both in this section (in the NWT and LANSCE discussions) and in Section II.B.2. Conventional Defense.

In the past, the nuclear weapons stockpile has been maintained through a strategy of surveillance, nuclear and nonnuclear testing, and an active program of replacing old warheads with new designs. Today, our programmatic objectives support a comprehensive test ban treaty and nonproliferation efforts while maintaining assurance of the safety and reliability of a smaller stockpile. The nation's commitment to meeting these combined objectives has given rise to a new stockpile stewardship that maintains a safe and reliable stockpile without either nuclear testing or reliance on new-design warhead production.

The Laboratory is committed to meeting the near-term scientific and technical demands of our stockpile stewardship goals while strengthening our longer-term, technical, capability-based deterrent posture. The technical challenges associated with the program require that we continue to attract and retain first-class scientists and engineers; maintain a viable, healthy infrastructure that supports this mission; and develop a more insightful understanding of weapons science.

Weapons scientists and engineers must be able to predict, with confidence, whether a change observed in an aging stockpile weapon will affect its reliability or safety and will necessitate repair or remanufacture. They must be able to evaluate safety and performance for both the aging weapon and any remanufacture "fix."

We will gain confidence through improved computational capabilities for modeling and simulation and through investments in new experimental capabilities that will benchmark and validate computational models.

a. Nuclear Weapons Technology Program

The Laboratory Stockpile Stewardship Program underpins the technical basis for all nuclear weapons in the stockpile. This Stockpile Stewardship Program is conducted at Los Alamos through the NWT Program Office although there is considerable synergism with other programs that address the central Laboratory mission. The Stockpile Stewardship Program focuses on attending to and maintaining the stockpile. The objective is to ensure that warheads in the stockpile continue to meet certification criteria; that is, they must meet all operational and environmental requirements. Through this program, the Laboratory performs the fundamental research, the development of physical models, the integration of computer simulation codes, the experimental validation, and the systems engineering which are required for the certification of stockpile systems. In addition, the program sets all technical specifications for manufacturing and surveillance operations as well as for maintenance activities conducted by the DoD.

DOE is the sponsor for programs in NWT. Table 1 at the end of this section provides funding details. Within DOE Headquarters, NWT primarily interfaces with the Defense Programs (DP) offices DP-1, DP-10, DP-20, DP-40, DP-50, and DP-60.

In DoD, NWT's main customers are the U.S. Strategic Command, the U.S. Navy Strategic Systems Program Office, and the U.S. Air Force Nuclear and Counterproliferation Directorate. For nuclear programs, the primary customer interface within the Office of the Secretary of Defense is the Office of the Assistant to the Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs. Section II.B.2. Conventional Defense provides information on joint DOE/DoD activities.

To provide the technical basis for continued certification and reliability assurance, the Stockpile Stewardship Program relies on three interconnected areas of activity (see Figure 12). Those areas of activity are as follows: surveillance to allow us to examine and diagnose aging phenomena in stockpile weapons; assessment of the physical observations using detailed calculations and experiments to evaluate the safety and performance of each weapon; and development of appropriate responses—based on those expert assessments—that may include modifications to, or remanufacture of, warhead components or changes to operational procedures.

Figure 12. Surveillance, assessment, and response are the key elements of stockpile stewardship.

Initiatives such as the Accelerated Strategic Computing Initiative (ASCI), Atlas, Advanced Design and Production Technology (ADaPT), and Enhanced Surveillance are critical to enhancing the existing stewardship capabilities as the stockpile gets increasingly old and we move further from immediate test experience. Figure 13 shows conceptually how the new initiatives fold into the core stewardship program to enhance capabilities. ASCI, Atlas, and Enhanced Surveillance are described in Section II.D. New Initiatives. ADaPT is described in Section II.A.2. Stockpile Management.

Figure 13. The core R&D program, with the new initiatives folding back into the core as they mature.

High-Performance Computing

Stockpile computing consists of two components: (1) production nuclear-weapon simulation codes and (2) computational resources. The production codes are tools for stockpile analysis and assessment of surveillance findings, support recertification, and dual revalidation studies; enhanced surveillance; the Stockpile Life-Extension Program; and system safety studies. A production code is typically a large and complex collection of software modules that model hydrodynamics; explosives; neutron, charged-particle, and radiation transport; and nuclear reactions. Models must be properly integrated and must provide consistent and robust simulations over a wide range of physical conditions. Algorithms must be implemented in such a way that the software remains stable during simulation runs that may take hundreds of hours of computing.

The production codes play a vital role as test beds for new ASCI physics models and serve as the foundation for the validation of the new three-dimensional, enhanced ASCI codes. Codes being developed under ASCI will move into production as they are developed, validated, and demonstrated to be useful production tools for weapons designers and analysts.

Stockpile computing provides computational resources for execution of weapons calculations. The primary component is a server that comprises vector supercomputers, massively parallel processors, and workstation clusters. Other major components in the computational environment are the secure network and network services, short- and long-term data storage, and visual displays and printed output services.

Stockpile computing also includes a research element to identify and implement future enhanced production capabilities. The production computing environment must have powerful resources that are also exceptionally stable and reliable. Advanced computing hardware being developed under ASCI is expected to lead to powerful production computing resources as the new system capabilities are demonstrated and shown to provide highly reliable service. Section II.C.2. Theory, Modeling, and High-Performance Computing provides information on the infrastructure component of the ASCI program.

Stockpile Evaluation

As part of our ongoing responsibility, we perform weapon-by-weapon measurements and analyses to assure that the stockpile is safe and reliable.

Surveillance

As the production complex continues to shrink, Laboratory programs that replace or continue many essential surveillance functions are reassigned. Responsibilities for surveillance of pits, detonators, and some valves have already been assigned to the Laboratory, replacing activities formerly performed at the production plants. NWT and the Nuclear Materials and Stockpile Management (NMSM) Program Office work closely together on surveillance. Section II.A.2. Stockpile Management addresses NMSM's activities in this area. Generally, NWT defines the testing requirements and assesses the surveillance results, and NMSM conducts the tests and reports the results. We work together to improve surveillance procedures and to develop enhanced surveillance tools that will allow prediction of component lifetimes.

Annual Certification

In his call for negotiation of a zero-yield comprehensive test ban in August 1995, President Clinton stated,

As a part of this arrangement, I am today directing the establishment of a new annual reporting and certification requirement that will ensure that our nuclear weapons remain safe and reliable under a comprehensive test ban.

This requirement demands yearly certification of each weapon in the stockpile and places great confidence in our science-based stockpile stewardship capabilities. Technical data and assessments from all parts of the national program are collated for each Los Alamos system in the stockpile. Conclusions drawn from that data allowed the evaluation of all these systems for certification.

Dual Revalidation

The Dual Revalidation project is a system in which teams from the three designated weapons laboratories (Los Alamos, Lawrence Livermore, and Sandia) independently evaluate a particular weapon system to see whether it conforms to requirements and to identify potential aging problems. This activity can take several years per weapon system. Dual Revalidation provides a more in-depth analysis than is possible with an annual certification.

The Los Alamos W76 system is the first chosen for dual revalidation. A Los Alamos-Sandia (New Mexico) team has developed

a plan for test analysis over the 3-year period of the project. This team will recalculate past nuclear and hydrotest data and define a new series of calculations and hydrotests. A Livermore-Sandia (California) team will independently calculate and review the same data as a check for completeness and accuracy and will perform independent experiments related to the system.

Surety

Surety assessment addresses the safety, security, and control of nuclear warheads over the complete weapons cycle, from design and manufacture, through DoD custody, to final dismantlement. We are pursuing an aggressive surety assessment program, with calculational modeling and experiments, to develop an understanding of how surety-related insults affect stockpile weapons. Surety assessment involves assessing technologies and designs proposed for inclusion in the Stockpile Life-Extension Program and providing recommendations concerning surety issues. Methods include ensuring that stockpile systems meet DOE and DoD surety standards through formal assessment activities (for example, nuclear explosive safety studies, joint weapon-system safety assessments, the weapon appraisal process, dual revalidation, and other formal assessment processes) and identifying vulnerabilities through analysis by members of the surety community.

Joint DOE/DoD studies evaluate accident scenarios (credible abnormal environments and credible combinations of abnormal environments), assess weapon response, quantify risks, and identify goals for improvements. Section II.B.2. Conventional Defense provides further information on these studies.

Assessments provide the impetus for developing improved models and acquiring better data to represent more closely the ways in which a warhead will be affected by potential storage, transport, operating, and accident environments. Carefully diagnosed hydrotests, crash tests, and component tests generate the data required for assessment models.

Remediation (Response)

The retirement of the B53 has increased the overall surety (safety, security, and control) of the U.S. nuclear weapons stockpile. At the same time, the DOE/DoD community has expanded and tightened the criteria for weapons surety. Our assessment effort is coupled with a remediation program, including component design and engineering, through which we can improve weapons surety when refurbishment or component replacement is required.

Hydrodynamic Testing

Hydrodynamic tests, high-explosives-driven experiments for studying primary implosions, constitute our most important aboveground, nonnuclear testing capability because they address the most critical element of the weapon related to stockpile reliability—the functionality and safety of the primary stage. We perform several hydrotests per year dedicated to the continued safety and reliability of the stockpile.

Dual-Axis Radiographic Hydrotest

The principal diagnostic tool for hydrodynamic testing is high-resolution radiography. The best radiographic facilities currently available are Los Alamos's pulsed high-energy radiographic machine emitting x-rays (PHERMEX) and Lawrence Livermore's flash x-ray facility (FXR). Technical advances that significantly increased the capabilities of PHERMEX will feed the design and enhance the performance of the next-generation machine, the dual-axis radiographic hydrotest (DARHT) machine.

When complete, the Los Alamos DARHT facility (see Figure 14) will provide major improvements needed for stockpile evaluation and assessment. DARHT is designed as a multidagnostic national user facility for evaluating nuclear weapons. The state-of-the-art facility will include

- significantly improved x-ray resolution and penetrating power;
- time sequencing, spatial separation, and stereo-view capability;
- contained or open-air testing capability (phased implementation of containment); and
- complete electronic and optical data-acquisition systems.

Figure 14. The Dual-Axis Radiographic Hydrodynamic Test facility will enable us to perform high-resolution radiography from two axes, thereby facilitating one-point safety tests for nuclear weapons.

High Explosives

High explosives are energetic, organic metastable materials. As such, their potential to change or degrade with time is significant. The detailed understanding of high-explosives performance, safety, and aging is paramount to assuring the safety and reliability of the aging stockpile. To this end, all of the high-explosives-related projects at Los Alamos (from basic science through fabrication) have been consolidated under a joint program between the NWT and the DoD program offices. This is the first step in focusing and coordinating all the aspects of high-explosives science, engineering, and application within the Laboratory's weapons program.

Subcritical Experiments at the Nevada Test Site

In the absence of underground nuclear testing, we need to improve our knowledge of the dynamic properties of nuclear materials to better assess the effects that aging or new manufacturing techniques may have on weapon performance. Subcritical experiments at the Nevada Test Site are one important means of addressing these concerns. These experiments will involve nuclear materials such as plutonium, but they will not produce self-sustaining nuclear reactions. These experiments complement dynamic experiments that will be conducted at other Laboratory facilities.

Neutron Radiography, Neutron Scattering, and Materials Science

LANSCCE provides a valuable resource for a large number of scientific experiments in materials science research. Through neutron scattering and radiography, LANSCCE can assist our stewardship efforts. Scientists will be able to address a wide variety of materials issues, including aspects of high-explosives burn, shocks, aging-related phenomena, and equations of state. LANSCCE capabilities also allow the measurement of nuclear cross sections. Neutron radiography permits nondestructive measurement of a weapon component's internal structural changes. LANSCCE contributions to stockpile stewardship are further discussed at the end of this section.

Materials and Manufacturing

The materials and manufacturing initiative focuses on research and development (R&D) activities and is closely integrated with other DOE/DP activities such as industrial partnering, process development for stockpile management, and the ADaPT initiative. For example, close integration of the weapons design efforts with the ADaPT initiative is critical in an era that allows neither nuclear testing nor new weapons production. Proposed improvements to the manufacturing processes are critical to our ability to respond to problems that may arise in the stockpile. (For more information on the ADaPT initiative and process development for stockpile management, see Section II.A.2. Stockpile Management.)

The goals of the materials and manufacturing initiative goals include

- characterizing existing components and materials, processes, and models;
- developing replacement materials for those materials no longer available;
- developing R&D methods that facilitate
 - the design of advanced manufacturing tools and methods,
 - agile manufacturing (including rapid prototyping and near-net-shape casting as well as model-based product and process realization),
 - requalification of parts and components,
 - qualification of replacement materials and components, and
 - development of environmentally benign material and production processes; development of industrial partnerships for ADaPT and production process technologies; and maintenance of critical facilities that support materials and fabrication requirements.

High-Energy-Density Physics

Our science-based approach to stockpile stewardship requires a detailed understanding of the physics at the ultrahigh energy densities in a nuclear device. Such detailed understanding requires sophisticated computer models validated against experimental data. Until recently, most experimental data has come from nuclear tests. The ban on testing has resulted in the need for laboratory experiments exploring critical aspects of the physics that occur in nuclear explosions. Such experiments and their analyses provide (1) information on physical processes that occur when matter is elevated to high energy densities, (2) the means to continue developing the special skills needed for understanding nuclear weapons, and (3) a better set of computational techniques for assessing the safety and reliability of the stockpiled systems.

Two different approaches to addressing high-energy-density problems—pulsed electrical power sources and high-energy lasers—are used to perform weapons physics experiments and to develop new experimental techniques. Pulsed-power approaches include laboratory capacitor bank systems, Pegasus, the new Atlas facility (see Section II.D. New Initiatives), and two high-explosives-driven pulsed-power systems, Procyon and Ranchero. High-energy-laser experiments are conducted in coordination with the national Inertial Confinement Fusion (ICF) Program.

Pegasus

Experiments are conducted in a laboratory environment to explore weapons physics issues of immediate importance to the Stockpile and Stewardship Management Program. Experiments exploring advanced hydrodynamics in compressible and incompressible media provide detailed data to benchmark weapons design codes. Experiments that explore the behavior of material under relevant shock conditions provide quantitative information about shocked surfaces.

Explosive Pulsed-Power Systems

Procyon provides near-term access to Atlas-like drive conditions on a one-shot basis, allowing us to develop experimental techniques and diagnostics and to produce weapons physics data. In the longer term, systems like Ranchero provide access to even higher total energies to extend weapons physics experiments to even higher energy-density regimes.

Inertial Confinement Fusion

Los Alamos plays a central role in the national ICF Program. ICF Program goals are (1) an ignition demonstration at the National Ignition Facility (NIF) and (2) increased utility of ICF facilities to resolve weapon issues. By emphasizing target physics, our research supports capability that overlaps the NIF program and Los Alamos stockpile responsibilities. Our experimental program conducts research at three laser facilities—Lawrence Livermore's Nova, University of Rochester's Omega, and Los Alamos's Trident. Our ongoing target physics research, which includes a wide range of topics in implosion physics and hohlraum plasma dynamics, aims to resolve issues associated with both ignition and stockpile physics.

Archiving-Related Activities

Archiving and assessment programs support both weapons science and the stockpile. Archiving previously recorded nuclear weapons data provides a wealth of information needed for assessing stockpile weapon systems and improving models and codes needed to better understand details of weapons science. The archiving program provides data to weapons designers and engineers for the assessments and analyses they perform when revalidating stockpile safety and reliability and exercising new computational models, capabilities, and codes. The archiving program includes four principal activities:

- Archiving teams have responsibility for analyzing a stockpile system and for carrying out related nonnuclear experiments.
- The archiving process will be a principal mechanism for training the next generation of designers, engineers, and diagnosticians.
- The archived data provide a base-line for analyzing the safety and reliability of the aging stockpile and for recertifying, extending lifetimes, and developing modifications, if required.
- For the next few years, archiving activities will focus on supporting the W76 warhead dual-revalidation process, the W87 warhead life-extension program, and the B61.

Future Contingencies and National Response

The uncertainties of the post-Cold War era require that we assess potential future contingencies and help to provide for national response options. The goals of this initiative include

- emergency response programs to counter nuclear terrorism (in support of the Federal Bureau of Investigation, the Department of State, and DoD);
- threat assessment and proliferation response, including consequence and situation analysis, vulnerability and countermeasures planning, and foreign-warhead modeling;
- nuclear test readiness at the Nevada Test Site; and
- support for treaty verification and arms control initiatives.

Stockpile Maintenance and Options

While we are not designing or constructing new nuclear systems, there still remains a need to update and modify elements of weapons systems to assure reliability and function. Stockpile maintenance functions include repair and modification of weapons systems (such as the B61-11); maintenance of customer relationships; and provision of technical support, advice, and oversight for routine maintenance and retirement. Stockpile options activities include

- developing options for stockpile life-extension programs and
- exploring design options, including analysis, assessment, and feasibility determination.

Our efforts focus on anticipating what is needed to extend weapon-system lifetimes and then extending those lifetimes in a manner that will also maintain safety and reliability. Most component changes for specific nuclear weapons are classified. However, appropriate for discussion in this forum is the implementation of tritium storage systems with longer limited-life-exchange intervals. These longer intervals will reduce weapons maintenance and extend reliability.

b. Accelerator Production of Tritium

Tritium was formerly produced at DOE material production reactors that were designed and built in the 1950s. The last one was shut down in 1988. The nation's tritium requirements currently are being met by recovering tritium from nuclear weapons dismantled as part of the nation's stockpile reduction program. However, tritium, which is essential to the functioning of the stockpile, has a half-life of about 12.5 years and decays at a rate of 5.5% each year. Consequently, a supply of tritium must be available if the nation is to ensure the reliability of its nuclear weapons.

DOE has been investigating the use of accelerators to produce tritium for the nuclear weapons stockpile. The APT technique uses a high-power (130-MW) proton accelerator to produce a very high flux of neutrons by spallation reactions in a target, which, in turn, produces tritium through reactions on ^3He .

On December 5, 1995, the Secretary of Energy approved a record of decision supporting the need for a new tritium supply and announced a dual-track plan to ensure an adequate supply. The plan included (1) initiating action to purchase an existing commercial light-water reactor for conversion to a defense facility and (2) authorizing work to design, build, and test critical components of an accelerator system for tritium production. In late 1998, DOE will select one track to serve as the primary source of tritium.

In July 1996, DOE announced a contract award of about \$3 billion to Burns & Roe Enterprises, Inc., (BR) and General Atomic (GA) to design, and possibly to build, an accelerator tritium production facility at DOE's Savannah River Site in South Carolina. In February 1997, DOE declared Los Alamos as the national project office for APT activities.

APT work will be centered at Los Alamos through the preliminary design phases, transferring to the Savannah River site during final design and construction. Los Alamos will retain design authority for the accelerator, target/blanket, and tritium extraction facilities and will provide technical oversight throughout the life of the facility.

During engineering design and demonstration, engineers and scientists from Sandia, Lawrence Livermore, and Brookhaven national laboratories, the Thomas Jefferson National Accelerator site, and Westinghouse Savannah River Corporation will work with Los Alamos and BR/GA to develop and operate several prototype systems. The most important of these is the low-energy demonstration accelerator that will serve as a model for the "front end" of the final production accelerator. Other activities will include demonstrating the tritium-production components of the plant and performing material irradiations at LANSCE to verify design lifetimes.

The APT work at Los Alamos will result in nearly \$200 million worth of procurement during the next 5 years. If DOE selects the accelerator technology, by 2001 the APT Project Office is scheduled to be moved from Los Alamos to Savannah River, where construction of the APT plant will take place.

Table 2 at the end of this section provides the projected funding for APT.

c. LANSCE Contributions to Stockpile Stewardship

LANSCE is a powerful spallation neutron source facility (see Figure 15) that includes the Manuel Lujan Jr. Neutron Scattering Center (Lujan Center), the Weapons Neutron Research (WNR) facility, the world's most powerful proton linear accelerator, and the proton storage ring (PSR). LANSCE is a major component of the Laboratory's strategic plan to become the U.S. center for the development and use of spallation neutron sources. In 1996, LANSCE completed its transition to becoming a DOE/DP facility. Its primary mission is to carry out research in support of stockpile stewardship and management. A second, synergistic mission, funded by the DOE Office of Energy Research (OER), Office of Basic Energy Sciences, is to serve as a national neutron science user facility. This second mission is described in Section II.B.1.d. LANSCE: National Neutron Science User Program.

LANSCE and the "neutron laboratory" initiative are vital to DOE in a number of ways. First, LANSCE will provide data fundamental to surveillance and assessment of a weapon's nuclear package. Second, LANSCE is the central facility for development of technology for the production of tritium, one of the paramount stockpile support requirements. Third, neutron science and technology is critical to Laboratory core competencies in advanced materials science, nuclear science, particle beam technology, and nuclear weapons science—all of which are needed to fulfill the Laboratory's role in the stewardship and support of the nation's nuclear weapons stockpile. And finally, LANSCE provides opportunities in basic research, which help establish the center as both a magnet to attract new talent to Los Alamos and, through science-based stockpile stewardship, a bridge to the weapons program for that talent.

Stockpile Stewardship Activities

Researchers are using LANSCE to address a range of issues critical to long-term weapons stewardship (see Figure 16). Neutron diffractometry, small-angle scattering, reflectometry, and inelastic scattering techniques are being used to answer materials science questions related to the aging of weapon components. LANSCE is providing a better understanding of the underlying science involved in predicting the behavior of explosively compressed plutonium, the surveillance of materials deep inside an aging nuclear device, and the study of the performance and sensitivity of high explosives. High-intensity, high-energy neutron beams are being used to develop and test methods for locating defects nondestructively with neutron radiography. And, in collaboration with its sister weapons laboratories, Los Alamos is engaged in research toward a new approach to hydrotest radiography based on high-energy protons.

Weapons material science research at the Lujan Center includes crystallographic studies of plutonium and other weapons materials and the subsequent identification of relative phase compositions. Crystallographic texture is being examined as a potential indicator of manufacturing and hydrodynamic performance. Neutron-diffraction-based measurements of three-dimensional internal strain fields will provide benchmarks for finite-element structural modeling of weapon components and contribute to better lifetime predictions for weapon parts. Measurement of Debye-Waller factors and phonon spectroscopy provide information on interatomic potential for plutonium equation of state (EOS)

Figure 15. The Los Alamos Neutron Science Center produces intense sources of pulsed spallation neutrons, which provide the U.S. scientific

community with the capability to perform experiments that support national security, civilian, and industrial research.

modeling and the generation of better EOS tables for weapons simulation codes. Microstructure analysis of high explosives using small-angle neutron scattering is being used to characterize the effects of aging and damage on high-explosive microstructure and, hence, on sensitivity. Neutron scattering is also key in examining hydrogen migration and corrosion in weapon components.

High-precision measurements made at LANSCE of nuclear cross sections and other nuclear observables allow Los Alamos to

exploit the full potential of data from past nuclear tests. The newly installed germanium array for neutron-induced excitations (GEANIE) at WNR is being used to measure plutonium-238 production by neutron bombardment of plutonium-239, allowing us to use past data to provide direct information on the in situ weapon spectrum.

Dynamic shock-wave experiments at LANSCE have provided the first-ever simultaneous measurements of temperature, particle velocity, and shock velocity in a dynamic, strongly shocked sample. These unique measurements, carried out on a microsecond time scale, are made possible by the PSR's extremely high instantaneous current. Dynamic neutron-resonance-absorption spectroscopy experiments have measured the internal temperatures of shocked or detonated high explosives. This never-before-obtainable information will be critical in the development of the capability for modeling advanced high-explosives reactive burn and EOS modeling.

Being electrically neutral, neutrons can penetrate deeply into matter in a nondestructive way. Los Alamos is developing static neutron radiography techniques that can provide enhanced contrast compared with that obtainable from x-rays, enabling inspection of the condition of low-Z materials deep inside a high-Z assembly. Successful scoping work and proof-of-principle tomographic reconstructions have been carried out at the WNR facility. Current work is focused on improved resolution and speed. A blind, defect-finding test on a weapon mockup will provide the ultimate test of this new technique.

Figure 16. LANSCE is addressing critical stockpile stewardship and management issues.

Los Alamos is leading the effort to research and develop high-energy proton radiography for dynamic applications. Proton radiography can provide quantitative information beyond what is available using x-ray-based radiography. This information will help enable conventional hydrotests to play an expanded role in validating the stockpile without nuclear testing. The proton radiography concept was conceived at LANSCE and subsequently studied and developed there. However, Los Alamos has also explored the technique at the higher energies available at Brookhaven National Laboratory's Alternating Gradient Synchrotron. Successful proof-of-principle experiments conducted in 1996 at 7 and 10 GeV suggest that protons with very high energy (perhaps 30 GeV or more) may provide critical advantages over x-rays for dynamic radiography applications. Laboratory researchers are planning a series of further experiments (including dynamic experiments) at the lower energies available at LANSCE in order to develop detector technology, modeling capability, and other expertise necessary for possible future hydrotest applications. Elsewhere, we expect that LANSCE dynamic proton radiography experiments on small-scale, high-explosives-driven assemblies will prove extremely interesting in their own right for the study of weapons-related hydrodynamics. The study of the proton radiography concept is now part of a DOE-sponsored tri-laboratory effort toward definition of a potential next-generation hydrotest facility.

LANSCE Facility Improvements

LANSCE is a major national asset (\$700 million replacement value) that can be leveraged to provide cost-effective solutions to national needs in defense, industrial, and basic research applications. To meet these needs, LANSCE is improving and enhancing its facilities. A \$35 million reliability improvement project,

funded by DoD, has been under way since 1994 and is scheduled for completion in 1998. These improvements include a new spallation target at the Lujan Center, direct H⁻ injection into the PSR, and improved access to experimental areas. This project will provide more reliable and convenient operations, will extend the annual run cycle to 8 months, and will increase the spallation target power to 80 kW. Operations funding is expected to increase to support the longer run cycle. Benefits of both this effort and improved operations are already apparent, with significant reliability gains in the 1995 and 1996 run cycles compared with those of the recent past. In 1996, a high-resolution gamma-ray-detector array, GEANIE, was installed at WNR. This array, obtained from Lawrence Berkeley National Laboratory, is the first high-resolution, large-angle gamma-ray detector to be installed at a spallation neutron source.

To meet pressing national needs in the next 10 to 20 years before the 1-MW National Spallation Neutron Source is built, LANSCE has embarked on a \$44 million program to enhance its short-pulse spallation source (SPSS). This effort will provide LANSCE with performance levels equal to or better than those of the best pulsed spallation source in the world—the ISIS facility in the United Kingdom. The SPSS enhancement is jointly supported by both DP (at \$16.7 million) and OER (at \$25 million). DP is funding accelerator component upgrades designed to increase target power to 160 kW. These upgrades include a new H⁻ ion source and improvements to the radio-frequency bunching in the PSR. OER is funding the development of up to seven new instruments at the Lujan Center. Work on the SPSS enhancement project began in 1997. The accelerator upgrades are scheduled for completion in 2000, and the instruments are scheduled for completion in 2001.

The projected funding for LANSCE stockpile stewardship is provided in Table 3.

Table 1. Projected Funding for Nuclear Weapons Technology Program Office (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Program and Initiatives (DP0101)	64.4	70.1	70.6	63.2	67.3	67.3	67.3	67.3
Core Research and Advanced Technologies (DP0102)	119.8	139.6	128.8	119.4	127.2	127.2	127.2	127.2
Education Initiatives (DP0302)	5.2	4.6	3.6	3.6	3.6	3.6	3.6	3.6
Los Alamos Neutron Science Center (DP0102)	32.4	36.0	35.3	35.5	37.9	37.9	37.9	37.9
Accelerated Strategic Computing Initiative (DP0101)	17.3	31.0	48.1	46.1	49.1	49.1	49.1	49.1
Technology Transfer (DP0301)	32.5	14.0	14.0	10.0	10.0	10.0	10.0	10.0
Inertial Confinement Fusion (DP02)	21.0	23.8	22.0	21.9	21.9	21.9	21.9	21.9
Nuclear Emergency Search Team (DP0402)	3.4	7.3	9.8	9.8	9.8	9.8	9.8	9.8
Enhanced Surveillance (DP0401017)	3.9	9.4	11.0	5.0	19.0	19.0	19.0	19.0
Total	299.9	335.8	343.2	314.5	345.8	345.8	345.8	345.8

Table 2. Projected Funding for Accelerator Production of Tritium (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Accelerator Production of Tritium (DP0404012)	38.0	72.1	85.0	65.0	25.0	7.0	6.0	1.0

Table 3. Projected Funding for LANSCE Stockpile Stewardship (\$M).¹

Program Office	Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
NWT/DP	Operations and Research (DP0102013)	32.4	34.6	35.3	35.5	37.9	37.9	37.9	37.9
NWT/DP	Short-Pulse Spallation								
	Source Enhancement (DP0102013) ²	0.0	3.0	6.0	7.7	0.0	0.0	0.0	0.0
DoD	Reliability Improvement (400403)	4.0	8.9	1.4	0.0	0.0	0.0	0.0	0.0
Total		36.4	46.5	42.7	43.2	37.9	37.9	37.9	37.9

¹Funds are administered through the Los Alamos NWT and DoD program offices. This funding table shows selections from the funding to those program offices rather than additional funding.

²FY97 project funds are split into \$1.5 million in operating funding and \$1.5 million in capital funding. FY98 and FY99 funds are all capital funding.

2. Stockpile Management

The Laboratory, by virtue of its scientific and technical leadership in nuclear materials and stabilization issues, is expanding its national and international roles in integrating the technologies essential for responsible management of global nuclear materials. In doing so, the Laboratory is actively demonstrating ways in which science can serve society.

The majority of programs addressing the stockpile management element of our core mission reside in the Nuclear Materials and Stockpile Management (NMSM) Program Office. These programs address a spectrum of activities directly supporting the nuclear weapons stockpile, including all elements of plutonium technology, the limited-scale manufacture of plutonium pits, the surveillance or evaluation of numerous stockpile components, as well as the demonstration of technologies necessary for the manufacture of a variety of nuclear and nonnuclear components. They overlap with programs addressing the nuclear materials management element of our core mission and are allied with all elements of the core mission. For example, in NMSM's capacity to support surveillance, maintenance, and manufacturing tasks assigned to Los Alamos for the nuclear weapons stockpile, NMSM is linked to stockpile stewardship by a shared responsibility that is fundamental to DOE's strategy for emphasizing continued assurance of the safety and reliability of the enduring stockpile.

For NMSM programs, the major DOE customers are the DOE Albuquerque Field Office (DOE/AL) Weapons Programs and DOE/AL Weapons Quality Divisions along with the Office of Technology and Site Programs (OSTP); the Office of Nuclear Weapons Management (DP-20); the Office of Nuclear Energy (NE); and the Office of Fissile Materials Disposition (MD-1). NMSM programs are administered through five broad areas of responsibility: manufacturing and surveillance, materials and process technologies, stabilization and disposition, nuclear component readiness, and stockpile management facilities.

Projected funding for Stockpile Management is provided in Table 4 at the end of this section.

Stockpile Management Activities

The basis for continued confidence in the reliability and safety of the nuclear weapons stockpile is NMSM's rigorous stockpile

evaluation effort, which focuses on the surveillance of plutonium pits (the nuclear cores of warheads), Los Alamos detonators, selected gas-system components, and milliwatt radioisotope thermoelectric generators. Related work includes design evaluation of certain secondary components and preparation of special warhead mockups for joint field tests with the Department of Defense.

Stockpile support is an equally challenging work category with a different emphasis. The dominant initial task was to demonstrate our capability to rebuild pits, such as those sacrificed for surveillance work, on a laboratory scale to War Reserve (WR) specifications. The goal was for Los Alamos to transfer and preserve the technologies from Rocky Flats required to produce WR-quality pits. The initial requirement was to build a W88 pit (Trident II) in FY98, followed by pits for the W87 warhead (Peacekeeper) and B61 bomb. Companion manufacturing tasks included rebuilding a beryllium part and several nonnuclear components (such as detonators, neutron-tube targets, and calorimeters). These manufacturing tasks were an extension of production capability transfer from plants being closed to Los Alamos under the auspices of nonnuclear reconfiguration and as part of the downsizing and consolidation efforts under way in the Weapons Complex.

Los Alamos was then given a mission by DOE to establish the technologies required for manufacturing most of the pit types in the enduring stockpile. In addition, Los Alamos must develop or enhance specific technology areas associated with pit rebuilding, including beryllium machining, tubulation, interfacing of pit materials, and development of certain joining processes. The range of assignments in the production arena made it advisable in FY96 for NMSM to establish offices dedicated to manufacturing management and weapons quality. Activities associated with pit rebuilding—namely, calibration, production control, Material Control and Accounting (MC&A), analytical chemistry, preparations for building the W87 and B61, resource planning, quality control, and manufacturing management—will need appropriate budgetary support if the overall effort is to succeed.

Collaboration with Savannah River: Tritium and Other Activities

Los Alamos and the Westinghouse Savannah River Site continue to address broad focus areas of collaboration in tritium technology, including surveillance of certain components as well as processing and recycling of tritium to support the weapons program. The two organizations have begun exchanges of technical and management staff, have agreed to share some Los Alamos R&D responsibilities, and have started developing the capacity at Los Alamos to handle an overflow of process development and surveillance functions from Savannah River.

Los Alamos has initiated a small study funded by Savannah River on tritium processing for the Commercial Light Water Reactor option for tritium production. Los Alamos also supplied Savannah River with a portable tritium stripper and studied reservoir vulnerability in an accident situation involving fire. The collaborations on tritium science and the master plan for tritium fill and recycle are an integral part of the effort for the Laboratory's tactical goal for Science-Based Stockpile Stewardship and Management.

Other tasks in the collaboration between the two organizations include completing implementation of the technology for dispo-

sition of excess fissile materials; beginning the conceptual design of modular production systems useful for future component production; and making progress in the development of multisite environmental cleanup technologies.

Materials and Process Technologies

Los Alamos has strongly supported the DOE strategy for downsizing and consolidating the Weapons Complex. These areas of support include

- management of nuclear materials;
- research in advanced manufacturing and processing;
- development and demonstration of storage technology;
- safeguards and security; and
- handling and processing of plutonium, uranium, tritium, lithium, and high explosives.

We have also directed key efforts toward reducing the exposure of workers to radiation, minimizing environmental impacts, and developing waste minimization technologies such as efficient fabrication processes, reprocessing systems, and residue recovery techniques.

Pit Manufacturing

Following lengthy national review of the Programmatic Environmental Impact Statement, DOE decided in December 1996 to assign Los Alamos the responsibility for limited-scale manufacture of up to 50 pits per year, with sprint capacity to 80 pits, by the year 2005. Establishing and maintaining this capability are essential for our understanding of the safety and reliability of existing nuclear weapons, as well as for the ability to replace or repair aging components.

While a predictive capability for component lifetimes is being developed, Los Alamos has mounted an aggressive effort to enlist sustained support for the evaluations of existing nuclear components. Work continues with our colleagues at Lawrence Livermore National Laboratory, Savannah River Site, and Pantex to develop contingencies for larger-scale pit-production requirements. Along with new technologies now being developed, the 50-pit manufacturing assignment for the Los Alamos Plutonium Facility (TA-55) is the basis for the design of a modular production capability that could be deployed rapidly if the present modest and optimistic requirements change. The study team has released a report showing the distribution of supporting tasks among the sites for the case of rapid reconstitution of pit manufacturing. The pit production efforts contribute to the Laboratory's tactical goal for Science-Based Stockpile Stewardship and Management.

Manufacturing Technology

The concerted effort to bring pit manufacturing capabilities online is linked to a Process Development Program related to the Advanced Design and Production Technology (ADaPT) Initiative. ADaPT will demonstrate the capability, low-cost flexible response, and scalable capacity for nuclear weapons products by providing advanced manufacturing and material technologies such as processes that are agile and safe and that minimize hazardous waste. The products that drive this initiative are repaired and rebuilt systems and components, including primaries, secondaries, and nonnuclear components, for the enduring stockpile.

With the downsizing of the production complex, the intent of ADaPT is to focus and accelerate the development and deployment of technologies, processes, and methods required to maintain an affordable, effective, safe, and reliable nuclear deterrent. Partnerships with private industry will be an important strategy, and a major emphasis will be on coordination across the complex because of the common goals for plants and laboratories. ADaPT has strong ties with the enhanced surveillance and pit rebuild and surveillance programs as well as with other activities such as reservoir development and production, physics design for manufacturing, and environmental requirements. An important aspect will be on the integration of design, production, and qualification processes.

ADaPT is formally scheduled to be funded in FY98. However, the Process Development Program, which begins at modest level in FY97, will further some of its process improvement goals. At Los Alamos, it is manifested by the effort to bring pit manufacturing capabilities into reality and by small efforts in high explosives, tritium, nonnuclear components, assembly/disassembly, and secondaries. All of the latter areas are closely linked to activities at the four remaining plants—Kansas City, Pantex, Savannah River, and Oak Ridge Y-12.

Uranium Technology

The major goals of our uranium technology activities are (1) to develop state-of-the-art capabilities for uranium chemical processing and recovery and for metal making and fabrication and (2) to provide effective materials management practices for inventory reduction and accountability. One important near-term goal is the design, development, and operation of the uranium line for special separation science (ULISSES), which will provide a flexible and highly instrumented test capability for demonstrating new processing technologies. High-priority and overall programmatic goals of ULISSES are to reduce the current inventory of uranium residues at Los Alamos and to introduce processes that will curtail waste and residue generation in future manufacturing operations.

An important goal of the nuclear materials technology effort at the Laboratory is to reduce—to acceptable levels, as defined by regulations—the hazard of all liquid waste leaving the boundaries of TA-55. To achieve this objective (even as work assignments are increasing), scientists will use a variety of existing technologies and will continue to identify new technologies for, among other tasks, reducing the volume of the waste stream and removing, destroying, recycling, or immobilizing the hazardous components. This effort will potentially result in a dramatic reduction of the environmental effects of liquid-waste discharges from nuclear materials processing at TA-55, a decrease in long-term waste management and storage costs, and the development of spinoff technologies that support private industrial waste efforts.

Special Recovery Line

Formal startup of the special recovery line, which enables us to handle plutonium contaminated with tritium, was achieved this year. Six pits from Rocky Flats were successfully processed.

Stockpile Management Nuclear Materials Facilities Upgrades

Los Alamos has the mission of providing the full range of plutonium technologies, manufacturing, and surveillance activities to DOE. This role is increasing with time. Three upgrades are of particular importance this year. Together, these three projects provide the foundation for nuclear component readiness. The goal is to establish and maintain an ability to meet DOE's wide range of plutonium needs—including surveillance and limited pit manufacture—in a safe, reliable, and environmentally responsible way.

Compliant nuclear materials facilities are an attainable goal. A program manager position has been added by NMSM so that an experienced person can focus on all the Stockpile Management facilities and can develop more effective methods of working across facility/division boundaries for sharing best practices for facility operations. The TA-55 Plutonium Facility is recognized as the leader in Category 1 nuclear safety management systems at Los Alamos, and the operating division is sharing these practices with other facilities as implementation of all the components of Integrated Safety Management begins. As new requirements are proposed by the regulatory side of DOE, the Laboratory will strive to engage the programmatic side of DOE in the discussion of solutions so that funding and priority decisions are made in partnership with DOE.

TA-55 Capability Maintenance and Improvement Project

The nation's only fully functioning facility for compete plutonium handling, processing, and R&D capability, TA-55 is also the nation's newest plutonium facility even though it is already 20-years old. Several of the building systems need upgrading, and components approaching the end of their useful life need to be replaced. A Capability Maintenance and Improvement Project is being started to provide the modifications required for limited-scale pit manufacturing as well as the extensive refurbishments of the safety systems at TA-55 and associated facilities. To meet the projected military requirements for manufactured pits, this upgrade project has been identified for Los Alamos through the Stockpile Stewardship and Management Programmatic Environmental Impact Statement (SSM-PEIS) Record of Decision. Key Decision Zero was issued on May 17, 1996; the Conceptual Design Review is being validated now for the technical scope, schedule, and cost baseline; and Title I design must be started in the first quarter of FY99. The funding need in FY99 is \$26.2 million for the beginning phase of construction. The total estimated cost is expected to be in the range of \$350 to \$400 million.

Nuclear Materials Storage Facility

Renovation of the Nuclear Materials Storage Facility (NMSF) is needed to correct deficiencies that have prevented use of that facility, to address modern expectations and regulations, and to ensure that the facility can be operated safely and effectively. The renovation project is authorized by DOE and was funded as a new start in FY97. Operational status of this facility is essential to the long-term success of the Laboratory's integrated nuclear materials program. The NMSF provides a centralized location for the consolidation and the intermediate- and long-term storage of the Laboratory's nuclear materials inventories. These inventories are currently dispersed in Category 1 storage vaults at several Labora-

tory sites and represent a significant issue of worker radiation exposure. The storage facility must be in operation by FY02 because the storage vault at TA-55 will be at full capacity by that time. The total estimated cost for renovation is \$45.1 million.

Chemistry and Metallurgy Research Building

The Chemistry and Metallurgy Research (CMR) Building is 44 years old and houses the analytical chemistry labs that are crucial to supporting nuclear materials operations at TA-55, including pit rebuilding, manufacturing, and surveillance. Renovation of the building is a safety and lifetime-extension project that has been authorized by DOE and must go forward. Funding for the FY98 construction work is included in the DOE budget submission. The total estimated cost is \$174.1 million. The work will be performed in two phases, which began in FY92; it is scheduled for completion in FY02.

Analytical chemistry tasks at CMR that support the total nuclear materials program at Los Alamos include

- preparing and certifying plutonium standards;
- stabilizing nuclear materials;
- characterizing radioactive waste constituents;
- developing new and improved techniques for analyzing nuclear materials;
- supporting pit rebuilding, surveillance, and manufacturing activities; and
- maintaining the infrastructure for waste management and material accountability efforts.

Other Nuclear Materials Facilities

Los Alamos Critical Experiments Facility

The Los Alamos Critical Experiments Facility (LACEF) provides the Laboratory and DOE's nuclear facilities and nuclear materials programs with criticality safety support for specific facility process operations and for facility safety analysis. In particular, critical assembly experiments are performed at LACEF to assess the safety and performance of individual production operations and devices and to validate the results of computations. Pulsed-radiation facilities available at LACEF provide intense radiation fields for response tests of equipment such as criticality alarms. Training in criticality safety is provided to operations, support, and supervisory personnel throughout DOE. Implementation of the Defense Nuclear Safety Board (DNFSB) Recommendation 93-2 on criticality experiment capability includes expanding and updating the current nuclear criticality database. With help from the criticality community, the Nuclear Criticality Experiments Steering Committee has compiled and prioritized a list of experiments. The current LACEF program emphasizes the high-priority experiments from this list.

Weapons Engineering Tritium Facility

The Weapons Engineering Tritium Facility (WETF) is the only operating site that integrates expertise in boost-system design with operating facilities for tritium research and testing. Routine tasks reserved for the WETF include performing studies on the compatibility of reservoir materials; investigating containment issues; and transferring, separating, enriching, isotopically analyzing, function testing, unloading, loading, and packaging tritium and its mixtures. Similarly, deuterium/tritium gas mixtures can be prepared, stored, mixed, analyzed, and loaded at the

WETF. Beginning in late FY97 or as upgrades to the facility are finished, the WETF will provide direct support for the project to load neutron-tube targets as well as for TA-55's special recovery line for pit surveillance. In preparation for continuing and future assignments at WETF, seven workers completed formal training in boost systems and tritium facility operations.

Other Upgrades

Approval of justification for mission need for the Nuclear Materials Safeguards and Security Upgrades Project was issued on June 5, 1997. Los Alamos will now begin the Comprehensive Design Report required for the project to be supported as an FY99 Construction Line Item new start for the Phase 1 portion of the upgrade. Phase 1 encompasses three subprojects representing the most urgent needs: a new security host system plus alarm upgrades at key Stockpile Management facilities; replacement of the Personnel Intrusion, Detection, and Alarm System (PIDAS) at TA-18 and TA-55; installation of PIDAS at CMR; and modifications or upgrades to alarms and access control systems at five key NMSM facilities. The total estimated cost for the 6-year project is \$73.6 million.

Significant upgrades are also planned for the TA-55 Fire Water Loop and the TA-50 Radioactive Liquid-Waste Treatment Facility.

Nonnuclear Reconfiguration

With the downsizing and consolidation of the Nuclear Weapons Complex, certain activities that were conducted at the Pinellas, Rocky Flats, and Mound facilities were relocated to Los Alamos. The Laboratory assisted the activity-transfer groups in planning, scheduling, and defining the development and process prove-in activities needed to ensure a smooth transfer. The Laboratory became a receiver site for several nonnuclear technologies, including high-energy detonators, beryllium and pit support, calorimeters, and neutron-generator-tube targets. As needs dictated, Los Alamos conducted R&D activities related to design and production, supplied test components, and positioned itself to support delivery requirements as they developed. For example, the transfer of the activity for loading neutron-tube targets was completed in FY96, about 2 years ahead of schedule, and Los Alamos delivered several dozen tritiated tube-target development units to Sandia. Calorimeter technology, important in assays of plutonium isotopes, has been transferred to Los Alamos as well, and the TA-35 Calorimetric Assay Laboratory is now operational.

In addition, the transfer of high-energy detonator technology is to be completed in FY97, and the transfer of beryllium and pit support will be finished by the end of FY98.

Late in 1995, Los Alamos demonstrated the capability for performing detonator evaluations, and formal surveillance operations began in FY96. The assignment for manufacturing detonators for the future stockpile has begun with the model 1E33 (used on the W78/76 warheads). For this assignment, Los Alamos has formed a product realization team with the AlliedSignal Kansas City Plant. Los Alamos has also been designing and fabricating detonator simulators used in flight-test units for stockpile evaluation. The simulators have WR-quality standards, and Los Alamos has now demonstrated the ability to produce simulators to those rigorous specifications for two consecutive years.

Los Alamos also established bonded storage capability; transferred production documentation and shelf-life detonators from the Mound Plant; established a cost-effective capability to receive, control, and distribute certified production-support material (such as cleaning fluids and cotton gloves) for use in all WR production; and reconfigured a firing chamber to meet surveillance testing requirements. Recently, the Laboratory demonstrated satisfactory detonator surveillance operations in a formal quality survey.

It is important to note that the Nonnuclear Reconfiguration project provides for some facility modifications necessary to accommodate the capability transfers from other plants. Outyear funding declines signal progress toward this end, but an increase in the core budget will be needed to pay for the expanded workload. Building upgrades in this project are needed for production assignments in calorimetry, high-power detonators, pit support, beryllium technology, neutron-tube-target loading, and production support is needed in terms of records from Rocky Flats.

Environmental Management

Los Alamos remains committed to the goal of reducing its vault backlog of legacy nuclear materials by the year 2002, a target based on the DNFSB Recommendation 94-1 concerning the stabilization of nuclear materials. Los Alamos is the only site to have stabilized and packaged any plutonium and oxide for long-term storage, and we now have a total of 110 containers filled that meet the DOE storage criteria. By the end of FY97, we will have met the goal of stabilizing the high-risk items in our storage vault within the 3-year DOE time limit.

Table 4. Projected Funding for Stockpile Management (\$M).¹

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Stockpile Management (DP0401) ²	119.4	142.4	152.2 ³	240.6	309.9	331.1	344.9	354.4
Nonnuclear Reconfiguration (DP040303) ⁴	20.4	15.3	9.5	0.0	0.0	0.0	0.0	0.0
Total	139.8	157.7	161.7	240.6	309.9	331.1	344.9	354.4

¹Budget figures do not include general plant projects, capital equipment, or capital construction dollars.

²Enhanced Surveillance funding is included in the table for NWT projected funding and is not included here.

³FY98 increase is for zero-sum transfer of facilities from NWT to NMSM.

⁴The present Nonnuclear Reconfiguration Program will conclude in FY99, leaving in place the capability for refurbishment of nonnuclear components.

3. Nuclear Materials Management

Our Nuclear Materials and Stockpile Management (NMSM) Program Office is the focal point for contributions to the Nuclear Materials Management element of our core mission. Contributions include materials surveillance, materials accountability, U.S./Russian disposition work, heat-source development, and R&D work—at Los Alamos as well as Rocky Flats—associated with environmental management technologies. These activities overlap and mesh with the NMSM programs addressing the Stockpile Management element of the core mission.

Projected funding for Nuclear Materials Management is provided in Table 5 at the end of this section.

Materials Surveillance

The materials surveillance category currently funds two materials management efforts. First, the neutron-source recovery project, which is sponsored by DOE Defense Programs-20, was created to provide a mechanism for retrieving unwanted plutonium-239/beryllium neutron sources from public institutions and companies as well as from government agencies. Chemical reprocessing of the retrieved sources reduces the radiological risk from high neutron radiation and gamma radiation. Through the DOE Office of Waste Management (EM-30), Los Alamos anticipates an expansion of the neutron-source recovery project to include recovery and processing of plutonium-238/beryllium and americium-241/beryllium neutron sources.

Second, in addition to local software and analysis support for materials management forecasting and other studies, funding is provided for a technical advisory, change-of-station position at DOE/DP-22 in Washington for Los Alamos experts as needed. Special studies there generally involve systems analysis or specific issues in the overall nuclear materials management arena.

Materials Accountability

To achieve flexibility, accuracy, and responsiveness in nuclear materials management, the Laboratory will continue to improve its inventory database and data management methods. Our efforts in managing nuclear materials are designed to ensure that

- the Laboratory's nuclear materials inventories are adequately assessed;
- the future nuclear materials needs of organizations with identified core competencies are adequately addressed in planning activities;

- existing on-site inventories are used safely and efficiently;
- nuclear materials usage is tracked and properly reported to DOE; and
- operational activities affecting the makeup of the nuclear material inventories are performed properly and meet programmatic as well as regulatory and safety requirements.

The Laboratory conducts these activities in a way that ensures compliance with DOE Order 5660.1A, Management of Nuclear Materials.

Fissile Materials Disposition

Following warhead dismantlement, nuclear materials disposition in both the U.S. and Russia is essential to continuing the reduction of nuclear risk. Initial implementation activities must focus on securing, stabilizing, and storing surplus plutonium belonging to the U.S. and the former Soviet Union. Plutonium must be recovered from weapon components and converted into unclassified forms that are appropriate for disposition options. More importantly, the transparency that these unclassified forms provide enables the immediate placement of this plutonium under broader inspection and safeguards regimes—bilateral, multi-lateral, or international. Such placement promotes irreversibility: it will be politically difficult for the host country to reuse the plutonium for weapon purposes. Although U.S. and Russian choices for disposition methods may differ, it is essential that both countries move forward on parallel paths.

Today's disposition work by Los Alamos capitalizes on preliminary steps initiated by the DOE Office of Fissile Materials Disposition and others. Stabilization of U.S. plutonium processing residues is under way, storage technologies have been developed, and the design of a safe, modern storage facility is in process. Los Alamos is the lead laboratory for weapon component disassembly and conversion, nuclear fuel technology, plutonium storage (both U.S. and Russian facilities), and material conversion (preparing stabilized materials for disposition) and is the co-leader for systems analysis and for nonproliferation, safeguards, and security. Our major disposition activities include disassembly and conversion of weapon components and nuclear fuels technology.

Weapon Component Disassembly and Conversion

The Los Alamos Advanced Recovery and Integrated Extraction System (ARIES), a key element of the national disposition program, provides a stable, unclassified plutonium product assayed and packaged for long-term storage (see Figure 17). The ARIES pilot demonstration project is in its second year and should be operational in the second quarter of 1998; Los Alamos has initiated the design effort for the ARIES production facility. Much of the technology in ARIES is applicable to the Russian challenge of pit disassembly and conversion, and ARIES modular components can be tailored and/or fielded in transportable systems for use elsewhere in the U.S. or in Russia. Los Alamos has begun discussions with the Russians that ideally will lead to collaborative R&D work, to construction of a Russian prototype disassembly and conversion system, and ultimately to a Russian plant producing a steady stream of excess material stabilized and packaged into safeguarded and verifiable storage prior to final disposition steps.

Figure 17. The Automated Recovery and Integrated Extraction System is one approach to pit conversion. It relies on the fact that plutonium quickly combines with hydrogen, forming a powder. The entire operation takes place in a fully automated glove box.

Nuclear Fuels Technology

Los Alamos has the only U.S. capability for producing reactor fuel of plutonium and uranium mixed oxides (MOX). The Spent-Fuel Standard (the Committee on International Security and Arms Control recommends that recovery of plutonium after disposition be just as inaccessible for weapons use as that material in spent fuel from commercial reactors) requires plutonium and uranium to be fabricated into MOX pellets before they are burned in a nuclear reactor for disposition—a major U.S. option and the option favored by Russia. Los Alamos has demonstrated fabrication of MOX pellets from weapons material and is proceeding with the fabrication. Russia is developing MOX technologies as well. The Los Alamos work in mixed oxides, along with our disassembly and conversion efforts, is of mutual benefit to the two countries and bodes well for future nuclear arms reduction and materials disposition initiatives. These efforts collectively support the Laboratory's tactical goal for the Plutonium Future.

Nuclear Vision Project

Just as work at Los Alamos and elsewhere some 50 years ago served as the impetus for developments in military and civilian applications of nuclear science and technology that have shaped history, the end of the Cold War and other changes in the world situation present us with a compelling opportunity to examine the global nuclear enterprise. The objective of the Nuclear Vision Project is to explore how the evolution and impact of future nuclear science, materials, energy, and weapons technologies, along with international strategies to minimize nuclear materials, might be shaped over the next 50 years to realize a global vision that best balances the realization of nuclear benefits and the minimization of nuclear dangers. The basic elements of the project are a series of internal and external exploratory workshops; a set of issues for research and analysis, such as modeling of global energy needs and nuclear power scenarios; and an outreach program to link work at the Laboratory with related work elsewhere. Many complex issues

will emerge as we explore the broad structural alternatives of possible futures, which may be possible to understand to a useful degree so that we can help shape paths toward desirable ones.

Heat Sources

The development of radioisotope heat sources for both space and terrestrial electrical generators continues to require work with plutonium-238. In general, activities include

- designing radioisotope heat sources;
- developing processes for fabricating plutonium-238 fuels;
- fabricating various plutonium-238 fuel forms;
- performing safety tests and postmortem examinations of tested heat sources;
- performing safety assessments of radioisotope power generators; and
- performing materials research, development, and testing and service evaluations for various applications.

Most recently, plutonium-238 work for the National Aeronautics and Space Administration focused on supporting the Cassini mission to Saturn and the Pathfinder mission to Mars (see Figure 18). Cassini is scheduled for an October 1997 launch and uses as many as 157 of the lightweight, radioactive heat sources that we furnished last year. Pathfinder, launched in December 1996, contains the Sojourner robotic vehicle that is exploring the Martian surface. Three small, lightweight, radioactive heat sources built by Los Alamos and positioned inside the Sojourner's suspension axle provide warmth to batteries and electronics.

In the national security realm, plutonium-238 work for the Stockpile Management Program is limited to surveillance and disposal of milliwatt heat sources.

Figure 18. A plutonium-238 heat source rests on a crucible. These heat sources powered space missions in the 1970s. Most recently, Los Alamos provided heat sources to NASA for its Pathfinder mission to Mars and planned Cassini mission to Saturn.

Environmental Management R&D

To address the Defense Nuclear Facilities Safety Board Recommendation 94-1, the Laboratory is providing support to DOE for stabilizing nuclear materials; Los Alamos is the lead laboratory for R&D related to Recommendation 94-1. The Laboratory is providing other sites with stabilization guidance based on risk-based prioritization, stabilization standards, stabilization processes, packaging for long-term storage pending disposition, and surveillance during the storage period. The Laboratory is also overseeing a core technology program that will improve our understanding of underlying material interactions and will ensure that technical capabilities are available in the future to deal with any unforeseen problems with materials in storage. Because of the diverse capabilities at Los Alamos that have been developed for R&D programs, the Laboratory is uniquely suited for the task of stabilizing minor quantities of materials around the complex. In coming years, Los Alamos may be asked to support stabilizing work on unusual material forms.

The Laboratory is supplying technical assistance for developing residue management strategies at the Rocky Flats Environmental Technology Site as progress is made toward closure of this site over the next decade. Los Alamos has established a memorandum of understanding with Kaiser-Hill, the new contractor at Rocky Flats, that provides a framework for our involvement. A team of Los Alamos personnel is stationed at Rocky Flats to provide direct technical support to Kaiser-Hill in areas of nuclear materials management, waste management, stabilization technologies, and environmental restoration plans for the eventual closure of the site. The work at Rocky Flats, as well as the stabilization work at Los Alamos, contributes to the Laboratory's Plutonium Future tactical goal.

Table 5. Projected Funding for Nuclear Materials Management (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Materials Surveillance (DP0405)	7.4	2.3	2.2	2.2	2.2	2.2	2.2	2.2
Program Direction (DP053)	0.7	3.6	3.0	3.0	3.0	3.0	3.0	3.0
Fissile Materials Disposition (GA010)	9.7	21.6	23.0	23.0	23.0	23.0	23.0	23.0
Heat Sources (Nuclear Energy) (CAF70)	13.0	11.0	12.9	12.9	12.9	12.9	12.9	12.9
Environmental Management R&D (EW7040) ¹	12.6	15.1	14.0	13.0	15.2	14.5	17.0	15.0
Total	43.4	53.6	55.1	54.1	56.3	55.6	58.1	56.1

¹Included in Environmental Restoration and Waste Management data.

4. Non- and Counterproliferation

In November 1996, President Clinton said the following in a message assuring Congress that the United States has the capability to prevent the illegal importation of nuclear, biological, and chemical (NBC) weapons into the country.

The [U.S.] has developed and maintains myriad international and domestic programs to prevent the illegal importation of weapons of mass destruction (WMD) into the United States...at least 20 countries have or may be developing nuclear, chemical, and biological weapons. Moreover, terrorist groups have become increasingly capable, often employing lethal, wide-ranging and sophisticated operating methods and technical expertise. This trend is exacerbated by the spread of dual-use technologies, many of which have legitimate civilian or military applications.

...The Departments of Defense and Energy...have developed programs that have succeeded in eliminating or more fully safeguarding tons of fissile materials in the former Soviet Union. These materials—essential to nuclear weapons production—could be targeted for acquisition by terrorist groups or pariah nations and used against the United States.

In his first address to employees of the DOE soon after his confirmation, Secretary of Energy Peña said the following:

We must maintain the capacity and resources to assure the safety and reliability of our nation's nuclear deterrent...we must also keep nuclear weapons out of the wrong hands—worldwide. There is no higher national security priority...and it will receive my active participation.

DOE assumes responsibility for combating proliferation and its many related threats. Responsibilities include providing technologies that allow for intelligence monitoring and arms-control treaty verification, assessing foreign nuclear threats, strengthening global controls on nuclear materials and weapons, protecting nuclear materials from theft or diversion at DOE facilities, and responding to nuclear emergencies.

The national security programs of DOE play a key role in ensuring national and international security. The DOE Office of Nonproliferation and National Security (DOE-NN) focuses on reducing the danger posed by WMD. This office is concerned about proliferation by nations and by the potential spread of these lethal technologies to subnational terrorist groups. DOE-NN works to ensure that the superpower nuclear arms reductions are irreversible and that the world never will see a resumption of nuclear arms races. Preventing the spread of WMD materials, technology, and expertise; detecting proliferation worldwide; reversing proliferation (both horizontal and vertical) of nuclear weapons capabilities; and responding to WMD emergencies are the central elements of the DOE-NN approach. Specific DOE-NN program areas are

- nuclear material security (domestic and international);
- preventing the spread of WMD expertise in the former Soviet Union (FSU);
- developing technology for treaty monitoring and proliferation detection;
- chemical and biological weapon (CBW) nonproliferation;
- preventing nuclear smuggling and terrorism;
- emergency management and response; and
- intelligence analysis and reporting.

The DOE Defense Programs multiprogram laboratories (Los Alamos, Lawrence Livermore, and Sandia) are particularly appropriate resources for carrying out the DOE nonproliferation program (see Figure 19). DOE relies on the national laboratories to respond to the rapidly evolving proliferation threat with effective, dependable technologies. Los Alamos scientists and engineers work closely with colleagues at universities and other laboratories in the U.S. and around the world—particularly with colleagues at Sandia and Lawrence Livermore national laboratories. This tri-laboratory relationship has helped to make the DOE-NN program efficient and productive in supporting the President's nonproliferation and export-control policies.

Los Alamos Director Dr. Siegfried Hecker recently testified as follows to the Senate Armed Services Committee:

Los Alamos is proud of its record in supporting past nonproliferation efforts and is applying its multidisciplinary scientific and engineering capabilities to help meet these new challenges. For example, we lead the highly successful Lab-to-Lab effort working jointly with Russian scientists and engineers to protect their weapons-usable nuclear materials; our innovative sensors and small satellites are helping to develop new national monitoring and detection capabilities; and we are developing new capabilities to counteract terrorism threats involving the potential use of nuclear, biological, or chemical agents against our civilian population.

Los Alamos has been an international leader in nonproliferation and arms-control technology since its founding in 1943. The Laboratory counts many "firsts" in responding to the threat of nuclear proliferation. Since the 1950s, nuclear weapons experts at the Laboratory have been leaders in assessing foreign nuclear threats. In the 1960s, the Laboratory developed the first widely used nuclear safeguards technology and the first satellite sensors for nuclear test monitoring. In the 1970s, we helped establish the Nuclear Emergency Search Team and the Accident Response

Figure 19. Los Alamos is supporting the national initiative intended to ensure the transparency and irreversibility of nuclear arms reduction.

Group. In 1994, the Laboratory led the securing of Russian and FSU weapons and materials by using our contacts with Russian scientists at counterpart nuclear weapon institutes. As noted by President Clinton and Dr. Hecker, this effort has been very successful in improving controls on nuclear materials in the FSU.

The Nonproliferation and International Security (NIS) Program provides nonproliferation and counterproliferation programs at Los Alamos (see Section II.B.2.f. Work for Others for information on the counterproliferation work done by NIS). The NIS mission is to develop and apply the science and technology required to prevent, detect, reverse, and respond to proliferation. We work actively on many fronts to control nuclear proliferation and smuggling. For example, we are developing new sensors and systems, including sensitive NBC-agent sensors, to detect proliferant activities of all kinds. Use of these sensors will range from unattended, ground-based instruments to space-based instruments on satellites. We also are adapting advanced information and computing technologies to meet the challenge of NBC proliferation and terrorism.

The NIS program consists of three major components: Nonproliferation and Arms Control, Research and Development, and International Technology. These program components, addressed in detail below, are supported by the Center for International Security Affairs (CISA), by NIS Division, and by the other Laboratory technical divisions. The major DOE customer interfaces for the NIS programs are

- Nonproliferation and Arms Control—Office of Arms Control and Nonproliferation (NN-40), Office of Security Af-

fairs (NN-50), and Office of Emergency Management (NN-60);

- Research and Development—Office of Research and Development (NN-20); and
- International Technology—Office of Energy Intelligence (NN-30).

Information on the performance of the NIS program is available in the *NIS Self-Assessment*.

Nonproliferation and Arms Control

Nuclear deterrence remains a cornerstone of our national security policy. A key element of deterrence is the Nuclear Nonproliferation Treaty (NPT), which was indefinitely extended in 1995. Another is the 1996 signing of the comprehensive treaty banning all nuclear tests by the five declared nuclear weapons states. Supporting the nonproliferation regime is complicated by a number of factors, including the following:

- Special nuclear materials (SNM)—formerly inaccessible materials that are essential to nuclear weapons construction—are becoming more accessible.
- Nuclear weapons technology has become more widely available.

The increased availability of plutonium has made its proliferation a serious concern. Plutonium is produced during the reprocessing of spent fuel rods from commercial nuclear power reactors

and is recovered during the dismantling of nuclear weapons. Prompt action is required to ensure that plutonium from dismantled weapons—particularly those in the FSU—is not diverted to the illicit manufacturing of nuclear weapons. Diversion of only a small quantity of this material could enable terrorist groups or nations that are not recognized as members of the international nuclear weapons community (usually called proliferant states) to develop a nuclear weapons capability.

NIS provides support to international nonproliferation activities and the Laboratory's directly related tactical goals: (1) The Plutonium Future and (2) Reducing Nuclear, Biological, and Chemical Proliferation and Terrorism Threats. NIS makes nonproliferation technologies available to a national and international community that not only includes DOE but also the Department of Defense (DoD), the Department of State, the Arms Control and Disarmament Agency, and the International Atomic Energy Agency (IAEA). These technologies include effective remote-sensing and monitoring devices (see Figure 20), low-cost satellites, and high-speed information networks. Nonproliferation technologies provide accurate indications, warnings, and assessments of possible diversions of SNM from acceptable peaceful uses to military applications. The technologies also facilitate worldwide control of critical information related to weapons design and development.

In partnership with the Nuclear Materials and Stockpile Management Program Office, NIS is co-champion of the Laboratory tactical goal related to plutonium. The strategic direction of the goal is to be a focal point in developing a national and international vision for the plutonium future; to help strengthen national and international management and control of plutonium; and to address issues regarding weapons proliferation, safety, and the environment. This tactical goal is addressed in more detail in the *Los Alamos National Laboratory FY 1996–1998 Tactical Plan*.

NIS supports the objectives of the DOE Office of Arms Control and Nonproliferation by conducting technology and technical support programs in the areas of FSU nuclear material protection, control, and accounting (MPC&A); international policy and analysis; international safeguards and regional security; and export control. The overall objectives of these programs are to

- improve the security of nuclear materials in the FSU;
- support development and implementation of U.S. national security and foreign policies related to arms control and nonproliferation;
- support treaties, agreements, pertinent national security directives, and presidential decision directives;
- enhance the effectiveness of international, regional, and bilateral safeguards and physical protection of nuclear materials; and
- control the export of nuclear-weapons-related equipment, materials, and technologies.

FSU Nuclear Material Protection, Control, and Accounting

NIS leads a team of six DOE laboratories that is reducing the risks of nuclear weapons proliferation by strengthening systems of nuclear MPC&A in the FSU. Countries presently involved include Russia, Kazakhstan, Ukraine, Belarus, and Latvia. Improvements are being made at nuclear weapons facilities as well as

Figure 20. Personnel- and vehicle-monitoring technologies developed at Los Alamos under the Laboratory-to-Laboratory program have helped to improve significantly the security of more than 8 tons of plutonium and highly enriched uranium located in more than 40 facilities in the former Soviet Union.

commercial and research institutes. The program focuses on plutonium and highly enriched uranium (HEU)—uranium enriched to greater than 20% uranium-235. By the end of 1996, improvements had been made at more than 40 facilities possessing more than 8 tons of plutonium and HEU.

International Policy and Analysis

NIS provides direct technical and analytical support (“back-stopping”) for the negotiation and implementation of arms-control and nonproliferation treaties and agreements, and other ongoing activities. Our objective is to provide sound analyses for both long- and short-term policy options. NIS has initiated a base-line analytical program that focuses on long-term strategy in both arms control and nonproliferation.

International Safeguards and Regional Security

NIS enhances the capabilities of the verification system established by the NPT by improving the effectiveness and efficiency of international, regional, and bilateral safeguards and foreign physical protection. This support ensures that nuclear materials and facilities worldwide are used only for peaceful purposes. The program provides a technical basis for creating U.S. nonproliferation and national security policies designed to prevent the spread of nuclear weapons.

NIS implements U.S. nonproliferation policy by supporting the efforts of the IAEA, participating in negotiations of new international agreements for cooperation in the peaceful uses of nuclear energy, and reviewing and approving subsequent arrangements under the Nuclear Nonproliferation Act and Atomic Energy Act.

Export Control

NIS provides direct technical and analytical support to the Nuclear Transfer and Supplier Policy Division within the DOE Office of Arms Control and Nonproliferation. The objective of this

program is to provide a sound technical base for studies and analyses that support the implementation of national and international nuclear nonproliferation and export-control policies. Principal tasks are performed for export-control issues related to the FSU and to information systems.

Safeguards and Security Research and Development

NIS addresses the existing, evolving, and future need for safeguards and security research and development (R&D), primarily in enhancing the accuracy of nuclear MPC&A.

Research and Development

In addition to developing sensors, NIS applies its analysis and modeling capabilities to a broad range of activities that pose threats to domestic and international security. A primary goal is detecting and characterizing the proliferation, testing, and use of WMD, including weapons-related materials, equipment, and processes such as fissile materials production.

The Laboratory develops remote-sensing, monitoring, and assessment technologies for detecting and identifying emanations, effluents, underground structures, and other distinctive signatures of potential nuclear weapons R&D efforts. Members of the defense community, including DOE, DoD, the Department of Justice, and the Intelligence Community, apply these technologies in both overt and covert configurations and in local, regional, and worldwide deployments. NIS encourages compliance with nuclear test ban treaties by developing and fielding treaty verification sensors that ensure that any nuclear weapons test—regardless of whether it is conducted underground, in the atmosphere, or in space—will be observed and monitored.

Nonproliferation and Verification Research and Development

NIS performs work in nonproliferation and verification for the DOE Office of Research and Development, which sponsors the nation's largest R&D program supporting nonproliferation and arms-control policy objectives. Principal task areas include on-site systems, regional monitoring systems, remote sensing systems, and advanced systems.

On-Site Systems

R&D activities associated with on-site systems involve radiation detection, warhead dismantlement, SNM monitoring, on-site geophysical measurements, cooperative monitoring, effluent detection and analysis, and geophysical measurements.

Regional Systems

Los Alamos activities associated with the development of regional systems involve effluent detection and analysis and geophysical measurements. NIS is participating in such projects as developing simpler approaches for the radiochemical determination of key radionuclides associated with nuclear devices and developing and testing devices for analysis of ultrasmall air samples containing krypton and xenon isotopes. NIS also contributes to the Subsurface Nuclear Detonation Analysis Research Project, which encompasses research needed to develop analytical tools for monitoring a comprehensive test ban treaty with high confidence and with a minimum number of false alarms.

Remote Systems

Laboratory involvement in remote systems includes many activities, such as the following:

- developing on-board instrumentation for detecting nuclear explosions for the Defense Support Program and Global Positioning System satellite programs;
- operating the array of low-energy x-ray imaging sensors (ALEXIS) satellite and analyzing the collected data;
- developing and flight-testing an advanced radio-frequency detection and characterization system aboard a small spacecraft, for example, the ALEXIS/BLACKBEARD and FORTE programs (see Figure 21); and
- developing remote ultralow-light-level imaging systems for fielding on ground-based, airborne, and spaceborne platforms.

Figure 21. The FORTE satellite, shown here as an artist's concept, will improve the ability of the U.S. to detect clandestine atmospheric nuclear tests by measuring the nuclear-generated electromagnetic pulse from such tests.

Advanced Systems

Los Alamos involvement in advanced systems includes development of advanced concepts such as rugged, vibration-free cryocoolers; participation in a collaboration of five national laboratories to develop and demonstrate laser-based systems for remote optical detection and characterization of proliferation activities; and development and testing of knowledge fusion technologies, machine-learning systems, and advanced computational methods capable of automating and enhancing the analysis of multisource sensor data.

International Technology

Reducing proliferation and terrorism threats is made more urgent and difficult by increases in regional strife, growing worldwide inventories of SNM, the technical simplicity involved in producing and modifying biological and chemical agents, and the availability of missile technology. The problem is further complicated by the specter of acts of terrorism by subnational groups employing WMD and of organized international criminals trafficking in nuclear materials and nuclear weapons components. An effective national intelligence program is essential to meeting these threats. The mission of the NIS International Technology

Program is to provide the U.S. Intelligence Community with the tools and technology needed to meet this daunting challenge.

Technology Assessments

A robust analytic program for assessing foreign programs that could contribute to or be involved in the development and/or production of such weapons must be at the heart of an effective program to prevent proliferation of WMD. In support of the DOE Office of Energy Intelligence and other elements of the Intelligence Community, Los Alamos performs assessments using technical experts who understand fully the technologies and processes involved and, at the same time, address nontraditional methods of acquiring the materials and expertise needed to realize the aims of the proliferant. NIS monitors foreign science and technology developments—for example, “cyber” or information warfare—to prevent damage to our national security by technological surprise. NIS develops new methodologies for acquiring, cataloging, and analyzing the large volumes of data currently available and essential to a quality assessment. NIS develops tools employing state-of-the-art information-management technologies to enhance the effectiveness of these experts and thereby achieves force multiplication in these times of constrained fiscal and personnel resources.

Proliferation and Terrorism Response

U.S. nonproliferation efforts are unlikely to be totally successful in deterring all nations or subnational groups from acquiring nuclear weapons and other WMD and their means of delivery. The U.S. must be prepared to respond to situations in which the threat posed by adversaries possessing such weapons is real and immediate. NIS develops and provides a full spectrum of capabilities for responding to threats to domestic and international security, including, when necessary, methods for mitigating and neutralizing these threats. These capabilities are available to senior policy-makers in DOE, DoD, the Intelligence Community, and national and local law-enforcement agencies.

Center For International Security Affairs

The mission of CISA, which reports to the NIS program director, is to develop, coordinate, and implement international programs aimed at reducing threats to the U.S. from WMD. Over the past several years, Los Alamos has developed a special relationship with the Russian nuclear weapons design institutes. In addition to extensive scientific interactions, the Laboratory has led the organization of the laboratory-to-laboratory program in nuclear materials control and other efforts that have a direct effect on stabilizing the Russian nuclear weapons complex. CISA serves as the Laboratory focal point for interactions involving Russia, China, and potential nuclear weapons proliferant states. CISA also provides technical assistance to government programs active in these areas.

CISA programs include the laboratory-to-laboratory effort in nuclear MPC&A; the Initiative for Proliferation Prevention (formerly the Industrial Partnering Program); support to the International Science and Technology Center; Nunn-Lugar-sponsored activities; and other relevant international programs.

An emerging danger is the possibility of nuclear proliferation resulting from the diffusion of knowledgeable experts from the nuclear design centers in the Russian Federation. Los Alamos is playing a leadership role in addressing the potential for such proliferation and in facilitating the transition of nuclear weapons scientists into areas of nonweapons R&D.

Funding Tables

Tables 6–9 provide the funding information for activities related to Nonproliferation and International Security Programs.

Table 6. Projected Funding for Nonproliferation and Arms Control (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
FSU Material Accountability and Control (GJ08)	8.7	17.0	29.7	31.2	32.7	34.4	34.4	34.4
International Policy and Analysis (GJ1201, GJ02)	2.5	2.7	2.5	2.6	2.8	2.9	2.9	2.9
International Safeguards and Regional Security (GJ04, GJ1202)	2.4	4.0	3.3	3.5	3.6	3.8	3.8	3.8
Nuclear Safeguards and Security R&D (GD)	7.9	6.5	8.7	9.1	9.6	10.1	10.1	10.1
Nuclear Transfer and Supplier Policy (GJ01)	6.6	4.7	4.3	4.5	4.7	5.0	5.0	5.0
Initiative for Proliferation Prevention (GJ09)	1.3	2.0	2.1	3.0	3.2	3.3	3.3	3.3
Total	29.4	36.9	50.6	53.9	56.6	59.5	59.5	59.5

Table 7. Projected Funding for Nonproliferation and Verification R&D (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
On-Site Systems (GC0401)	4.9	6.9	7.0	7.4	7.7	8.1	8.1	8.1
Regional Monitoring Systems (GC0402)	7.1	6.2	6.3	6.6	7.0	7.3	7.3	7.3
Remote-Sensing Systems (GC0403)	28.7	25.2	25.7	26.9	28.3	29.7	29.7	29.7
Advanced Systems (GC0404)	13.4	15.4	15.7	16.5	17.3	18.1	18.1	18.1
New Initiatives (GC) ¹	0.0	5.2	5.8	6.1	0.0	0.0	0.0	0.0
Total	54.1	58.9	60.5	63.5	60.3	63.2	63.2	63.2

¹Not included in Summary Tables in Appendix.**Table 8. Projected Funding for International Technology (\$M).**

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
DOE (NT)	5.6	6.0	7.6	8.0	8.4	8.8	8.8	8.8
Total	5.6	6.0	7.6	8.0	8.4	8.8	8.8	8.8

Table 9. Summary of Projected Funding for Nonproliferation and International Security Programs (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Nonproliferation and Arms Control (GJ, GD)	28.1	38.2	50.6	53.9	56.6	59.5	59.5	59.5
Nonproliferation and Verification R&D (GC)	54.2	60.1	60.5	63.5	60.3	63.3	63.3	63.3
International Technology (NT)	5.6	5.5	7.6	8.0	8.4	8.8	8.8	8.8
New Initiatives ¹	0.0	0.0	3.0	3.2	9.7	10.2	10.2	10.2
Total	87.9	103.8	121.7	128.6	135.0	141.8	141.8	141.8

¹Not included in Summary Tables in Appendix.

5. Environmental Stewardship

a. Environmental Management Program

The Environmental Stewardship element of the Los Alamos core mission consists primarily of three major thrusts in the Environmental Management (EM) Program. Environmental Stewardship addresses aggressively cleaning up the legacy from 50 years of operations and managing waste from both ongoing and legacy operations. It also includes implementing waste minimization/pollution prevention in all operations, thereby improving the Laboratory's environmental performance and avoiding future environmental vulnerabilities. Finally, Environmental Stewardship is enabled by the development of science and technology to address long-standing remediation and waste management problems both for DOE and worldwide.

To prevent confusion, it is important to note that as a part of the Environmental Stewardship element of our core mission, there is an initiative in EM called the Environmental Stewardship Initiative. The initiative is a specific thrust area of waste minimization/pollution prevention, described later in this section.

The Environmental Stewardship mission element, through our EM Program, receives support from several DOE Environmental Management program offices, including Environmental Restoration (EM-40), Waste Management (EM-30), and Integrated Science and Technology (EM-50). The major DOE customer interfaces for the Laboratory's EM programs are the DOE Albuquerque Operations Office (DOE/AL) Assistant Manager for Environment/Project Management and Assistant Manager for Energy, Science, and Technology, as well as the Los Alamos Area Office (DOE/LAAO) Assistant Area Manager for Environment and Projects.

DOE's Office of Environmental Management has identified six strategic goals to achieve its vision to establish a new standard of excellence in restoring, protecting, and enhancing the environment:

- reduce mortgage and overhead costs to free up funds for further environmental risk reduction;
- eliminate and manage the most serious risks in our DOE system;
- protect worker health and safety;

- create a collaborative relationship between DOE and its regulators and stakeholders;
- focus technology development on cost and risk reduction; and
- establish a system that is managerially and financially in control.

In June 1996, DOE initiated a 10-year plan for completing complexwide cleanup of legacy waste by the year 2006. Complete cleanup is defined as follows:

- all legacy waste is disposed of;
- currently generated wastes are managed by generating organizations;
- all remediation and decontamination and decommissioning efforts are complete; and
- transuranic and other wastes are stabilized and in long-term storage.

DOE also initiated a plan to transfer ownership of operational waste management facilities and the cost to manage such waste to the facility administrator by 1999. For Los Alamos, ownership of these facilities and management costs will transfer to the defense programs sponsored by DOE Defense Programs. The total DOE funding for environmental programs is shown in Table 10.

Waste Management and Environmental Restoration

In partnership with DOE, the University of California (UC) developed performance goals for the Waste Management (WM) Program and the Environmental Restoration (ER) project; these goals emphasize results most important to DOE. The use of performance goals represents a significant departure from past agreements for conducting WM and ER activities. By collaboratively developing performance goals, DOE and UC become co-advocates when negotiating milestones with the New Mexico Environment Department (NMED) and the U.S. Environmental Protection Agency (EPA). Both DOE and UC also understand and agree to accept both positive and negative impacts of programmatic decisions.

Waste Management

The mission of the WM Program is to aggressively avoid new waste generation and to safely and cost effectively treat, dispose of, or, when necessary, store waste to enable DOE's and the Laboratory's other missions, programs, and priorities. Table 11 lists the WM facilities at Los Alamos, the types of wastes handled, and the operations conducted at each site.

The Laboratory's WM activities are conducted in compliance with DOE orders for managing radioactive waste and with state and federal regulations for managing hazardous wastes, including mixed radioactive waste, and other nonradioactive wastes. The Laboratory's hazardous, chemical, and mixed waste management activities are regulated by NMED and EPA. WM manages hazardous and toxic chemical wastes, low-level radioactive waste (LLRW), low-level mixed waste (LLMW), radioactive liquid waste, and transuranic (TRU) and TRU-mixed wastes.

In FY96, WM conducted work in accordance with the DOE-approved base-line and the related FY96 and FY97 tactical plan. To measure its progress as a best-of-class operation, we benchmark the program's activities and operations against other exemplary

Table 10. Projected Funding for Environmental Restoration and Waste Management (\$M).¹

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Corrective Action (EW11)	00.11	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Environmental Restoration (EW20 and EX20) ²	59.45	48.90	61.60	60.50	65.00	65.00	65.00	65.00
Waste Management - Defense (EW31) ³	64.10	57.10	61.40	71.40	80.60	97.20	100.80	96.00
Technology Development (EW40)	07.80	08.90	06.00	04.20	04.40	04.60	04.90	05.10
Basic Science Program (EW45)	00.00	02.00	02.00	02.90	03.10	03.20	03.40	03.60
Transportation Management (EW50)	00.07	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Program Direction (EW60)	00.01	00.04	00.00	00.00	00.00	00.00	00.00	00.00
Facility Transition (EW70)	13.60	18.80	15.80	14.00	16.20	15.50	18.00	16.00
Compliance and Program Coordination (EW90)	00.35	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Facilities and Sites (EX2010)	02.74	03.36	00.00	00.00	00.00	00.00	00.00	00.00
Uranium Mill Tailings Remedial (EX2040)	00.01	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Waste Management - Non-Defense (EX31)	00.40	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Total	148.64	139.10	146.80	153.00	169.30	185.50	192.10	185.70

¹Construction and capital equipment costs are included in total funding.²EX20 does not extend past FY97.³EW31 includes past WIPP activities.**Table 11. Waste Management Facilities and Operations.**

Waste Type	Facility	Operations Conducted
Chemical	TA-54, Area L	Accumulation, repackaging, and shipment off-site
LLRW	TA-54, Area G	Compaction and disposal
LLMW	TA-54, Areas L and G	Storage, preparation, and shipment off-site
Radioactive Liquid	TA-50, Building 1	Treatment and solidification
TRU and TRU Mixed	TA-54, Area G and West TA-50, Building 69	Storage, retrieval, characterization/certification, and shipment off-site Characterization, size reduction, and certification

programs and refine its processes. DOE and WM have developed several performance objectives to achieve this best-of-class ranking. We will eliminate the LLMW legacy (as measured in the current Site Treatment Plan) by September 2003 and will manage any LLMW generated after that time on an annual throughput basis. We plan to begin shipping TRU waste to the Waste Isolation Pilot Plant in April 1998 and to implement an accelerated 10- to 15-year plan for shipping remaining TRU waste currently held in storage. Another specific goal for future years includes continually reducing the cost of performing waste management work. In FY97, WM plans to reduce work-related costs by 3% by improving processes, aggressively managing and reducing legacy waste, and preventing or reducing generation of future mission wastes through the Environmental Stewardship Initiative.

WM was the subject of an Independent Technical Review by DOE in 1996. As a result of actions taken in response to the review, WM was reorganized and streamlined. It reduced total UC and subcontract staffing by 19% and reduced costs by approximately \$13 million for FY96; costs for projects will be reduced by approximately \$64 million for the period FY97 through FY01. WM revised the original plans for reducing legacy waste and associated Laboratory liabilities. It developed and implemented a much more aggressive plan for reducing legacy LLMW and developed a plan, which is being reviewed by DOE, to reduce the Laboratory's inventory of legacy TRU waste. If approved and implemented as submitted, the aggressive TRU legacy reduction

plan will result in a net savings to DOE of \$80 million out of a potential \$165 million. To achieve this net savings, funding for the WM Program for the next 8.5 years must increase by approximately \$10 million per year. Finally, the program is setting the standard and playing a leadership role in cost-effective mobile characterization of TRU mixed waste, which is a high priority issue for DOE.

Environmental Restoration

In the ER project, our mission is to clean up the Laboratory and Los Alamos townsites as fast as possible in the most cost-effective manner. Over 2,000 sites that may have been contaminated over the past 50 years have been designated for corrective action to determine what actions, if any, need to be taken to achieve a "no further action" status. These sites range from the size of a tabletop to areas of several acres and include past disposal sites as well as areas of reported spills. Environmental restoration activities include decommissioning of sites and facilities such as radiochemistry laboratories and test reactors in a manner that provides adequate protection from radiation exposure, isolates radioactive and hazardous contaminants, and provides locations for new Laboratory initiatives.

On March 8, 1990, EPA issued the Hazardous and Solid Waste Amendment (HSWA) module to the Laboratory's Resource Conservation and Recovery Act operating permit. The

HSWA module sets forth procedural requirements for assessing and remediating sites that meet the definition of solid-waste management units. In addition, the ER project has entered into a Document of Understanding with Sandia National Laboratories-New Mexico (SNL-NM), DOE, EPA, and NMED for the purpose of facilitating timely and cost-effective implementation of corrective action.

ER invites active stakeholder involvement, including frequent public meetings and reading-room access, to allow the public to become informed and supportive of ER activities. Meetings with EPA and NMED occur frequently, and computer links have been established between the Laboratory and these agencies. The Facility for Information Management, Analysis, and Display, which is managed by the Earth and Environmental Sciences Division, provides site information to ER personnel, DOE, and regulatory agencies.

DOE customer feedback indicates ER effectively used an innovative heap-leaching process to remove uranium contamination from a site for reuse. Additionally, ER has used innovative approaches, including recycling during decontamination and decommissioning, that minimize waste. FY97 continues the theme of working towards mutually agreed-upon outcome-oriented performance objectives. ER has developed a plan to complete the remediation work in less than 10 years, having thus far identified over 1,000 sites (of the roughly 2,000 potentially contaminated sites) as requiring no further action. The Laboratory also supports a DOE field initiative to further expedite the cleanup of national laboratory sites by stabilizing and incrementally increasing the funding of the cleanup of these sites over 5 years. The result of this could be the cleanup of 97% of the national laboratory sites within the 5-year period. As ER continues to emphasize remediation activities, highly contaminated or complex sites will require greater attention. These sites include a dozen of material disposal areas and rugged canyon areas.

Decommissioning of obsolete sites and facilities such as test reactors and other nuclear facilities is an essential part of the ER project. This activity provides adequate protection from radiation exposure, isolates radioactive and hazardous contaminants, reduces the mortgage costs associated with maintaining facilities, and provides space for new Laboratory efforts. The following are the highest priority projects planned for decontamination and decommissioning:

- removing high-explosive buildings from the 1940s that are located at TA-16,
- decontaminating a phase-separator pit at TA-35,
- decommissioning the Omega West reactor,
- decommissioning several older, surplus facilities, and
- removing high-pressure tritium-handling equipment from a building.

Waste Minimization/Pollution Prevention

In a specific thrust area called the Environmental Stewardship Initiative, EM leads the work of minimizing waste and pollution at the Laboratory. The purpose of this initiative is to improve the Laboratory's environmental performance and to avoid future environmental vulnerabilities by reducing and, when possible, eliminating waste and pollution created during the Laboratory's ongoing and future operations. Effective environmental stewardship will improve Laboratory productivity by minimizing expen-

sive-to-dispose-of wastes, build trust of surrounding communities in the Laboratory by demonstrating the Laboratory's commitment to the best environmental practices, and reduce potential for Laboratory shutdowns and fines.

The initiative's long-term goals for the Laboratory are to produce no avoidable waste, release minimal hazardous gases, use minimum natural resources (especially energy and water), and procure only environmentally preferable products. Achievement of these goals demands consideration of all aspects of the Laboratory/environment interface and Laboratory-wide support for process and system improvements.

The Environmental Stewardship Initiative has four major elements: waste minimization, air emissions minimization, environmentally preferable procurement, and conservation. Individually and collectively, these elements of environmental stewardship build on the Laboratory's successful Pollution Prevention Program and integrate and systematize the Laboratory's long-standing efforts to protect the environment.

- Waste minimization is effected by the Environmental Stewardship Office and the Laboratory's technical divisions. Waste minimization activities include reducing the size of radioactive materials management areas (where radioactive waste is produced), conserving LLRW landfill space by recycling radioactive metals, recycling electroplating/plating effluent, recycling gloveboxes, sorting and segregating radioactive waste, and implementing a "Green is Clean" program to minimize suspect radioactive wastes.
- Air emissions minimization is jointly managed by the Laboratory's Environment, Safety, and Health Division and the technical divisions. Activities to minimize air emissions include eliminating and consolidating stacks and upgrading processes to eliminate emissions.
- Environmentally preferable procurement is being implemented through a partnership between the Environmental Stewardship Office and the Laboratory's Total Integrated Procurement System. This element focuses on achieving effective implementation of the DOE-mandated affirmative procurement program, installing a Laboratory-wide environmentally preferable product information system, and instituting a product-substitution education program.
- The Conservation Project is a cooperative effort of the Environmental Stewardship Office; Johnson Controls, Inc.; and the Laboratory's Facilities, Security and Safeguards Division. As part of an overall mission of promoting the protection of natural resources, the project encompasses the Laboratory's sanitary waste recycling program and the adoption of programs for maximizing energy conservation, effective land management, and use of gray water.

The Environmental Stewardship Initiative calls for developing and implementing Laboratory-wide process changes that promote good environmental practices. First, the initiative is promoting waste awareness through a waste set-aside-fee program in which fees are collected for waste production. The income from these fees is invested in waste-minimizing capital improvement projects. Second, the initiative is developing analyses of each Laboratory waste stream to determine the most cost-effective solutions for reducing waste and environmental vulnerabilities. This work is being done in preparation for 1999 when all programs will be charged for the waste they generate. The Environmental Steward-

ship Office and the Waste Management Office are developing pilot projects for full recovery of waste treatment, storage, and disposal costs. Third, the initiative is the Laboratory's point of integration for achieving the 1999 Departmental pollution prevention goals for reducing routine hazardous and radioactive wastes. Finally, the Laboratory is reducing production of unnecessary waste through CHEAPER, a project that facilitates exchange of unused chemicals among the Laboratory's technical divisions and Sandia National Laboratories.

Integrated Science and Technology

The Integrated Science and Technology Program is working to develop and implement more-effective methods for solving user-identified environmental problems. Charged with developing timely, cost-effective, and comprehensive solutions, this program focuses on applying the Laboratory's science and technology base to local, regional, and global environmental problems. The program builds on the Laboratory's history of excellence in multidisciplinary problem-solving through scientific and engineering innovation, progressive management, quality facilities, exceptional business practices, and effective demonstrations. Our approach can be summarized by the phrase "Environmental Problem-Solving through Science and Technology."

The Integrated Science and Technology Program Office works with many segments of the environmental community, including U.S. government agencies (DOE, EPA, the Department of Defense, the Department of Commerce, and the Department of the Interior), international agencies and organizations, private industry, and universities. One example of an environmental science application developed at Los Alamos is polymer filtration in which water-soluble polymers are used for metal-ion recovery. After the polymer binds to metal ions (for example, plutonium, silver, mercury), the polymer/metal association is filtered and concentrated using off-the-shelf ultrafiltration equipment. The resultant metal can be recycled; the water meets all regulatory requirements for cleanliness. This technology has three times the capacity of common ion-exchange resins and is less expensive to operate. In a second example, Los Alamos and Faraday Technologies, Inc., are developing an electrochemical process to treat hazardous and/or radioactive wastes that contain metal solutions, cyanide solutions, nitrate solutions, and various organic wastes that may contain chlorinated organic compounds. This technology does not generate secondary waste for many waste types and is easily controlled, thereby eliminating the potential for uncontrolled emissions or explosions. Many other environmental technologies are described on a Web Site (see Appendix D for Web site address).

The Laboratory also continues applying its strong scientific and engineering capabilities to facilitating the solution of waste management, environmental restoration, nuclear materials, and facility stabilization problems at other DOE facilities.

The largest segment of this work involves the remediation of the high-level waste tanks at Hanford. The Laboratory continues to make significant contributions to these remediation efforts in the areas of tank safety and the pretreatment and characterization of tank wastes; these areas are project elements of the Tank Waste Remediation Program at Hanford. Recently, Los Alamos personnel prepared safety assessments for two important proposed operations on the tanks: rotary mode core sampling (RMCS) and

saltwell pumping (SWP). The RMCS will allow samples to be taken in the solid and sludge layers in the tanks; these samples will yield important information regarding characterization of the tank wastes. The SWP operation will allow liquids to be pumped from many of the leaking, flammable-gas, single-shell tanks. Both of these operations are milestones in the Tri-Party Agreement between DOE, EPA, and the Washington State Department of Ecology. The Laboratory expects to receive additional assignments of this nature during the next several months. Field Programs personnel continue to do more generic research and development on flammable-gas concentrations in the tanks and mitigation of potentially explosive mixtures of hydrogen gas.

The Laboratory is providing complex-wide support to DOE for nuclear materials stabilization associated with the Defense Nuclear Facilities Safety Board Recommendation 94-1, which outlines several environmental safety and health vulnerabilities in the DOE Complex. As the lead Laboratory for 94-1 research and development of plutonium residues, Los Alamos is providing other sites with technical guidelines for risk-based prioritization, stabilization standards, stabilization processes, packaging for storage of plutonium for possible future use, and surveillance during the storage period. A team of Los Alamos personnel is stationed at Rocky Flats Environmental Technology Site to provide direct technical support in nuclear materials management, waste management, and environmental restoration as site-closure strategies are developed.

The Laboratory is involved in deactivating neutron sources that are abandoned or no longer needed by research or industrial organizations. For several years, the Laboratory has deactivated plutonium-239/beryllium neutron sources and responded to emergency situations for plutonium-238/beryllium and americium/beryllium sources. The Laboratory is further developing its capabilities to deactivate neutron sources over the next 5 to 10 years.

b. Los Alamos Neutron Science Center

Accelerator-Driven Transmutation Technologies

In addition to the work coordinated through EM, Los Alamos is pursuing accelerator-driven transmutation technology concepts for excess plutonium disposition, nuclear waste transmutation, and subcritical energy production at the Los Alamos Neutron Science Center (LANSCE). This technology uses a high-power proton accelerator to produce an intense source of neutrons that is used to convert longer-lived isotopes into shorter lived or stable isotopes. A system for the accelerator-driven transmutation of waste (ATW) requires a front-end chemistry system to convert nuclear spent fuel into the appropriate form for transmutation and a back-end chemistry system to prepare transmuted waste into a form for storage. The target/blanket system in which the isotopes are converted consists of a liquid heavy-metal target to produce the neutrons and a conversion blanket region into which the nuclear waste is inserted. An ATW system eliminates the long-lived isotopes that are the main source of toxicity for geological repositories. This procedure has the following features:

- it can almost completely eliminate long-lived nuclear waste;
- it can treat all forms of nuclear waste;
- it requires only short-term storage for its waste stream;
- it extracts essentially all of the available heat energy (which can be used to generate electricity);

- it requires much less nuclear waste to be in the system at any given time; and
- known perturbations to the system cause it to shut down safely.

Much of the technology for ATW already exists or is in the process of being developed, and the accelerator technology being developed for the Accelerator Production of Tritium (APT) project exceeds the needs for proposed ATW systems. The principal focus at Los Alamos has been on determining the best technical approaches to the accelerator-driven neutron source and to the chemistry for processing the incoming waste and the residual waste after transmutation. Collaborations with other national laboratories (Argonne, Oak Ridge) and industry (Rockwell) are looking at the chemistry-processing concepts. Other industries (Bechtel, Westinghouse, B&W, General Atomic, Northrop Grumman) are interested in the accelerator and target/blanket system. Los Alamos has established working collaborations with scientists from international organizations in the following countries: France, Italy, Sweden, Czech Republic, Russia, and

South Korea. France has just begun a major program in ATW at their Cadarache nuclear reactor institute. Italy is proposing to build a large accelerator that would be used in collaboration with other European countries, including France, to demonstrate the viability of ATW. The Japanese have proposed a similar large-scale accelerator transmutation facility be built in the next 5 to 7 years.

The current international situation opens the possibility of major collaborations between the U.S., the Russians, the Europeans, the Japanese, and perhaps others on the phased development of ATW technology. There appears to be some convergence on the technical concepts that should be tested as part of a transmutation program. DOE has the best facility in the world at LANSCE to begin these studies. If successful, larger-scale activities are possible in the U.S., Europe, and Japan in which technical information could be shared. The APT accelerator, if built at Savannah River, could eventually serve as a major U.S. testbed for a scale-up of ATW if the demand for tritium were to decline in the future.

At present, funding for this activity is provided by Laboratory-Directed Research and Development.

B. CIVILIAN NATIONAL MISSIONS, CONVENTIONAL DEFENSE, AND INDUSTRIAL PARTNERSHIP

Activities described in this section address strategically selected national challenges in civilian missions, conventional (i.e., non-nuclear) defense, and industrial partnership that are synergistic with our core mission and with our capabilities. These activities, while providing scientific and technological solutions to national problems, are essential to the long-term vitality and excellence of the Laboratory; they help provide intellectual stimuli, cutting-edge technology drivers, and new program seeds for Los Alamos.

1. Civilian National Missions

Civilian programs address issues in such areas as energy, environment, health care, national infrastructure, and education.

a. Environmental Management

In addition to providing support for the Environmental Stewardship element of the core mission, the Environmental Management (EM) Program supports civilian national missions and conventional defense in several projects. Many of the projects are embedded within Environmental Stewardship projects that have already been described (see Section II.A.5. Environmental Stewardship).

The following are some additional examples of work done at EM. The Laboratory receives funding from the Department of Defense to assist them in detecting, characterizing, and neutralizing unexploded ordnance as well as hazardous and radioactive contaminants found on military bases and testing grounds. We have partnered with the Environmental Protection Agency in support of their "Green is Clean" chemical substitution program. We have also established a long-term collaboration with Hughes Aircraft to develop additional applications of our research using supercritical carbon dioxide as a cleaning agent. The dry-cleaning industry (currently a major user of hazardous chemicals and solvents and producer of toxic waste byproducts) will be one of the primary beneficiaries of this supercritical technology.

The Los Alamos EM Program Office is also the owner of a programmatic Laboratory tactical goal. The purpose of this internally funded tactical goal is to further Los Alamos's environmental science base through the use and leveraging of the Los Alamos core mission of Reducing the Nuclear Danger. Supporting national security, this tactical goal addresses the environmental aspects of the national infrastructure. For the next 2 years, the key thrust of this goal is to use the resources provided by the Advanced Supercomputing Computer Initiative to demonstrate unique Los Alamos capabilities for solving problems in the global environment; specifically, we will provide a simulation of weather patterns through coupled ocean/atmospheric models that cannot be performed anywhere else. Predicting major geological or weather events is essential to developing mitigation strategies. It is anticipated that this simulation will demonstrate to the global environmental community that Los Alamos is indeed the leader in the field of applied computational science.

b. Energy Technology Programs

The Energy Technology (ET) Program at Los Alamos is administered by the Civilian Industrial Technology Program Office. The ET Program serves as the primary Laboratory contact for the DOE's Energy Efficiency and Renewable Energy (EE) office, Nuclear Energy (NE) office, and Fossil Energy (FE) office, as well for as various reimbursable customers such as the Department of Transportation (DOT) and the Nuclear Regulatory Commission (NRC). Projects in ET's portfolio support the nation's strategic energy needs in energy supply and the environment, integrated chemical and materials processing, and transportation and infrastructure. These projects focus on improving the nation's energy efficiency, enhancing energy independence, and developing renewable energy sources. A summary of ET's projected funding is listed in Table 12 at the end of this section.

Energy Efficiency and Renewable Energy

Los Alamos supports a number of programs in energy efficiency, ranging from electrical energy systems to buildings to transportation. These programs make use of the Laboratory's competencies in computing, chemistry, materials, theory, systems engineering, and geosciences, among others. This section outlines the DOE/EE programs that Los Alamos works on and highlights some of the major projects.

Electrical Energy Systems

The Laboratory's Superconductivity Technology Center is one of three U.S. centers established by DOE. The center's goal is to develop practical high-temperature, high-current-density superconductors for power applications. Such applications include motors, cables, generators, and magnets for energy storage and other industrial and medical uses. The center's specific mission is to form partnerships with U.S. industry to expedite the development of high-temperature superconductor (HTSC) technology with commercial feasibility. The emphasis in developing these partnerships is on power applications of HTSCs although the Laboratory does respond to strong industry interest in collaboration on electronics applications. FY96 marked a number of significant milestones in this program, such as high-temperature superconducting tape that delivers world-record current levels. Industry interest continues to flourish, leading to collaboration with organizations like the American Superconductor Corporation and the Electric Power Research Institute.

Geothermal Systems

Building on work originally done for the geothermal hot dry rock program, Los Alamos has developed a methodology for use in oil and gas exploration that we are applying to hydrothermal and geothermal exploration. We have deployed sensitive downhole seismometers to detect microseismic events generated along fractures in reservoirs. The downhole seismometers record events too small to be detected at the surface, and data analysis reveals the fracture location and areal extent. Geothermal companies are working with Los Alamos to develop a test of the applicability of the seismic method to geothermal fracture mapping. Knowledge of fracture location and areal extent in geothermal reservoirs would greatly reduce the cost of exploration and development.

Hydrogen

As DOE programs in hydrogen have expanded, Los Alamos has supported DOE/EE's objectives in understanding the combustion characteristics of H_2 . Los Alamos has long maintained a combustion modeling expertise in a code called KIVA; this expertise is currently being applied to DOE/EE's hydrogen program. In addition, Los Alamos expertise in fuel cell development is being used to examine commercialization of fuel cells with hydrogen as the base fuel. The discussion on advanced automotive technologies later in this section provides further detail on fuel cells.

Buildings Sector

In FY96, Los Alamos began a new project to develop a high-efficiency "green" light bulb for the Building Technology office of DOE/EE. This program leverages the Laboratory's considerable materials science expertise in coatings and thin-film technology. Success in this program may lead to completely new lighting systems.

Industrial Energy

Los Alamos continues to participate in DOE's Industries of the Future program. This DOE initiative is aimed at providing pre-competitive, enabling research in several energy-intensive U.S. industries, including forest and paper, steel, aluminum, metal casting, glass, chemicals, and petroleum refining. Current industrial technology efforts include the following projects.

- The Center for Multiphase Fluid Dynamics, founded in FY96 with Los Alamos as the lead laboratory, seeks to integrate and develop the resources of industry, government, academia, and professional societies to enable reliable analysis in multiphase computational fluid dynamics. Current programs are in place with the petroleum and chemical industries, and the center has just completed a technology road map for DOE.
- The Combustion Research Program's primary goal is to develop advanced multidimensional computer programs for the analysis of practical combustion systems. The Laboratory has applied such research to the in-cylinder dynamics of internal combustion engines and to continuous-spray combustors, with the aim of designing cleaner, more efficient combustion systems.
- The Advanced Industrial Materials Program began as a theoretical effort and has evolved into several programs. Research includes activities in materials processing, materials for separations, and refractory materials. Current investigations focus on intermetallics, ceramic processing and joining, new technologies for polymer processing, and chemical vapor infiltration.
- The Laboratory's theoretical design and experimental work have played a strong role in DOE's Catalysis Program. The goal of our activities is to provide design and selection tools for chemical process catalysts.

Advanced Automotive Technologies

Funded by DOE/EE's Office of Propulsion Systems, the Fuel Cells for Transportation Applications Program continues studying fuel cells as power supplies for consumer vehicles and buses. The program's basic research focuses on development of alternative catalysts, improvement of fuel cell performance, fuel reforming,

and cost reduction. The program's applied research uses the Laboratory's systems integration, modeling, technology, and economic assessment capabilities. The core fuel cell program at Los Alamos has the objective of developing proton-exchange-membrane fuel cells for alternative transportation with ultralow emissions. In addition, DOE's Office of Transportation Technologies funds the Laboratory's Partnership for the New-Generation Vehicle projects such as innovative exhaust sensors, advanced powder metallurgy manufacturing, engine management using adaptive controls, and high-performance computing for automobile design. Other projects focus on lithium battery research and low-cost aluminum alloys, polymer active materials for ultracapacitors, and catalysts for nitrous oxide reduction.

Nuclear Energy

Isotope Production and Distribution Program

Los Alamos is one of seven production sites for DOE's Office of Isotope Production and Distribution and produces a variety of isotopes for commercial purposes. At Los Alamos, the isotopes are produced by target irradiation at the Los Alamos Neutron Science Center. Associated activities include projects aimed at developing processes for target irradiation, isotope separation, and generator development to promote the use of radioisotopes in nuclear medicine and in other commercial applications (for example, radiation sources and tracers). Los Alamos is currently involved in a collaborative effort with Sandia National Laboratories to establish a capability for molybdenum-99 production. We are providing target fabrication support for Sandia's reactor irradiation program to generate molybdenum-99.

Uranium Enrichment

Los Alamos has supported DOE/NE's uranium enrichment initiatives in areas such as remote sensing of canisters and in the Highly Enriched Uranium Transparency Program. The Laboratory has recently participated in a U.S./Russian technical collaboration concerning the blending of highly enriched uranium at low-enriched-uranium facilities.

Fossil Energy

Coal Programs

ET continues to support DOE/FE's efforts to establish the future directions of coal research and development (R&D) in the United States. We assist FE's Clean Coal Technology Program with three projects. First, to support international clean coal technology, we are exploring international applications and innovative partnership ideas for products developed under the program (an

example of this work involves collaboration with the National Mining Association). Second, we are examining innovative partnership concepts to transfer clean coal technology into private-sector applications. Third, we are helping identify and evaluate future needs of the coal R&D program. For more information about the Clean Coal Technology Program, see Section II.D. New Initiatives.

Gas Programs

The thermoacoustic natural gas liquefier is the most significant Los Alamos project in the gas program. This effort focuses on developing a natural-gas-powered natural gas liquefier with no moving parts and requiring no electrical power. The project is expected to enhance efficiency and reliability while lowering cost for the liquefaction process, and it has spawned a cooperative research and development agreement (CRADA) with a liquefaction company. In addition, the gas program supports some Advanced Computational Technology Initiative work such as a project on multiphase fluid simulation for unbalanced drilling.

Petroleum Programs

The last 5 years have seen a dramatic shift in funding emphasis within the U.S. petroleum industry. Driven by many years of low product prices and the need to reallocate scarce funds for investments related to environmental compliance, oil and gas producers have been forced to re-evaluate every aspect of their business—including research, development, and demonstration investments and technology partnering—for reduced risk and cost. Operating through the Natural Gas and Oil Technology Partnership, Los Alamos responds through the mechanism of collaborative projects to bring its capabilities to the oil and gas industry. Participation by both industry and Los Alamos is required on all projects; universities join teams when appropriate. Alliances established through the partnership combine the resources and experience of the nation's petroleum industry with the capabilities and technologies of Los Alamos. This integration expedites development of advanced technologies for improved natural gas and oil recovery.

Partnership projects with the domestic petroleum industry foster a spirit of cooperation that features cost sharing, vastly streamlined proposals and reporting requirements, flexible agreements to meet customer needs, and industry review panels that set the priorities for technical projects. Proposed Los Alamos projects are reviewed and prioritized by one of the following industry groups:

- Borehole Seismic Forum,
- Oil Recovery Technology Review Panel,
- Computational Technology Review Panel,

Table 12. Projected Funding for Energy Technology (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Energy Efficiency and Renewable Energy	11.0	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Nuclear Energy	5.0	7.0	6.3	5.5	5.5	5.5	5.5	5.5
Fossil Energy	3.0	3.7	5.2	5.2	5.2	5.2	5.2	5.2
Total DOE Funding	19.0	23.9	24.7	23.9	23.9	23.9	23.9	23.9
Reimbursables	24.1	24.3	24.3	24.3	24.3	24.3	24.3	24.3
Total	43.1	48.2	49.0	48.2	48.2	48.2	48.2	48.2

- Drilling and completion engineering associations, or
- Petroleum Environmental Review Panel.

Our current partnership projects include

- advanced processing of three-dimensional seismic data from the Gulf of Mexico;
- advanced reservoir management for independent producers;
- deep-fracture-system mapping with the use of microseismic events;
- reservoir simulations which make use of innovative gridding technology;
- next-generation microhole drilling and instrumentation systems;
- optimized reservoir production through pore-scale to field-scale investigations; and
- improved well perforation techniques.

c. Energy Research

The programs funded by DOE's Office of Energy Research (OER) generally fall in the area of science and technology, and they make significant contributions to national security, industrial competitiveness, and energy resources. Energy Research activities are conducted through the Los Alamos Science and Technology Base Program Office. They contribute to a wide spectrum of fundamental and strategic research in areas such as materials science, neutron scattering, high-performance computing, and biosciences. Energy Research activities are an extremely important component of the Laboratory's basic research program. The programs often involve partnerships with universities and industry, a healthy interaction between experiment and theory, and use of techniques and ideas from different fields in solving significant, focused scientific problems.

A summary of the projected funding for Energy Research is listed in Table 13 at the end of this section.

Basic Energy Sciences

The DOE Office of Basic Energy Sciences (OBES) supports research that will advance the scientific and technical knowledge and skills needed to develop and use new and existing energy resources in an economically viable and environmentally sound manner. The OBES focuses on research in materials sciences, chemical sciences, energy biosciences, geosciences, and engineering. OBES also oversees the operation of many of DOE's large, state-of-the-art basic research facilities. As a part of their facility responsibilities, OBES supports a national neutron science user facility at the Los Alamos Neutron Science Center (LANSCE). The LANSCE user program is described in Section II.B.2.d. LANSCE: National Neutron Science User Program.

Materials Science

At Los Alamos, materials science activities funded by OBES provide knowledge essential to defense, energy efficiency, energy research, industrial competitiveness, and other areas of strong national interest, especially those requiring the development of new materials. Relatively fundamental and long-term research efforts consider DOE technologies and industrial needs and integrate a number of Laboratory core competencies. These efforts also involve one or more of Los Alamos's multidisciplinary science fac-

ilities such as the Manuel Lujan Jr. Neutron Scattering Center (the Lujan Center), the National High Magnetic Field Laboratory (NHMFL), the Advanced Computing Laboratory (ACL), the Ion Beam Materials Laboratory, and the Electron Microscopy Laboratory.

Projects involving high-temperature superconductors and correlated electron materials and the photoelectron spectroscopy of transuranic materials focus on cutting-edge experimental and theoretical research and integrate their activities with the Laboratory's considerable capabilities in condensed-matter theory. One key interdisciplinary effort in understanding materials properties involves a theory and modeling project to extrapolate from microscopic to mesoscopic properties of materials.

The synthesis and processing of advanced materials and studies of the behavior of materials in extreme environments are critical to DOE technologies and national needs. The mechanical properties project has brought to Los Alamos international recognition in the field of materials texture measurement and prediction. Materials texture is critical to advancing DOE weapons technologies and computer codes, which are being used by more than 200 industries, laboratories, and universities. The thermal physics program has become a world leader in developing thermoacoustic science and technology and was expanded to investigate new technologies in the area of oscillatory thermodynamics. The research program in the unified theory of evolving microstructures was developed in collaboration with industry.

In our studies on irradiation effects in ceramics, researchers are investigating new approaches to developing radiation-resistant materials critical for energy applications. Combined plasma- and ion-implantation techniques are being explored with industry to synthesize advanced coatings. The materials science program developed a laser-based laboratory light source to study photoemission in transuranic materials. Using this light source, Los Alamos scientists are able to measure the electronic structure in plutonium without having to handle and transport it to other locations.

The world's longest-pulse, high-field magnet, funded by DOE, will be collocated with the other components of the Los Alamos NHMFL Pulsed-Field Facility, funded by the National Science Foundation (NSF). This interagency DOE/NSF collaboration will provide a unique user facility to users from DOE laboratories, industry, and universities. The magnet, when completed in 1998, will provide nondestructive 100-tesla magnetic fields for periods lasting up to 10 milliseconds, which is a thousand times longer than is available anywhere else. The magnet is a uniquely powerful tool for studying high-temperature superconductors and the electronic structure of materials at unprecedented resolution. Funding for the NSF component of this project is included in the 60/65 B&R code in Table 22 at the end of Section II.B.3. Industrial Partnership. OBES supports this NSF-funded effort.

Chemical Sciences

Programs supported at Los Alamos by the DOE/OBES Division of Chemical Sciences are funded through the Molecular Processes branch of the office, which funds several projects through the Heavy-Element Chemistry Program, including efforts in aqueous speciation in both neutral and basic media as well as organometallic chemistry. In the organometallic chemistry project, researchers are synthesizing compounds in novel coordination en-

vironments and are studying the compounds' reactivity as a means of understanding chemical trends in the actinide series (as well as important differences between d- and f-metals) in the absence of aqueous solvation. Projects examining aqueous speciation chemistry contribute important knowledge about the chemical behavior of plutonium and other actinide elements that supports Laboratory and DOE efforts in environmental restoration, waste repository performance assessment, and residue stabilization. The newest effort funded through the Heavy-Element Chemistry Program seeks to examine the optical spectroscopy of neptunium and plutonium in aqueous solution. Preliminary experiments are directed at looking for luminescence from neptunyl and plutonyl ions in solution.

Other work supported at Los Alamos looks at the activity of unsaturated transition metal complexes in solution for binding and activating small molecules such as sulfur and nitrogen oxides, hydrogen, alkanes, and silanes. This effort has been important in understanding the nature of activation involving "sigma-bound" small molecules as intermediates in stoichiometric or catalytic reactions. Many of these processes are key in the functionalization of important chemical feedstocks or in environmental catalysis.

Finally, a theoretical effort is directed at using advanced Monte Carlo techniques to develop improved models that describe the physical behavior of multicomponent mixtures, particularly with respect to questions of fluid-phase demixing. The results of these approaches are important in guiding and interpreting experimental measurements that require knowledge of solution thermodynamic behavior.

Geosciences and Engineering

DOE/OBES supports Los Alamos research projects in geosciences and engineering that are focused on developing a basic understanding of problems and processes in Earth's crust, mantle, and near-space environment. These projects are active in four areas: geophysics, geochemistry, solar/terrestrial physics, and engineering research on particle suspensions.

Geophysics projects involve both experimental and modeling components. Geophysicists are analyzing electrical and seismic properties of rocks and minerals to allow determination of the thermal state of Earth's upper mantle and crust and to better understand seismic data, including applications to weapons test monitoring. Elastic wave phenomena in rock samples under non-linear regimes are being investigated as new approaches to evaluating reservoirs, seismic response, and applied problems such as failure of concrete. New methods are being developed and tested for modeling and processing seismic data, with particular application to oil and gas reservoir characterization.

Geochemical projects focus on detailed characterization of geologic systems and basic interaction processes. Techniques have been developed to analyze natural radioactive materials and to characterize young geologic processes. Uranium-decay-series disequilibrium and cosmogenic helium and neon are the central focus of this research. Microorganism-interaction mechanisms with soil materials, particularly applied to iron utilization, is a new component for the geochemical research.

Solar-wind research integrates plasma theory, computer simulations, and spacecraft data analysis to study solar wind-magnetospheric coupling as well as aspects of magnetospheric dynamics.

Engineering research on particle suspensions in Newtonian and non-Newtonian liquids integrates experimental and numeri-

cal simulation approaches to quantify basic process understanding. This research has industrial and geologic system applications.

Health and Environmental Research

Health and environmental research at Los Alamos provides information required to analyze and ameliorate long-term health and environmental effects associated with energy and defense technologies. These activities are supported by the Laboratory's core competency in Bioscience and Biotechnology. The Laboratory's approach to biosciences, based on combining expertise in the life sciences with capabilities in the design of complex instrumentation and in computation, provides a unique opportunity to contribute to nationally important problems such as health care and environmentally conscious manufacturing technologies.

Human Genome Studies

Established in June 1988, the Laboratory's Center for Human Genome Studies (CHGS) is a national center of excellence for the development and application of techniques that will eventually lead to an understanding of the structure and function of the human genome. The program has been organized into four broad areas of research and support: physical mapping, DNA sequencing, technology development, and biological interfaces. Efforts are distributed across five Los Alamos divisions among which there is extensive interdisciplinary cooperation. Support to the project consists of expertise in the areas of cell biology, cytogenetics, flow cytometry, molecular biology, informatics, and robotics in order to construct gene libraries and physical maps of chromosomes as well as to sequence DNA.

In a major restructuring of its Human Genome Program, DOE's Office of Health and Environmental Research (OHER) has recently created the DOE Joint Genome Institute (JGI) to integrate work previously pursued in parallel fashion at its three major human genome centers located at Los Alamos, Lawrence Livermore, and Lawrence Berkeley national laboratories. Research collaborations between the three centers are being greatly strengthened for more effective use of the unique expertise and resources at the individual institutions. Each laboratory has been assigned oversight of particular categories of tasks required within the overall goal of the JGI to generate high-quality genomic sequence data.

One of the two major task areas for which the CHGS will be responsible is verification and preparation of clones before they are fed into the production sequencing operation of the JGI. This task also assumes responsibility for assessing the accuracy with which the resulting sequence data represent both the clones that were sequenced and the human genome in general. The second area of specialization for which the CHGS will be responsible is internal informatics. This body of tasks requires coordination and integration of informatics support within the JGI and each of the individual genome centers. Additionally, the CHGS will be responsible for ensuring the accuracy and generation of correct sequence assemblies, associated annotation, and data submissions to the public databases, the Genome Sequence Data Base and the Genome Data Base.

Structural Biology

Answering the most fundamental questions about living systems requires understanding the structures and interactions of the

macromolecules that carry out the basic functions of life. The size and complexity of these molecules require sophisticated technologies to unravel the detailed structures and structural dynamics underlying their ability to replicate or transcribe information, generate energy, sense foreign agents, and transport, synthesize, and degrade essential biochemical components. Los Alamos stewards unique user resources being used by the national biomedical research community for neutron scattering (at the Lujan Center), stable-isotope labeling, and databases that provide special opportunities for structural biology applications. These unique capabilities are combined with a strong, multifaceted structural biology program that enables Los Alamos scientists to address complex problems of high priority to DOE, such as understanding the molecular mechanisms underlying DNA damage recognition and repair, or developing biotechnologies for environmental remediation.

Toward these goals, Los Alamos scientists are applying high-field nuclear magnetic resonance spectroscopy and crystallographic techniques to obtain high-resolution structural data on key protein and DNA structures. X-ray and neutron solution scattering techniques are being used to unravel the interactions between these structures. Advanced optical and laser spectroscopies are being used to probe the structural dynamics of the protein and DNA during function, and advanced microscopy techniques are being used to image the larger assemblies they form. New theoretical and computational approaches are being developed for predicting and modeling the structure of DNA sequences and their interactions with proteins, as well as with drugs. In FY97, Los Alamos will begin a project that will expand our neutron scattering user facilities to include a new, dedicated protein crystallography instrument at the Lujan Center.

Health Effects and Life Sciences

DNA Damage and Repair. Los Alamos scientists are directing studies of DNA damage and repair in humans toward characterizing the properties of proteins that are involved in these processes. National and international efforts have resulted in the cloning and characterization of several genes that are involved in DNA excision repair. A similar effort is under way to identify and clone the genes that are involved in the repair of damage induced by ionizing radiation. Initiatives will attempt to identify other mammalian genes that may be involved in DNA damage recognition and repair. The remarkable developments emerging from the Human Genome Program make it possible to identify, measure, and understand risk factors associated with repair and suppressor genes and their functions, genome instability, and cellular recognition of damage to DNA as it relates to carcinogenesis and neoplastic progression. These genes and events are integrated into the current understanding of control of the cell division cycle, which is the unifying theme of the ongoing cell biology program at Los Alamos.

Molecular and Cellular Biology. The Laboratory's molecular and cellular biology research program includes studies of genome organization that emphasize the identification, isolation, and understanding of specific DNA sequences that are involved in mediating chromosome structure and/or regulating differential gene expression. Laboratory scientists are developing technologies for rapid detection and characterization of human mutations within mapping and sequencing activities. Laboratory research in cell-cycle metabolism and chromatin structure continues to focus on the structural and functional features of chromatin organization and

the way in which modulation of that organization is related to carcinogenesis. Los Alamos scientists are investigating the mechanisms by which physical and chemical agents alter genome organization, nucleoprotein composition, and associated biochemical functions.

Computational Biology

Computational biology builds on existing strengths in informatics, analysis, and modeling of biological data and systems and is synergistic with two core competencies at Los Alamos: (1) Theory, Modeling, and High-Performance Computing and (2) Bioscience and Biotechnology. Our primary emphasis is on genomics, molecular epidemiology and immunology, macromolecular structure and dynamics, biomedical technology, cellular structure and dynamics, and neurobiology.

Facility Development

The National Institutes of Health have drawn on the Laboratory's multidisciplinary capabilities to establish several facilities at Los Alamos. The National Flow Cytometry and Sorting Research Resource makes advanced flow-cytometric instrumentation available to the biomedical research community. The National Stable Isotope Resource develops new and efficient methods of incorporating stable isotopes into compounds of immediate use in biomedical research. The human immunodeficiency virus/auto-immune deficiency syndrome (HIV/AIDS) database collects and distributes DNA sequences and determines phylogenetic relationships. For more information, see Section II.B.1.f. Work for Others.

Biomedical Applications

The Magnetoencephalography Program focuses on combining magnetoencephalography and magnetic resonance imaging to achieve noninvasive functional imaging—with maximal spatial and temporal resolution—of the human brain.

Environmental Research

The primary mission of the DOE Environmental Research Program is to develop scientific tools to (1) understand, quantify, and predict the environmental consequences of energy-related activities and to facilitate improvements in the quality of environments adversely impacted by energy-related activities, and (2) understand, quantify, and predict the rate, magnitude, and potential environmental and socioeconomic consequences resulting from human-induced changes in the global climate system associated with energy-related greenhouse gases.

Global Climate Change Research. The Laboratory has a broad and growing program to study global climate change, supported in large part by DOE's OHER. Specific DOE support comes from three activities: Atmospheric Radiation Monitoring (ARM); Computer Hardware, Advanced Mathematics, and Model Physics (CHAMMP); and Quantitative Links. The ARM project seeks to make key atmospheric observations for use in global climate models. The CHAMMP project seeks to develop ultrafast computer models of the atmosphere and oceans. In addition, through its Institute for Geophysics and Planetary Physics, the Laboratory pursues a program of Campus-Laboratory Collaboration (the University of California CLC Program) with Lawrence Livermore and five University of California campuses (Berkeley, Los Angeles, Davis, Irvine, and San Diego-Scripps). Through its participation in CLC, the Laboratory broadens its climate studies capabilities.

Atmospheric Science. The goals of atmospheric research are to measure, understand, and predict atmospheric boundary-layer structure and evolution over inhomogeneous terrain and to apply this knowledge to DOE mission needs in air quality and climate change. This research is being applied in a study to characterize pollution from particulate and chemical constituents in the atmosphere around Mexico City.

Environmental Bioremediation Research. Many small, organic soil contaminants can be quickly and effectively degraded by microorganisms naturally found in the soil. Strategies that rely on augmenting the natural ability of living systems to remedy environmental damage are examples of bioremediation, which offers the promise of a dramatic lowering of cleanup costs. One example of an organic contaminant is trichloroethylene (TCE), which represents, even in minute trace quantities, a significant health hazard if found in drinking water. Los Alamos has recently embarked on a multidisciplinary effort that seeks to enable bioremediation of TCE. In collaboration with scientists at U.S. universities and at the Max Planck Institute in Germany, Los Alamos researchers have begun to use structural biology techniques to study one class of enzymes, the cytochrome P-450s, that might be engineered to degrade TCE.

High-Energy and Nuclear Physics

High-energy and nuclear physics research at Los Alamos involves an extensive experimental and theoretical program in many aspects of strong interaction and electroweak physics. This program includes a vigorous experimental program at Los Alamos and at other facilities, and an active and broad effort in theoretical nuclear and particle physics.

The LANSCE facility operates primarily to pursue neutron scattering. The Liquid Scintillator Neutrino Detector (LSND) was used at the Los Alamos Meson Physics Facility (now LANSCE) to search for neutrino oscillations. Evidence of the existence of these oscillations is mounting. If true, this result will have profound implications for nuclear and particle physics as well as astrophysics and cosmology. Future running of LSND at LANSCE is expected. The LSND also measures low-energy, neutrino-proton elastic scattering.

Laboratory scientists are leading several efforts at LANSCE using low-energy neutrons to study fundamental interactions. The Time Reversal Invariance and Parity at Low Energies (TRIPLE) experiment investigates parity violation in the scattering of low-energy neutrons with nuclei to study weak interactions in all nuclei. In another project, the first source of ultracold neutrons in this country has been developed at LANSCE. Future plans include new experiments measuring the neutron lifetime, neutron beta decay, parity violation in low-energy, neutron-proton scattering, and the neutron electric-dipole moment.

Los Alamos scientists are also leading experiments at other facilities using state-of-the-art detectors to probe fundamental aspects of nuclear science. The Laboratory's High-Energy Hadron Team is studying nucleon quark and gluon substructure in experiments at Fermilab and at Brookhaven's Relativistic Heavy-Ion Collider (RHIC). The Heavy-Ion Team is participating in a large experiment at the European Center for Nuclear Research (CERN) and is constructing several major parts of the Pioneering High-Energy Nuclear Ion Experiment (PHENIX) detector being built at the RHIC. The Low-Energy Team plays a leading role in

two large experiments studying neutrinos produced by the sun: (1) Soviet-American Gallium Experiment, a Russian experiment to detect very low-energy solar neutrinos, and (2) Sudbury Neutrino Observatory (SNO), a large heavy-water detector being constructed in Canada. The Nuclear and Particle Astrophysics Team at Los Alamos is leading a large collaboration in the construction and operation of Milagro, which will be the first high-duty-factor, all-sky detector of cosmic gamma rays in the energy range of 250 GeV to 10 TeV.

The theoretical physics program covers the complete spectrum of theoretical disciplines, ranging from traditional nuclear physics to superstring theory. The latter attempts to unify all of the fundamental forces of nature, including quantum gravity. This program incorporates traditional physics of the Standard Model (quantum chromodynamics, the theory of quarks and gluons, and the electroweak theory) as well as new physics beyond the Standard Model (such as superstring theory and its implications for the origin of the universe). A close relationship with the experimental program is maintained: for example, the implication of a massive neutrino and the theoretical basis of a quark-gluon plasma are both being vigorously pursued.

Fusion Energy

At Los Alamos, interest in fusion is based on the conviction that energy will become an extremely important issue in coming decades as oil becomes scarce and expensive. Despite the potential for fusion to address this widely recognized issue, national funding for fusion research has been declining. In response to reduced funding, the fusion research community has accepted guidance from the Fusion Energy Sciences Advisory Committee to restructure the U.S. program. Greater emphasis is being placed on plasma science as a knowledge base, and large facilities such as those needed for a tokamak-based technology development program have been delayed.

Important ideas can be studied at a modest scale to see if they provide an affordable development path for fusion energy. By emphasizing the understanding to be gained by experimental, theoretical, and technological studies as opposed to large-scale prototype demonstrations, exciting progress can be made within a constrained budget.

Some issues such as ignition physics in a tokamak require large devices and will need to be addressed through international collaboration. The International Thermonuclear Experimental Reactor is a successful example of an international approach, and the U.S. is participating to the maximum extent possible.

The Laboratory has strong ongoing plasma-science activities such as work on plasma theory and development of new experimental diagnostic methods. Los Alamos also develops new fusion technology such as high-power systems for feedback stabilization, tritium processing using the world-class Tritium Systems Test Assembly, and plasma-sprayed beryllium coatings for plasma-facing components.

Currently, Los Alamos is preparing proposals for new and innovative approaches to fusion. We are proposing a new series of experiments to study the ion physics of highly non-Maxwellian velocity distributions using a small device called the Penning Fusion Experiment. We are also proposing fusion experiments in a new regime called "Magnetized Target Fusion." They involve imploding metal liners at hypervelocity onto a plasma, which is

magnetized to suppress thermal conduction. Significant studies of the underlying science of fusion conditions appear possible using current and near-term pulsed-power systems, for example, ATLAS, which is now under construction at Los Alamos. We are developing a multisponsor Magnetized Target Fusion initiative that, if successful, will be included in the next Institutional Plan.

Office of Computational and Technology Research

Advanced Energy Projects

The Advanced Energy Projects Program explores the feasibility of a wide range of novel, energy-related concepts that evolve from advances in basic and applied research. These concepts are typically at an early stage of scientific definition and are premature for consideration by established applied research or technology development programs. The projects may be high-risk, exploratory concepts having applications spanning different scientific disciplines or technical areas.

The program provides a mechanism for converting basic-research findings to applications that eventually could impact the nation's energy economy and environmental concerns. Technical areas include physics, chemistry, materials science, engineering, and biotechnology. Projects can involve interdisciplinary approaches to solving energy-related problems.

These projects are dynamic and reflect the broad role of supporting research and development in improving the nation's energy outlook. Areas include novel materials for energy technology, renewable and biodegradable materials, uses of new scientific discoveries, alternative pathways to energy efficiency, alternative energy sources, and innovative approaches to waste treatment and reduction. As such, the Advanced Energy Projects Program is synergistic with a number of other Laboratory programs. It also provides the seed for larger, continuing programs of vital interest to the Laboratory.

Scientific Computing

Los Alamos is the site of one of DOE's High-Performance Computing Research Centers, the ACL. The ACL is a national leader in research, development, and deployment of advanced computing and information technologies. An architecture-independent programming environment currently under development

will provide scientists and engineers cross-platform mobility, and the development of technologies for the National Information Infrastructure continues to accelerate. For more information about the configuration of the ACL and its link to the core mission of the Laboratory, see Section II.C.2. Theory, Modeling, and High-Performance Computing.

High-Performance Computing and Communications Program

The interagency High-Performance Computing and Communications (HPCC) Program, begun in FY92, supports the research and development of the underlying computational and communications sciences that will enable the solution of important Grand Challenge problems. Currently, DOE's OER, through its HPCC Program, supports 12 Grand Challenges, 5 of which involve researchers from Los Alamos in collaboration with researchers from other DOE national laboratories and universities.

Global Ocean and Climate Modeling. This effort involves researchers from Los Alamos, the National Center for Atmospheric Research, and the Geophysical Fluid Dynamics Laboratory. It attempts to develop the first coupled model of Earth's climate system (ocean, atmosphere, and land surface) capable of extended simulations with an eddy-resolving ocean component.

Particle Physics Phenomenology from Lattice Quantum Chromodynamics. This inquiry simulates and tests the Standard Model of elementary particle interactions at the hadronic scale through several computationally intensive efforts.

Computational Accelerator Physics. This effort strives to develop the next generation of accelerator modeling tools pertinent to progress in developing technologies for the transmutation of radioactive waste, disposal of plutonium, energy production, and production of tritium.

Numerical Tokamak Turbulence Project. This project is intended to construct computer models to help researchers understand and predict the experimentally observed turbulent transport of heat and particles out of the tokamak core.

First-Principle Micromechanical and Continuum Modeling of Concentrated, Multiphase, Dispersed Systems. This activity seeks to combine recent advances in high-performance computing, theoretical mechanics, and parallel nonlinear algorithms to make a fundamental advance in our ability to predict—from first

Table 13. Projected Funding for Energy Research (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Fusion Energy (AT)	4.4	3.7	3.3	4.3	4.4	4.5	4.7	4.6
High-Energy Physics (KA)	0.7	0.8	0.7	0.7	0.7	0.8	0.8	0.8
Nuclear Physics (KB)	11.4	10.7	10.4	10.4	10.7	10.8	11.4	11.2
Basic Energy Sciences (KC)	29.2	19.6	18.3	18.3	18.7	19.1	19.5	19.8
Computational and Technology Research (KJ)	0.0	13.8	13.5	13.3	13.5	14.1	14.1	14.4
Biological and Environmental Research (KP)	19.0	20.0	22.9	23.4	23.8	24.8	24.8	25.3
BES/Short-Pulse Spallation Source Enhancement (KC) ¹	0.0	0.0	4.5	4.5	6.0	3.5	2.0	0.0
OHER/Short-Pulse Spallation Source Enhancement (KP) ²	0.0	1.5	1.5	1.5	0.0	0.0	0.0	0.0
Total	64.7	70.1	75.1	76.4	77.8	77.6	77.3	76.1

¹Basic energy sciences portion of LANSCE SPSS enhancement.

²Protein neutron crystallography instrument.

principles—transport phenomena in concentrated, multiphase, dispersive systems.

Computer Hardware, Advanced Mathematics, and Model Physics Program

The major goal of the DOE CHAMMP Program is to simulate and predict the long-term global and regional climate variations that lie at the heart of the U.S. Global Change Research Program. The CHAMMP Program combines advances in computer hardware, numerical techniques and algorithms, and modeling of basic physical processes to provide fidelity heretofore impossible in ocean and atmospheric simulations. The CHAMMP Program, in collaboration with the HPCC Program, is supporting the work of Los Alamos researchers on the Grand Challenge problem of global ocean and climate modeling. In addition, the CHAMMP Program directly supports the advanced infrastructure in the ACL and employs the Parallel Object-Oriented Methods and Applications (POOMA) framework, a software infrastructure created at Los Alamos that was designed to simplify the development of scientific applications codes on parallel computer architectures. POOMA is discussed in more detail in Section II.C.2. Theory, Modeling, and High-Performance Computing.

d. LANSCE: National Neutron Science User Program

In addition to serving in a national security role, the Los Alamos Neutron Science Center (LANSCE) serves as a national neutron science user facility, funded by the DOE Office of Energy Research (OER), Office of Basic Energy Sciences (OBES).

Basic research at LANSCE covers a wide range of topics in condensed-matter physics, nuclear physics, materials science, chemistry, structural biology, geology, and engineering. Static structure and atomic and magnetic fluctuations are probed in a variety of systems ranging from high-temperature superconductors to macromolecules that control muscle contraction in the human body. In many areas, such as the determination of the magnetic structure of grain boundaries and the measurement of the atomic structure of organometallic compounds, the information obtained is critical to next-generation technologies. Much of the basic research carried out at LANSCE involves university participation, and many of the experiments serve as an integral part of the education and training of young American scientists. Neutron scattering has also become an increasingly important component of industrial research, allowing scientists to probe the structures of materials such as polymers, catalysts, and structural composites that are essential for many modern industrial products.

LANSCE offers a range of instruments for probing the structure of materials, facilities for neutron irradiation, and spectrometers for addressing a variety of neutron-scattering issues as well as nuclear physics experiments. There are currently 10 state-of-the-art instruments, including a powder diffractometer with a higher resolution than any other instrument of its type in the U.S. and a

unique chopper spectrometer. As part of its continuing commitment to LANSCE, OER has agreed to fund, over the next 5 years, the construction of up to 7 additional instruments at the Manuel Lujan Jr. Neutron Scattering Center (Lujan Center). The first instrument, a protein crystallography station, will be funded by the Office of Health and Environmental Research (OHER) at \$4.5 million.

The remaining instruments will be funded by OBES at \$20.5 million. The OBES instruments will not be solely a Los Alamos effort; the national neutron scattering community will be involved in selecting the most appropriate instruments, and collaborative spectrometer development teams will design and construct each of the instruments. Work on the OBES instruments is scheduled to begin in 1998 and to be completed in 2002. The additional neutron scattering instruments are part of an overall short-pulse spallation source (SPSS) enhancement project, a cooperative effort between OER and DOE's Defense Programs (DP) Office, with DP simultaneously funding accelerator component improvements at \$16.7 million to increase target power to 160 kW. Work on the accelerator upgrades began in 1997 and is scheduled for completion in 2000. Completion of the SPSS enhancement will provide LANSCE performance levels that are equal to or better than the best pulsed spallation source in the world—the ISIS facility in the United Kingdom.

As a national user facility, LANSCE is committed to meeting user needs and addressing user concerns. In response to the number one user concern—beam-time availability and facility reliability—LANSCE is in the midst of a major reliability improvement project, begun in 1994 and scheduled for completion in 1998. This project will provide more reliable and convenient operations and will extend the annual run cycle to 8 months. Benefits of both this effort and improved operations are already apparent, with a successful 1996 run cycle of 5 months and significant improvement in reliability in 1995 and 1996 compared with that of previous years. LANSCE is also anticipating future budget increases to support both the lengthened (8-month) run cycle and the additional instruments at the Lujan Center. These budget increases will allow LANSCE to add additional instrument scientists and technicians to support the user program.

To maintain close ties to the user community, in 1996 LANSCE created an external committee, the LANSCE advisory board, to conduct periodic reviews and provide strategic guidance based on the perspective of the overall neutron science community. A LANSCE user group has also been organized to give individual users a means for participating in LANSCE. The inaugural meeting of the user's group was held at Los Alamos in August 1996 and drew over 170 users, the majority from outside of the Laboratory. Finally, to give users a single point of contact for the facility, LANSCE has appointed a full-time user coordinator.

Funds are administered through the Los Alamos Science and Technology Base Program Office (STB). Table 14 shows selections from the funding to STB, which should not be considered additional resources.

Table 14. Projected Funding for LANSCE through the STB Programs (\$M).

Program Office	Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
STB-OBES	User Program (KC0204)	5.8	6.4	10.0	10.0	10.0	10.0	10.0	10.0
STB-OBES	Research (KC0202050)	1.8	1.6	3.0	3.0	3.0	3.0	3.0	3.0
STB-OBES	SPSS Enhancement (KC0204) ¹	0.0	0.0	4.5	4.5	6.0	3.5	2.0	0.0
STB-OHER	SPSS Enhancement (KP1101010) ¹	0.0	1.5	1.5	1.5	0.0	0.0	0.0	0.0
Total		7.6	9.5	19.0	19.0	19.0	16.5	15.0	13.0

¹Capital funding.

e. Science and Math Education Laboratory Plan for Education Support

The success of the DOE and Laboratory missions depends on the availability of a well-educated work force and a science-literate public. Thus, education is an important component of the Laboratory mission. The place to start developing that work force and informing that public is in our schools. For many years, the Laboratory has maintained an active education program for all age levels, elementary through graduate school, funded primarily by Defense Programs (DP). This program continues despite shrinking national budgets. The Laboratory and DOE are science-rich resources that are able to provide unique enrichment and motivating experiences for both students and teachers.

The Laboratory has a unique contribution to make to science, mathematics, engineering, and technology education. All science education projects that we conduct are directly connected with the unique resources of the Laboratory, use the technical programs and core competencies as a basis, and involve Laboratory technical staff extensively. Many projects collaborate with or are conducted jointly with universities, and most of them involve the application of technologies such as computer networking and the Internet. Some projects are explicitly for the purpose of helping schools establish their own networks and become connected to the Internet.

The education projects support the Laboratory's tactical goals in diversity; corporate citizenship; science-based stockpile stewardship; the plutonium future; genome research; modeling, simulation, and high-performance computing; and regional economic development. The education projects support the technical goals by using relevant technical topics as content material while technical staff present information on the programs and science. In some projects, both teachers and students work with Laboratory personnel doing research on goal-related topics.

Many of our projects are directed toward systemic change in the educational process concerning the way science and math are taught. Our teacher enhancement projects spend a significant amount of time on pedagogy, showing the teachers by example better ways to teach science and math. We also work with the schools and administrators so that the teachers will have administrative support to be able to use the techniques learned. Our technology projects make a direct and immediate impact on the educational system and how teaching (and more importantly, learning) is accomplished. We collaborate with the statewide Systemic Initiative in Math and Science and the four-state Rural Systemic Initiative, which are funded by the National Science

Foundation. We also collaborate with the other national laboratories, other U.S. government agencies, the State Department of Education, and many universities and 2-year colleges. These partnerships help to leverage our resources, broaden the scope of our efforts, avoid duplication of effort, and fill in areas where we lack expertise.

Diversity is an important goal for our program. While a few of the projects are directly targeted at minorities and women, all of the projects emphasize diversity among their participants. We recruit extensively to broaden the representation of minorities and women in our projects. In FY96, more than half of the participants were minorities and almost half were female. Figure 22 shows this distribution graphically. Table 15 on page 56 shows the ethnicity and gender of the participants in each of the projects in FY96.

Figure 22. Diversity is an important emphasis in our Science and Math Education Program.

Project Descriptions and Statistics

In FY97, there are 24 science education projects being conducted. There were 33 projects in FY96. The Science Education Program includes projects for all grade levels. Figure 23 shows the distribution of the projects among the various grade levels. Table 16 on page 57 describes the current (FY97) science and math education projects at the Laboratory and provides a brief description of the projects and the number of participants in FY96. Depending on the project, participants may be any combination of students, teachers, administrators, or parents.

Several different types of projects are included in the overall Science Education Program. These projects include the following:

- research internships for both students and teachers;
- teacher enhancement workshops, where teachers learn about the work and the science at the Laboratory as well as

new pedagogical techniques that make science and math interesting;

- workshops that train teachers and administrators in the use of new technologies in the educational process;
- curriculum development in specific areas of science related to Laboratory expertise;
- projects that help students acquire critical-thinking and problem-solving skills;
- projects that help schools develop and implement computer networks and connections to the Internet;
- projects that expose students to the cutting-edge science, math, engineering, and technology used at the Laboratory;
- projects that help 2-year colleges develop courses that pertain to the skills needed at the Laboratory;
- projects that teach communication skills about science and math; and
- projects that are targeted at increasing the number of minorities and females in the fields of science, math, and engineering.

Figure 24 shows the distribution of projects among the categories. Most of the projects, however, have components in more than one category; in such cases, the project is counted in more than one category.

Program Changes and Plans

For the second year in a row, we have had to reduce the number of projects and participants in the Science and Math Education (SME) Program because of reduced funding. In FY97, funding is coming almost entirely from DP. In previous years, funding also came from other offices of DOE. It is our hope and plan that funding will remain stable for the next several years. See Table 17 on page 58 for the projected funding for the SME Program.

Every year we evaluate each project internally and have two or three projects evaluated by external experts. The projects, old or new, are evaluated against a set of criteria provided by DOE and against the project's own goals and objectives. Using these evaluations, we make improvements in all of the projects, delete a few projects, and add a few. Because of the budget cuts, it was possible only to start two new projects this year and to expand one, while discontinuing ten others. The two new projects were the Regional Teacher Enhancement Project and Science 2000—Summer Science Institute. The expanded project was Mentored Collaborative Research Using Resident University Teams. This latter program was new in FY96 and was very successful at introducing university-level students and faculty to stockpile stewardship technology. The project will be expanded with the addition of one new team of students and faculty. For several years, the DOE Office of Energy Research has funded a national program called Science and Engineering Research Semester (SERS), a very successful program. Because of funding cuts, the SERS program is no longer funded at Los Alamos. We have elected to continue this program with a new name, Undergraduate Research Semester, with DP funding.

All of the projects emphasize the use of new technologies in the educational process. We not only help schools establish their own computer and distance-learning networks and become connected to the Internet, but we also conduct many workshops to

teach teachers and administrators how to integrate these new tools into their everyday curriculum. We model these teaching techniques in our teacher-enhancement workshops.

The SME Program will continue to emphasize a close connection between the projects and the mission, goals, and core competencies of both the Laboratory and DOE. The program will continue to place an emphasis on postsecondary activities, as well as educational technology, teacher enhancement, and public understanding of science. In addition, the inclusion and encouragement of minorities and females will continue as an emphasis.

Figure 23. Science and Math Education Program distribution by grade levels.

Figure 24. Science and Math Education Program distribution by category.

Table 15. Participants in Science Education Programs (FY96).

	Total	Minorities	Women
Pre-College Programs			
<i>Student Programs</i>			
Critical Issues Forum	136	70	61
Summer Educational Experience for Disadvantaged	10	10	4
National Science Bowl	89	31	44
Practical Applications for Young Science Communicators	17	8	12
Robotics Workshop	60	25	8
New Mexico Supercomputing Challenge	905	342	289
Risks, Rewards, Responsibilities Curriculum Development	172	69	86
Total Pre-College Student Programs	1,389	555	504
<i>Teacher Programs</i>			
National Teacher Enhancement	21	11	16
Teacher Opportunities To Promote Science (TOPS)	26	5	18
TOPS Mentors	16	3	8
Science Outreach	25	16	17
Educational Networking Support	577	501	327
Systems Modeling	9	3	3
Teacher Environmental Assessment and Modeling	16	3	8
Teacher Research Associates	17	3	6
Risks, Rewards, Responsibilities Curriculum Development	2	0	1
Regional Educational Technology Assistance	40	9	25
Total Pre-College Teacher Programs	749	554	429
Undergraduate Programs			
<i>Student Programs</i>			
Historically Black Colleges and Universities	6	6	3
Two-Year College Initiative	18	16	8
Science and Technology Alliance	10	11	4
Underrepresented Minorities and Females Initiative	42	37	20
Science Engineering Research Semester	48	4	20
Pre-Service Institute for Science and Math	18	17	6
Atomic, Molecular and Optical Physics Summer School	14	0	4
Summer of Applied Geophysical Experience	22	2	11
Faculty and Student Teams	16	4	9
Mentored Collaborative Research	1	1	1
Total Undergraduate Student Programs	195	98	86
Graduate Programs			
<i>Student Programs</i>			
Historically Black Colleges and Universities	11	10	7
Underrepresented Minorities and Females Initiative	7	5	4
Atomic, Molecular and Optical Physics Summer School	1	0	0
Summer of Applied Geophysical Experience	8	5	1
Mentored Collaborative Research	2	2	1
Total Graduate Student Programs	29	22	13
Faculty Programs			
Historically Black Colleges and Universities	1	1	1
Two-Year College Initiative	24	10	2
Underrepresented Minorities and Females Initiative	1	1	0
Summer of Applied Geophysical Experience	1	1	0
Total Faculty Programs	27	13	3

Table 16. Los Alamos Science and Math Education Projects.

Projects	Grade Level ¹	Number of Participants per year ²	Category ³	Description
Teacher Opportunities to Promote Science	6–8	26	TE/ET	3-week summer institute, 3 academic-year workshops
Science 2000-Summer Science Institute	9–12	25	TE	3-week summer institute, 2-day academic-year workshop
Regional Teacher Enhancement Project	K–6	25	TE	3-week summer institute, 3 two-day academic-year workshops
Atomic, Molecular and Optical Physics Summer School	UG, GRA	15	SS	Summer institute, research internships
Mentored Collaborative Research	UG, GRA	4	SS	Summer research internships, academic-year followup
Critical Issues Forum	9–12	136	SS	Academic year work, spring forum, summer institute
Historically Black Colleges and Universities	UG, GRA	18	SS/TE	Summer or year-long research internships
New Mexico Supercomputing Challenge	9–12	905	SS/TE/ET	Academic year, spring forum, summer workshops for teachers
Regional Two-Year College Initiative	UG	44	SS/TE	Research internships for students and faculty
Undergraduate Research Semester	UG	48	SS	1-semester research appointment
Summer Educational Experience for the Disadvantaged	10–12	10	SS	10-week research participation
Summer of Applied Geophysical Research	UG, GRA	31	SS	3-week summer institute, academic-year data analysis
Underrepresented Minority/Female Initiative	UG	46	SS	Summer research internships, academic-year followup
Faculty and Student Teams	UG, GRA	16	SS/TE	Summer and academic-year research internships
Robotics Workshop	K–12	60	SS/ET	1-day workshop
Systems Modeling for Education	6–12	9	ET/TE	Development of computer-aided instructional curriculum
Model Nets: National Study of Viable Models of Networking Technology in K–12 Education	K–12	–	ET	National study of computer networking environments in K–12 education
Teaching Hearing Impaired Students to Speak	All	2	ET	Development of real-time computer display of vocal tract motion
Education Networking Support	K–12	400	ET/TE	Consultation on use of technology in education
Program Technology Support	All	–	ET/TE/SS	Incorporating technology in all science education programs
Practical Applications for Young Science Communicators	11–12	17	PU/SS	Academic year, 2-week summer institute
Science Education Information Online	All	–	PU/SS/TE	Educational information on the Internet
Radiation/Risk Assessment Curriculum Development	9–12	–	CI	Curriculum development and piloting
AIMS Curriculum Development	K–6	–	CI	Curriculum development
Equipment Gift Project	K–12	–	ET	Gifting of surplus equipment to schools

¹UG = undergraduate; GRA = graduate research assistant²Participants may be students, faculty, teachers administrators, or parents.³Categories: TE = Teacher Enhancement

CI = Curriculum Improvement

SS = Student Support

ET = Educational Technology

PU = Public Understanding

Table 17. Funding for Science Education (\$k).

Funding Source	Actual Cost FY96	Projected Cost FY97	FY98	Projected New BA FY99	FY00	FY01
KT	756.0	260.0	0.0	0.0	0.0	0.0
KV	0.0	0.0	0.0	0.0	0.0	0.0
DP01	160.0	20.0	0.0	0.0	0.0	0.0
DP03	5,229.0	4,578.0	3,600.0	3,600.0	3,600.0	3,600.0
Total	6,145.0	4,858.0	3,600.0	3,600.0	3,600.0	3,600.0

f. Work for Others

The first part of this section describes the contribution of Los Alamos program offices to Work for Others (WFO) activities that are predominantly non-Department of Defense (DoD). The DoD activities are described in Section II.B.2. Conventional Defense. The second part of this section is a summary of WFO activities by sponsoring organization. Budget summaries (including DoD) are also included in this part. (At the end of this section, see Tables 19–21 and Figures 25 and 26, which graphically represent the projected funding information.)

1. Work-for-Others Activities (Non-DoD) by Program Office

Nonproliferation and International Security

The Nonproliferation and International Security (NIS) Program develops and provides a full spectrum of capabilities for responding to threats to domestic and international security, including, when necessary, methods for mitigating and neutralizing these threats. These capabilities are available to senior policy-makers not only in DOE but also in DoD, the Intelligence Community, and national and local law enforcement agencies. Under the International Technology Program, NIS provides technical support in the development of innovative options for mitigating new security threats, including those associated with the worldwide proliferation of advanced conventional weapons. NIS provides

- advanced computational and analysis capabilities that enable rapid assessment of options for responding to evolving threats, including the capability to model the consequences of those response actions;
- a range of credible, high-confidence methods for locating, characterizing, and disabling nuclear, biological, and chemical weapons, including those of unknown design;
- technologies that battlefield commanders, military special forces teams, and law enforcement agencies can use in place of lethal force;
- real-time access to Laboratory resources and capabilities to support on-site reaction teams;
- creative technical solutions to “intractable” national security problems using the full range of expertise and competencies that exists at the Laboratory; and
- access to appropriate Laboratory technical capabilities to counter criminal activities and terrorism.

NIS is a major participant in NASA's space research program. NIS scientists publish regularly in such journals as the *Journal of*

Geophysical Research-Space Physics, *Geophysical Research Letters*, and the *Astrophysical Journal*. Some of the most significant of our recent publications describe discoveries of new phenomena in the high-latitude heliosphere by Los Alamos plasma instruments on-board the Ulysses spacecraft.

Some NIS Program activities that support the Laboratory mission of reducing the nuclear danger are funded as WFO projects. These projects include activities in international safeguards, the former Soviet Union (FSU) material protection, control, and accounting (MPC&A) program, and the Initiative for Proliferation Prevention (formerly the Industrial Partnering Program). See Section II.A.4. Non- and Counterproliferation for more information on these projects.

NIS WFO projects vary in duration. Work for NASA in development of space instrumentation and analysis of the resultant data can span several years. Some Los Alamos intelligence support activities have been ongoing for more than 20 years. However, many intelligence WFO projects are short term in nature, so the portfolio of NIS WFO projects varies greatly from year to year even though the funding level does not.

Nuclear Materials and Stockpile Management

A team of Los Alamos employees is assigned to the Rocky Flats Environmental Technology Site to provide a broad base of technical support to the Integrating Contractor, Kaiser-Hill, concerning clean-up of the remaining nuclear materials on-site and leading to the ultimate goal of site closure. The scope of this support encompasses all areas of special nuclear materials (SNM), including solutions, residues, and waste resulting from past SNM processing in which Los Alamos has relevant scientific and technical expertise and other unique capabilities, experience, and training. Examples include materials characterization, stabilization, processing systems modeling and analysis, dose modeling, and simulation. Consulting services are made available to resolve unexpected issues as they arise and to support new milestones and deliverables as they are identified and defined. Coordination with selected nuclear materials expertise at Los Alamos is provided on occasion as required by the Integrating Contractor.

Operational since FY96, the special recovery line (SRL) at the Los Alamos Plutonium Facility is designed for safely processing plutonium weapon components accidentally contaminated by tritium. The SRL provides for disassembly of components, sampling and analysis for tritium, decontamination of plutonium, and collection of tritium. Other plutonium items potentially contaminated with tritium can also be processed at the SRL. Several items at DOE's Mound Site in Ohio could become potential feed for the SRL once changes have been made to accommodate the variety of

material forms involved. Before processing can begin, hardware design, tooling development, material receiving details, sampling plans, process refinement, safety assessments, equipment tests, and procedural reviews must be finished. Consequently, much of the year will be consumed by preparations, and it is unlikely that the actual processing step can be scheduled until late in FY97.

Energy Research

The Energy Research programs at Los Alamos enjoy the support of complementary programs sponsored by the National Institutes of Health (NIH). There are currently 23 active NIH grants at Los Alamos funded by several institutes, including the National Institutes of General Medical Sciences, Environmental Health Sciences, Diabetes and Digestive and Kidney Diseases, Allergy and Infectious Diseases, Drug Abuse, the National Cancer Institute, and the National Center for Research Resources. This latter organization supports two national resources at Los Alamos. The National Flow Cytometry and Sorting Resource develops new measurement capabilities and biomedical applications of flow cytometry, makes its facilities available to the biomedical research community, and disseminates information through publications and an annual training workshop attended by national and international investigators. The National Stable Isotope Resource promotes the use of stable isotopes in biomedical research through developing new synthetic chemistry methodology and providing isotopically labeled materials to investigators throughout the country.

The remaining NIH grants are individual principal investigator efforts that complement and strengthen the Energy Research programs in the area of health and environmental science funded by the Office of Health and Environmental Research. These projects support DOE Office of Energy Research (OER) programs in cellular and molecular biology, with a focus on DNA repair; structural biology, with a current focus on protein structure and function; and functional brain imaging, with an emphasis on magnetoencephalography and the integration of multiple imaging modalities. The OER programs are further enhanced by NIH-sponsored projects in molecular spectroscopy, with an emphasis on protein dynamics, modeling of the immune system, and the construction of viral databases.

The NIH grants undergo peer review and are usually awarded for periods of 3 to 5 years. During this time, the NIH grants are renewed noncompetitively on a yearly basis. At the end of the award period, grants are again submitted for competitive renewal, which involves peer review by NIH study sections. The accompanying budget table (see Table 18) is based on noncompetitive renewal of the current NIH grants and makes no projections for the next competitive renewal cycles of the grants. Thus, the de-

cline in funding shown in the table reflects NIH grants reaching the end of their award period rather than anticipated decline in the overall level of NIH funding at the Laboratory. In some cases, for example the Flow Cytometry Resource, we know that the grant will be renewed, but the level of funding is still being determined. Hence, the projected funding is not included in the table.

Energy Technology

The Energy Technology Program Office had programmatic responsibility for the Nuclear Waste Management Program until April 1997, when it was transferred to the Environmental Management Program Office. This program is described in the Environmental Management part of this section.

The Transportation Analysis Simulation System (TRANSIMS) is a project sponsored by the Department of Transportation (DOT) and is a new simulation-based analysis system intended to model architectures of advanced transportation systems. It is an entirely new approach extending beyond modeling of traditional transportation systems. TRANSIMS is based on bottom-up generation of system activity and behavior using detailed simulations of interacting subsystems and traveler intelligence. In this approach, regional microsimulation and representation of traveler-by-traveler plans and travel execution yields emergent behavior patterns to predict transportation issues ranging from land use to air quality.

In the first year of the TRANSIMS effort, a proof-of-principle demonstration was completed that illustrated the approach's features and capabilities using an intermodal pilot study that focused on a national, metropolitan area. The TRANSIMS architecture is intended to provide a new and unique tool for regional-level, microscale system representation that will allow unification of issues in regional transportation planning and analysis, traffic engineering, and environmental impact analysis. TRANSIMS is the major element of the Federal Highway Administration's (FHWA) Traffic Modeling Improvement Program. In addition to FHWA, TRANSIMS is jointly supported by the Federal Transit Administration, the Environmental Protection Agency, and DOE at a total funding level of approximately \$5.5 million annually.

In addition, Los Alamos is working with FHWA to develop a neural network and data analysis techniques for real-time counting and classification of vehicles on the nation's highways.

Los Alamos maintains a solid effort working with the Nuclear Regulatory Commission (NRC) on nuclear safety and developing codes for compliance of reactors to safety regulations. This work has taken the shape of probabilistic risk assessment, disposition of nuclear materials, and criticality safety issues. Los Alamos continues to develop the transient reactor analysis code for application to NRC's needs.

Table 18. Projected Funding for NIH Grants (\$M).¹

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
NIH Grants	6.3	7.3	4.5	2.6	1.6	1.1	0.0	0.0
Total	6.3	7.3	4.5	2.6	1.6	1.1	0.0	0.0

¹For a description of the NIH grants at Los Alamos, see the text above in the Energy Research section.

The TRANSIMS and the NRC work are expected to extend beyond FY03.

Environmental Management

The Nuclear Waste Management Program. Also known as the Yucca Mountain Project, supported by DOE's Office of Civilian Radioactive Waste Management, this program studies the candidate site for the nation's first repository for high-level radioactive waste. Los Alamos has been a leader in characterization of this site, particularly in the areas of radionuclide migration, risk assessment of volcanic activity, and exploratory studies facility test coordination. The future of this facility is under consideration by Congress, but Los Alamos is expected to play a continuing role in the safe handling of nuclear waste at this site. This program was managed by the Energy Technology Program Office until May 1997.

External Computing Project

The External Computing project supports external customers in federal agencies and departments that choose to use the Laboratory's classified and unclassified high-performance computing (HPC) resources. Our ability to provide a cost-effective, quick time-to-solution capability for problems requiring high-performance computing makes Los Alamos an attractive choice for these customers.

Project members serve as advocates and liaisons for customers, ensuring their access to the collaborative resources and expertise available within the Computing, Information, and Communications Division and the Laboratory as a whole. The project members set up and participate in user group and quarterly review meetings, respond to requests from the user representatives, track and report usage monthly, monitor and troubleshoot network problems, and work to make external computing more economical for our customers.

In FY96, this program totaled \$8.1 million in funds-in agreements with our customers. The Defense Special Weapons Agency (DSWA) continued to be our major customer with a budget of \$6.0 million. In addition, in the first quarter of FY96, we provided HPC resources to others in the DoD community with special programmatic needs. Our other customers are principally contractors for the Naval Sea Systems Command (NAVSEA) in conjunction with their work on the Standard Missile Project. During FY96, we continued to receive good ratings from our customers for the quality of our services. Because of unusual circumstances, we were able to reduce our rates for HPC services for the fourth quarter of FY96 by about 30%. These reduced rates continue to hold for FY97. This project is expected to extend beyond the 5-year planning period.

In spite of pressures to perform its HPC computing at DoD Centers, DSWA continues to prefer to remain at Los Alamos and believes that our synergistic relationship benefits the programmatic needs of its agency and its contractors. DSWA committed \$5 million to scientific computing and communication work at Los Alamos in FY97. During the second quarter of FY97, we participated in writing a proposal to the DoD HPC Modernization Office to have DSWA become a Distributed Computing Center, located at Los Alamos. This will enable DSWA to recapitalize their computing resources at Los Alamos. Our relationship with NAVSEA contractors continues in FY97.

In a 1996 survey conducted by the Executive Committee of DSWA users, 84% of the customers who responded rated the

quality of the Laboratory's computing support as good or excellent. One respondent commented: "Los Alamos now provides not only state-of-the-art computers, needed to run contractor codes, but also mass storage, reliable network connectivity, printing and graphics capabilities, and excellent consulting and support services...a highly satisfactory, stable and reliable scientific computing resource..."

2. Summary of all WFO Activities by Sponsoring Organization

Federal Laboratory Consortium

Los Alamos provides managerial, technological, and scientific support for the activities of the Federal Laboratory Consortium (FLC) to all levels of the state, local governments, and private industry. Activities include the development of public affairs, long-range plans, goals, objectives, network linkages, application assessments, demonstration projects, and other tasks assigned by the FLC Executive Committee.

Department of Interior

The Laboratory provides computational support to the U.S. Geological Survey as part of the collaborative research and development effort in the application of computer science to earth science research, especially the numerical simulation of solid earth processes.

Department of Transportation

New legislation directs DOT to use the national laboratories to pursue research to develop high-technology approaches to the enduring problems of safety, efficiency, and the environment. Work at Los Alamos is currently being performed on TRANSIMS for the FHWA and on the development of a prototype simulation testbed used to evaluate alternative state measurement and state estimation schemes for traffic incident detection for DOT.

Environmental Protection Agency

Los Alamos will assess the viability of supercritical media as reaction media for the replacement of hazardous solvents for industrially important chemical or catalytic transformations. We will conduct bench-scale test reactions adapting established chemical systems of interest to the EPA's Office of Pollution Prevention and Toxics in the areas of carbon-carbon bond forming reactions (e.g., palladium-catalyzed Heck coupling) and on polymer supports designed to enhance ligand and catalyst solubility in dense-phase carbon dioxide.

National Aeronautics and Space Administration

The research programs have included solar physics, space plasma physics, magnetospheric physics, x-ray astronomy, gamma-ray astronomy, and theoretical astrophysics and have involved scientific experiments on U.S., European, Japanese, and Russian spacecraft. Participation in NASA Programs has provided valuable opportunities for technology development and scientific excellence in support of DOE programmatic missions in arms control, nonproliferation, and intelligence.

National Science Foundation

The National Science Foundation has awarded funding to the Science Education Outreach Office at Los Alamos to plan and implement a teacher enhancement program for elementary teach-

ers from Northern New Mexico. The goal of the program is to provide teachers with subject matter content and teaching strategies based on scientific inquiry and the scientific process; the teachers can then transfer this knowledge to their classrooms and thereby increase the interest and ability of their students.

Department of Health and Human Resources

This effort involves developing technologies for acquiring, managing, and disseminating nucleotide and amino acid sequence data, analyses, and associated information about the HIV genome and related cofactors in AIDS pathogenesis. The HIV Sequence Data Base, established in 1986, is responsible for the national collection and publication of all molecular information pertaining to AIDS. The database compendium is currently being distributed to approximately 1,500 researchers and institutions in over 50 countries. While the HIV sequences are the primary data being compiled and analyzed, the project is also charged with curatorial tasks associated with data on cofactors to AIDS pathogenesis.

In another project, the Laboratory provides analytical and computer support to the development of improved approaches to operating the Medicare Program. Another Laboratory effort involves supporting NIH—through numerous grants—in biomedical and behavioral research. Los Alamos support to NIH includes providing scientific knowledge related to health and disease and conducting and supporting biomedical and behavior research

Other Federal Agencies—Defense Related

Intelligence Community. Los Alamos applies its full range of scientific and technical expertise to solving nationally important problems relating to technical intelligence and emerging foreign technologies. We strive to apply information science techniques to Intelligence Community problems; understand changes in scientific and engineering research and defense infrastructures in the FSU and the People's Republic of China; understand nuclear

weapons programs; provide technical support for arms control and verification initiatives; enhance U.S. economic competitiveness; understand regional conflicts; and assist national efforts in counternarcotics, counterterrorism, and counterintelligence.

Other Federal Agencies—Energy

This program involves supporting the Smithsonian Astrophysical Observatory by (1) developing, constructing and testing the photodetector/event timer system for the Hydrogen Maser Clock payload and (2) providing Laboratory facilities, hardware and technical expertise to achieve Advanced X-ray Astrophysics Facility mirror calibrations and optical elements.

Department of State

We provide research, development, and technical support to the Program for Technical Assistance to International Atomic Energy Agency Safeguards. We also participate in a multilateral study on the direct use of spent, pressurized water reactor fuel.

Other Federal Agencies

Los Alamos provides research, development, and scientific expertise to other federal agencies such as the United States Postal Service and the Internal Revenue Service. Specific initiatives include enhanced methods of maximizing public access to electronic, integrated government services and automated electronic fraud detection of financial transactions.

Nuclear Regulatory Commission

Los Alamos provides assistance with operating reactor licensing, including analysis and code support, and with nuclear material safeguards. We support NRC research through reactor-safety analyses, reactor-safety computer code development and assessment, risk management methods, expert opinion evaluations, techniques for uncertainty analyses, computer security, and seismic experiments and analyses.

Table 19. Summary of WFO Funding (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Nuclear Regulatory Commission	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Department of Defense	52.0	54.0	39.0	40.0	40.0	40.0	40.0	40.0
Health and Human Services/National Institutes of Health	8.0	11.0	6.0	4.0	4.0	4.0	4.0	4.0
National Aeronautics and Space Administration	9.0	7.0	5.0	5.0	5.0	5.0	5.0	5.0
Environmental Protection Agency	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Other Federal Agencies	19.0	22.0	21.0	21.0	21.0	21.0	21.0	21.0
Private Industry	12.0	11.0	6.0	5.0	5.0	5.0	5.0	5.0
All Other Non-Federal	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total WFO Funding	103.0	109.0	81.0	78.0	78.0	78.0	78.0	78.0
Direct WFO Personnel (FTEs)	365	371	306	277	277	277	277	277

Table 20. Department of Defense WFO Funding (\$M).

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Department of Defense	46.24	45.57	33.31	34.31	34.31	34.31	34.31	34.31
ARPA-TRP: Office of Nuclear Energy	0.15	0.17	0.00	0.00	0.00	0.00	0.00	0.00
OSD/Joint Munitions Research	5.33	6.17	5.50	5.50	5.50	5.50	5.50	5.50
International Security	0.12	1.50	0.00	0.00	0.00	0.00	0.00	0.00
Strategic Environmental R&D	0.52	0.20	0.19	0.19	0.19	0.19	0.19	0.19
Total Department of Defense WFO Funding	52.37	53.61	39.00	40.00	40.00	40.00	40.00	40.00

Table 21. Other Federal Agencies WFO Funding (\$M).

Funding Area	Actual	Projected	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
	Cost FY96	Cost FY97						
Weapons Parts or Assemblies (400100000)	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Department of Commerce (400402000)	1.38	2.75	0.01	0.00	0.00	0.00	0.00	0.00
Department of Interior (400406000)	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Department of Transportation (400407000)	4.08	4.56	4.05	4.00	4.00	4.00	4.00	4.00
National Science Foundation (400410000)	0.27	0.61	0.09	0.00	0.00	0.00	0.00	0.00
Other Federal Agencies - Defense (400470000)	9.60	9.60	11.00	11.00	11.00	11.00	11.00	11.00
Other Federal Agencies - Energy (400480000)	0.20	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Department of State - POTAS (400801000)	0.87	1.32	1.00	1.00	1.00	1.00	1.00	1.00
Department of State - Other Nonproliferation (400802000)	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.08
Other Federal Agencies (400890000)	2.63	2.86	4.70	4.70	4.70	4.70	4.70	4.70
Total Other Federal Agencies WFO Funding	19.11	21.94	20.93	20.78	20.78	20.78	20.78	20.78

Figure 25. Funding: Work for Others (including DoD).

Figure 26. Personnel: Work for Others (including DoD).

2. Conventional Defense

The conventional defense programs sponsored by the Department of Defense (DoD) are vitally important to the mission of the Laboratory. DoD funding enables the Laboratory both to make innovative contributions to national security by meeting challenging DoD technology requirements and to improve our technical core competencies. Currently, DoD programs account for approximately 7% of the Laboratory's annual funding (a significant component of the Laboratory's budget) and are major contributors to our science and technology (S&T) base and internal discretionary funds. For a budget summary of DoD programs, see Table 20 in Section II.B.1.f. Work for Others. Figures 27 and 28 at the end of this section provide graphical representations of DoD funding and funded personnel, respectively.

The Los Alamos DoD Programs Office provides Laboratory-wide management oversight, coordination, market assessment, development, integration, and execution of DoD programs. These responsibilities include providing an organizational contact and focus for DoD and the armed services, as well as coordinating with DOE programs that are also of interest to DoD. Our mission is to apply the expertise of the Laboratory in defense science and technology to a broad spectrum of DoD requirements and future needs for national defense and security—from basic research to integrated, fielded systems. Our customer base within DoD spans the entire department, including the Office of the Secretary of Defense, the Joint Chiefs of Staff (JCS) and unified commands, the armed services, and numerous DoD agencies and entities such as the Defense Advanced Research Projects Agency and the Defense Special Weapons Agency (DSWA).

The vision for the U.S. force structure of the future has been defined by the JCS in Joint Vision 2010. Joint Vision 2010 projects a full-spectrum dominance of the battlefield of the future based on information superiority. Its components include

- dominant maneuver—coherent operations in air, land, sea, and space throughout the battle space to seize the initiative and control the tempo of battle;
- precision engagement—location of the enemy, command and control of friendly forces, precision attack of enemy forces and capabilities, and assessment of success;
- full-dimension protection—protection of our forces at all

levels and freedom of action to deploy, maneuver, and engage the adversary; and

- focused logistics—rapid response, geographic deployment, resource monitoring enroute, and delivered tailored logistics.

Identified priorities for joint warfare include information superiority, precision force, combat identification, joint theater missile defense, military operations in urban terrain, joint readiness, joint countermine, electronic warfare, information warfare, biological and chemical warfare (BCW) agent detection, real-time logistics control, and counterproliferation. Science and technology plans to achieve these capabilities encompass air platforms, BCW defense, information systems and technology, ground vehicles and watercraft, materials and processes, biomedical technologies, sensors and electronics, space platforms, human systems, and weapons.

DoD has prioritized its investment strategies as follows:

- rapidly apply superior technology to warfare needs through advanced technology demonstrations and advanced-concept technology demonstrations;
- reduce costs in both the acquisition and the life cycles of technologies;
- strengthen the industrial base by endeavoring to use the same technology and industrial base to build various military and commercial products;
- promote basic research to expand fundamental scientific knowledge that may lead to future warfare capabilities; and
- continue to develop superior military technology by retaining and recruiting excellent scientists and engineers and supporting them with first-rate facilities.

DoD has also identified research thrusts in biomimetics nanoscience, smart structures, broadband communications, intelligent systems, and compact power sources as underpinnings to its basic research program.

Recent and projected investments in the DOE Defense Programs nuclear weapons laboratories—Los Alamos, Livermore, and Sandia—also present significant opportunities that we can leverage to our advantage. These investments aim to stabilize the core nuclear weapons programs necessary to ensure a safe and reliable U.S. nuclear deterrent capability into the next century. Efforts include a strategic and sustained push in computational, virtual, and live-fire testing and in materials-based technologies required to support science-based stockpile stewardship. This revitalized S&T base for stockpile stewardship and management will result in an unparalleled array of people skills, facilities, diagnostics, and analytic capabilities that can address many of the demanding technological challenges facing the DoD in the twenty-first century.

Los Alamos has a history of supporting DoD armed service interests when its unique capabilities and nonaligned status apply to technology needs and requirements in the conventional defense arena. For example, the joint DoD/DOE Nonnuclear Munitions Technology (NNMT) Program conducted at the three laboratories meets DoD's conventional munitions S&T needs in energetic materials; detonators, fuses, and sensors; warhead technology; and supporting technologies. In addition, successful teaming with the

DoD laboratories, industry, and academia has led to rapid deployment of innovative, affordable technologies to the field. Los Alamos is especially well positioned to support Joint Vision 2010 and its concept of full-spectrum dominance of the battlefield.

As we project past the year 2000, Los Alamos seeks to become the DoD's preferred resource for (1) innovative solutions to national security requirements and (2) a strong, enduring S&T base for future needs.

Defense Technology Portfolio

We have organized our defense technology portfolio into the following technology and programmatic platforms. These platforms best support new DoD initiatives and requirements while addressing current commitments.

Conventional Weapons Technology

The Conventional Weapons Technology platform exploits and enhances the core strengths of the Laboratory for DoD and nuclear weapons technology applications in conventional munitions, high explosives and energetic materials, advanced warheads, and lethality and survivability. An important part of this effort is managing the Los Alamos component of the NNMT memorandum-of-understanding program, including both DOE funding (on behalf of the Nuclear Weapons Technology Program Office) and DoD funding. The NNMT Program is intended to bring about significant improvements in nonnuclear munitions capabilities across all the armed services' mission areas, provide tools for designers to use in developing new munitions, and benefit the core nuclear weapons programs. Research activities encompass those areas of munitions technology common to nuclear and nonnuclear weapons. Specific projects are selected by mutual agreement between Los Alamos and the DoD Office of Munitions on the basis of mutual benefit.

Current focus areas include energetic materials, initiation systems, computational mechanics, materials science, and warhead subsystems. We are developing new explosives that have the same performance as today's best materials but are significantly safer. New models for explosives behavior are being developed to predict quantitatively how explosives will behave in abnormal environments such as accidents or fires. Processes for converting energetic materials to environmentally benign products are being developed to support demilitarization of munitions. Initiation systems based on exploding foil technologies are under development to provide design flexibility, enhance weapons safety, and lower production costs. We are implementing major improvements in computer codes to simulate the behavior of weapons subsystems and systems. We are investigating new, physically based descriptions of material behavior to significantly improve the predictive capabilities of our codes. We are developing enabling technologies for new warhead concepts, employing such approaches as reactive coupling to the target and electronically adaptable output, and transferring these technologies to the DoD and its contractors. Finally, we are exploring antimine and hard-target kill technologies of importance to emerging DoD missions.

Modeling and Simulation

Simulation is defined as modeling of macroscopic systems for requirements, prototyping, acquisition, test and evaluation, oper-

ational planning, and training. Our DoD simulation program focuses on developing computer-based virtual representations of complex real-world phenomena. Modeling and simulation, combined with the disciplines of scientific theory and experimental testing, form a triad of scientific tools of inquiry that allow us to examine, understand, and better predict systems of great complexity. Simulations enable computer-assisted experimentation on weapons systems in the battlefield environment, including human-in-the-loop, and can significantly increase our understanding of such complex systems behavior. Coupled with advances in computer hardware and software, as well as the continued development of scientific theories of systems behavior, simulations are increasingly important tools for defense scientists and analysts. They also have an adjunct benefit in enabling us to demonstrate how our proposed technologies can impact the battlefield—a powerful means to supporting program development and acquisition decisions.

JointSim is a continuing initiative, beginning in FY95, to develop higher-level-architecture, object-oriented, composable, distributed simulations for defense planning, doctrine, tactics, acquisition, and virtual testing. SAMSON is a simulation environment for human-in-the-loop and hardware-in-the-loop testing and evaluation in real time. It is being implemented at and for the Naval Air Test Center at Patuxent River, Maryland. The Force Deployment Estimator, developed for the Force and Assessment Division of the JCS and used to study deployment and logistics issues for major force deployments, is an example of a systems analysis product that we can provide DoD to address real needs and problems. Our simulation work in support of testing and evaluation has been applied to creating virtual combat environments for the navy and air force to test actual combat aircraft. We are currently using the DoD simulation base and the technology developed for it as the basis for developing models and simulations that address a wide variety of national security issues.

Over the next several years, Los Alamos intends to emphasize the scientific and research underpinnings for the broad spectrum of ongoing simulation activities at the Laboratory. As simulations take a more influential role in our understanding and decision-making concerning technology acquisition and research, it is important to develop a comprehensive body of science to ensure that the technologies are appropriately developed and used. Currently, such a science does not exist. Our intent is to work with key sponsors in the DoD who share our interests and will benefit from the results.

Defense Beams and Sensors

The Defense Beams and Sensors platform encompasses beams (particle, laser, and microwave) and sensor technologies (active and passive) for DoD applications. Specific technology initiatives include BW/CW sensors; radio-frequency (RF) weapons; C3I (command, control, communications, and Intelligence) assets; satellite and unmanned aerial vehicle (UAV) sensors; battle-damage-assessment sensors; and arms-control verification projects. The generation and sensing of radiation from the low-frequency, acoustic-wave region to the extremely high gamma-ray frequency range has broad application in detection, weapon, and counter-measure systems. The thrust of the Los Alamos defense beams and sensors programs is to support these DoD systems from development of the required science base, through field testing and

demonstration of prototypes, to subsequent transfer of the technology to industry for mass production.

Los Alamos is developing diagnostic sensors at both ends of the radiation spectrum for DoD programs in arms-control verification, monitoring, and compliance. These diagnostic sensors include (1) acoustic-resonance probes for treaty verification activities that support the Chemical Weapons Convention and (2) sensors on military space satellites that detect broadband RF and laser attacks (miniaturized "smart skins"). Los Alamos is also developing the next generation of satellite sensors for detection of the RF component of the electromagnetic pulse generated by the atmospheric or exoatmospheric detonation of a nuclear weapon.

A major focus of the Los Alamos defense beams and sensors programs is to support the army's biological-weapon defense effort. For near-term applications, the Laboratory is developing helicopter-based, long-range standoff light-detection-and-ranging (LIDAR) sensor systems to provide early detection and warning of aerosol clouds that are characteristic of line-source biological agent releases. To complement the long-range standoff LIDAR system, Los Alamos is also developing the hardware and biology for a ground-vehicle-based miniature flow cytometer that can detect and identify specific agents and, thus, the nature and possible hazard associated with specific aerosol clouds. For longer-term applications, Los Alamos is participating in the DoD Joint Biological Remote Early Warning System (JBREWS) advanced-concept technology demonstration. The JBREWS system would provide wide-area, large-volume coverage for biological-agent detection and identification using robust and inexpensive hardware based on existing technology concepts.

Advanced Concepts

The Advanced Concepts platform encompasses advanced materials, nonlethal technologies, special applications and operations, reduced signature technologies, UAVs, aircraft propulsion systems, and other advanced concepts. Reduced signature technologies can enhance the defensive capabilities of our forces. We are developing advanced structural and coating materials, improving signature modification techniques, and analyzing and assessing foreign signature mitigation techniques. Advanced aircraft frame and propulsion technology programs focus on the design and manufacture of new materials, testing and performance evaluation of component designs, development of innovative turbojet ignition systems, and optimization of cost efficiency in manufacturing processes. Recent advances in the development of lightweight armor materials and deployment of retrofit armor for aircraft have also gained DoD interest. Low-cost, advanced aircraft avionics designs focus on state-of-the-art defensive warning systems, data reduction technologies, and advanced display technologies. Many of these technologies are applicable to the Joint Advanced Strike Technology Program for the development of the next-generation attack fighter.

A major area of interest is nonlethal technologies that could be exploited by the military in operations other than war, specifically in low-intensity conflict, peacekeeping, and special operations. In such missions, delaying and standoff nonlethal defenses could enable success while minimizing the threat to our servicemen, reducing collateral damage, and preserving human life. Nonlethal technologies are also applicable to the needs of the U.S. drug enforcement community. RF (high-power microwave) weapon sys-

tems are undergoing development at Los Alamos for these applications. These weapons are based on compact, explosively driven packages that produce giant electrical pulses for the upset or "soft kill" of electronic systems.

High-Performance Computing

The Laboratory's high-performance computing initiatives in support of DoD are designed to develop a computing environment that enables the solution of large-scale, complex problems for both defense and dual-use applications. This computing environment must allow for distributed computing, management of large data sets, visualization of complex problem outcomes, rapid transmission of information between computing and hardware platforms, and development of new paradigms for modeling and simulation. Los Alamos is a primary player in the national High-Performance Computing and Communications initiative and participates in a broad variety of related projects with industry, universities, and other national laboratories. The Laboratory has made fundamental contributions in the areas of massively parallel processor technologies and applications, high-performance data storage systems, visualization techniques, and high-speed networking. Recent examples are the high-performance parallel interface and high-performance data system/high-performance storage system projects.

Over the past 12 years, Los Alamos has integrated supercomputers funded by the DSWA into its computational environment and operated a long-haul, secure network that supports 600 validated users at 120 geographically distributed sites. This cost-efficient model has provided the DoD computing community with mature and early-access supercomputing resources for both classified and unclassified work. Using the extensive range of computing resources and personnel talent available, we work with the DoD computing community to solve applied problems. An example is the development of a state-of-the-art software package for DSWA to perform one-dimensional, coupled electron-photon transport calculations. On the basis of this successful partnership, the Laboratory is exploring ways of leveraging past investments and future mutual interests to expand collaborations with the DoD in high-performance computing.

Environmental Technologies

As a response to the nation's substantial investments in the environment (in both capital and human resources), the Laboratory is adapting its technology to solve environmental problems. The Laboratory uses its expertise in a variety of situations ranging from solving problems at DoD testing or operational sites to fulfilling our national responsibilities that arise from international treaties. Examples of national programs that use our expertise include weapons stockpile reductions, the Base Realignment and Closure program, and the Strategic Environmental Research and Development Program. Past and present efforts include the use of supercritical water oxidation and biotechnology to destroy explosives and propellants. These and other technologies are being investigated as alternatives to the current practices of open burning and detonation, which may not be permissible options in the future because of public opposition and regulatory requirements. Many new technologies are evolving, with a strong emphasis on teaming between Los Alamos, other laboratories, industry, DOE, DoD, and other federal agencies.

Biotechnology

The Laboratory's investment in basic bioscience and biotechnology over the past several decades has placed us in an excellent position to provide DoD with a broad spectrum of capabilities to address specific needs. Immediate needs are (1) providing advanced technologies that support the injured soldier on the front line with diagnosis and life support and (2) providing expert advice to the medic through telecommunications capabilities that link the battlefield with the remote hospital or specialist expert. The Los Alamos TeleMed project is ideally suited to support this latter need. Other capabilities in biophysics, particularly magnetoencephalography and superconducting quantum interference devices, optical and ultrasonic techniques, and human tissue modeling for accurately representing the impact of projectiles on soft tissue and internal organs, are tools which can support the former need.

A "smart-film" dosimeter that records potential exposures to chemical or biological agents would be an invaluable aid in determining the underlying cause of nonspecific illnesses such as the Gulf War Syndrome in soldiers. A very successful and ongoing program in forensic identification of biotoxins is another example of Los Alamos technology that is being applied to a program of

rapid detection and identification of agents of biological warfare. Our capabilities in structural biology could also help clarify the structural features of the surface interaction between a biotoxin and a cell. Combining the Laboratory's modeling and simulation resources with high-resolution nuclear magnetic resonance experiments, x-ray diffraction, and a biology neutron scattering station at the Los Alamos Neutron Science Center would enable determination of the molecular structure of the toxin surface so that synthetic analogs can be developed to provide blocking agents that interfere with the toxicity process.

In addition to its battlefield application, TeleMed can support DoD Health Affairs in fulfilling its responsibility to provide the health needs of the military community. Currently, Health Affairs has 12 TRICARE regions in the U.S., which desperately need a common capability to keep track of patient's medical records and to provide real-time, on-line diagnostics support to medical doctors regardless of location. The strengths of the Los Alamos approach—namely to provide scalable, flexible architectures that are based on state-of-the-art software and also take advantage of existing commercial products and standards and the Internet infrastructure to maximize functionality at the lowest possible cost—are germane to DoD's needs.

Figure 27. DoD funding.

Figure 28. DoD funded personnel.

3. Industrial Partnership

The U.S. Department of Energy's Defense Programs face unprecedented challenges of stewardship for an aging nuclear stockpile, cessation of nuclear testing, reduced federal budgets, and a smaller manufacturing complex. Partnerships with industry are essential in developing technology, modernizing the manufacturing complex, and maintaining the safety and reliability of the nation's nuclear capability. The past decade of federal support for industrial partnerships has promoted benefits to U.S. industrial competitiveness. Recent shifts in government policy have reemphasized the importance of industrial partnerships in accomplishing agency missions. Nevertheless, abundant opportunities exist for dual-benefit, mission-driven partnerships between the national laboratories and industry.

The Laboratory's Civilian Industrial Technology Program Office (CITPO) connects the Laboratory's scientific and technical talent with the technical needs of industry, universities, and government to both help ensure the national security of the United States and to strengthen our nation's economic and technology base. Industrial interactions remain a key contributor to the scientific vitality of the Laboratory. Indeed, the Laboratory recognizes that working with industry is a business necessity, and as a result, industrial partnering goals and objectives have been incorporated into each of the Laboratory's tactical goals.

As long as the Laboratory's compelling mission of reducing the nuclear danger remains strong and continues to require a vigorous science and technology base, the Laboratory will participate as one of the key players—along with universities and industry—in the modern R&D community. Partnerships can contribute to mission-oriented programs such as the Accelerated Strategic Computing Initiative or strengthen the core competencies of the Laboratory.

Table 22 at the end of this section provides projected funding for industrial partnership.

CITPO Management, Administration, and Leadership

Congress has mandated that every national laboratory shall maintain an Office of Research and Technical Assistance (ORTA), which is responsible for managing and administering technology transfer agreements, licenses, and intellectual property. For Los Alamos, CITPO is the designated ORTA. The CITPO director

and staff represent Los Alamos technology transfer activities to DOE, the University of California (UC) Regents, all federal and state agencies, and industry.

CITPO promotes and markets the Laboratory's scientific and technical capabilities, as well as develops and implements long-term strategic partnerships that team Los Alamos and DOE with other federal agencies, key industry sectors, and universities. Not only do these activities enhance the Laboratory's ability to perform its national security mission, they also heighten industry's awareness and use of the Laboratory's intellectual property assets, scientific expertise, and unique facilities. The major program responsibilities of this program office include the following:

- Defense Programs Technology Partnership Program,
- negotiation and execution of agreements with the private sector,
- industry-sponsored programs,
- intellectual property management,
- technology commercialization and marketing outreach,
- institutional program development and Laboratory-directed R&D,
- entrepreneurship activities,
- regional economic development, and
- Industrial Fellows Program.

CITPO promotes and supports strategic partnerships that bolster the Laboratory's core competencies and enhance defense programs. These partnerships result in the transfer of technologies and ideas to the industrial sector, thereby strengthening the international economic competitiveness of the United States.

The industrial partnership team works closely with researchers and program managers at the Laboratory to partner with industry. The team has executed over 230 cooperative research and development agreements (CRADAs), which represent nearly \$500 million of company and Laboratory collaborative research efforts over the life of the projects. The team negotiates approximately 70 funds-in and user-facility agreements each year, bringing in approximately \$15 million. It also negotiates 20 or more commercial licenses each year.

To support and facilitate industry interactions, the program office maintains Laboratory databases of available competencies, hosts numerous industrial visits, and establishes technical assistance links for all incoming calls from industry and small businesses.

Future industrial agreements to establish research partnerships are likely to concentrate on consortia of industries rather than individual companies. In addition, there is a trend toward agreements (CRADAs and licenses) that involve more than one DOE Laboratory, as well as partnerships that have the potential to be very broad based and multiyear, incorporating a whole suite of agreements.

Defense Programs' Industrial Partnerships

Partnerships with industry have become a business necessity for the Laboratory for three basic reasons.

- Through our partnerships with industry, we learn and incorporate many "best practices" from industry.
- Partnerships with industry maintain and enhance our core competencies and directly support Laboratory mission requirements.

- The application of our technical and human resources to industrially relevant problems contributes to a stimulating and challenging multidisciplinary research environment that allows the Laboratory to attract and retain some of the world's best scientific talent.

Underlying and supporting all these reasons is the fact that all federal laboratories are supported by federal taxes and, thus, represent a major investment of public resources. It is appropriate, therefore, that the results of the research and development conducted for government purposes be made available to benefit the U.S. economy.

Los Alamos and the other DOE laboratories have much to learn from technology and methods developed in the private sector. This is especially true as the weapons manufacturing complex consolidates around the laboratories. The manufacturing complex of the future must be flexible, modular, efficient, and environmentally benign. It must also be integrated across multiple research, development, and fabrication sites. Through partnerships, our scientists and engineers work with the best researchers in both industry and universities, learning and adopting the best integrated manufacturing practices wherever they reside. The goal is to modernize the Laboratory and the DOE Complex in order to deliver higher-quality, more cost-effective products to our primary customer, the U.S. Department of Energy.

Small Business Initiative

Los Alamos National Laboratory has become a leader in the development and promotion of partnerships with small businesses across the nation. For 5 years, DOE Defense Programs has funded the Small Business Initiative, a special program for interactions with small businesses. With these funds, the Laboratory has undertaken more than 50 CRADAs with small businesses in the U.S.

In addition, Los Alamos has designed unique programs to provide Laboratory access to small businesses. We identify trade associations with predominantly small business memberships that have technical interests complementary to the Laboratory's technical strengths. The trade association identifies industry-wide problems which we attempt to solve. Any Laboratory-developed solutions are shared with the trade association members.

When approached by a small business for short-term technical assistance, we can help free-of-charge when the problem area is also of interest to the Laboratory's nuclear weapons program. If this short-term problem requires a longer interaction for success, the Small Business Personnel Exchange program might be suitable. Under this program, we can support a small business researcher's short-term visit to the Laboratory or send Laboratory personnel to a company to work on problems of mutual interest.

Through the Small Business Initiative, the Laboratory seeks to enter partnerships with small business suppliers to the nuclear weapons complex. Such partnerships are designed to ensure continuing vital interactions between the complex and the small business community. It is particularly advantageous when the supplier is a regional business.

Royalties

In UC's prime contract with DOE for the management and operation of Los Alamos National Laboratory, there is a requirement that the annual Institutional Plan contain information about the use of royalty income from licensing of the Laboratory's intellectual property. As part of the UC system, the Laboratory is provided guidance through the university's royalty distribution policy. The UC policy was rewritten in mid-1997 and provides for (1) deduction of direct administrative costs for patenting and licensing activities; (2) 35% of the remainder of the fee and royalty income to be distributed to the inventor(s); (3) 15% (minimum) to go to a research and development pool at the Laboratory; and (4) the balance to be used by the Laboratory at its discretion. There is also a provision for the DOE laboratories in the UC system to write site-specific policies, which Los Alamos plans to do. The Laboratory-specific policy proposal will follow the basic UC guidelines, but it will contain more details about which costs will be considered administrative. In addition, it will propose that all fee and royalty income not distributed to inventors, as well as administrative costs, will go to the division/group that originated the invention. This income can be used by the organization for furtherance of its goals.

Regional Economic Development

For several years, the Laboratory has placed a strong emphasis on contributing more to the economic health of north-central New Mexico. New Mexico's economy is dominated by small businesses—more than 98% of the state's enterprises fit this description. These enterprises are predominantly in the service and tourist sectors. The majority of our regional employment, however, is dependent upon the federal government. As pressures to reduce the federal deficit continue, the effect of government downsizing severely impacts the region. In response, the Laboratory is actively promoting new business start-ups based upon Laboratory technology. Since FY96, the Small Business Initiative has been allowed to focus the majority of its financial resources on partnering with regional companies and supporting new business start-ups. In FY97, this funding has grown to \$1.5 million.

With innovative programming, such as entrepreneurial leave for up to 2 years and the ability of Laboratory staff to provide consulting services in addition to their full-time employment, more Laboratory staff members are considering entrepreneurship. The Laboratory offers special workshops on commercializing Laboratory technology and expertise to Laboratory staff. Regional companies and economic development professionals are also benefiting from the information presented by national experts at these workshops. These approaches, coupled with strategies to prompt Laboratory suppliers to become part of the region, will ensure Laboratory contributions to the growth and diversity of the regional economy.

Continuous Quality Improvement

The Laboratory's technology transfer professionals strive to expedite and execute quality partnerships with the industrial sector to benefit DOE, our partners, and the taxpayers—from assistance to regional small businesses to assistance that benefits both industry and the Laboratory's Stockpile Stewardship mission. CITPO employs continuous quality improvement methods for its entire customer base.

Table 22. Funding for Industrial Partnership (\$k).

Funding Area	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Defense Programs Technology Partnership Program R&D Cooperative Agreements (DP0301)	14.0	14.0	10.0	10.0	10.0	10.0	10.0
Industry-Sponsored Programs and Partnerships Funds-In Programs (60/65)	12.0	16.0	20.0	26.0	33.0	40.0	50.0
Total	26.0	30.0	30.0	36.0	43.0	50.0	60.0

C. Competency-Related Activities

1. Laboratory-Directed Research and Development

The Laboratory-Directed Research and Development (LDRD) Program is congressionally authorized as a vehicle by which the Laboratory invests in cutting-edge research that will both maintain and extend the science and technology capabilities that support our mission. LDRD provides funds for projects across the entire spectrum of competencies and disciplines underlying the Laboratory mission. Most projects funded by LDRD benefit both the national security and civilian missions of the Laboratory.

The LDRD budget consists of both operating and capital equipment funds (see Table 23 at the end of this section). Funds for LDRD are generated through the application of a uniform assessment to direct-funded (DOE and Reimbursable Work for Others) programs at Los Alamos. The actual operating and capital equipment funding available to LDRD each fiscal year is contingent upon the total Laboratory budget and the DOE-approved assessment rate for each year, which is limited to a maximum of 6%.

A breakdown of the LDRD Program actual and projected costs from FY96 through FY03 is shown in Table 23. In FY96, the DOE-approved assessment rate was 5.5%, and the actual Laboratory operating costs were \$1,008 million. The projected LDRD costs for FY97 are based on a DOE-approved rate of 6% and an increased Laboratory operating budget. Level funding is assumed for FY98 and beyond.

The LDRD Program at Los Alamos is subject to congressional requirements, applicable DOE regulations and orders, primarily DOE Order 413.2, and the prime contract between the University of California and DOE. LDRD financial activities are also conducted in accordance with generally accepted accounting principles and cost accounting standards.

LDRD Program Structure

The LDRD Program includes three components: Individual Projects (IP), Competency Development (CD), and Program Development (PD). Projects in each category are selected through competition, and each proposal is reviewed by scientific management and/or peer review before it is selected for funding. The funding breakdown among the three components is determined annually by the Laboratory Deputy Director for Science and Technology following close consultation with the technical working group of the Laboratory Leadership Council. In FY96, LDRD funded 356 projects for a total expenditure of \$57.2 million. The funding distribution among the three components (IP, CD, and PD) was 38%, 37%, and 25%, respectively. In FY97, the distribution will change to 33%, 46%, and 21%. In FY98 and beyond, the distribution is expected to be 34%, 46%, and 20%. This redistribution of funding reflects the Laboratory's continued emphasis on scientific thrusts, which are part of the CD component. The scientific thrusts represent some of the most exciting and promising ideas generated by our scientific and technical staff in broad support of our mission.

Individual Projects

The IP component focuses on staff-initiated research and development in uncharted territory, that is, on scientific work that

possesses extremely high potential and long-term return on investment. The life span of IP projects is generally 3 years. Proposals are solicited directly from the scientific staff, with little or no requirement for a direct link to near-term programmatic needs. However, the emphasis is on state-of-the-art science and technology. We believe that approximately one-third of the LDRD budget is about the minimum necessary to sustain a critical mass in this component. The IP component supports high-quality basic and applied research in nine disciplinary categories: atomic, molecular, optical, and plasma physics, fluids and beams; biosciences; chemistry; engineering sciences; geosciences, space sciences, and astrophysics; instrumentation and diagnostics; materials sciences; mathematics and computational sciences; and nuclear and particle physics.

Competency Development

Competency Development has been the LDRD component most subject to change in recent years; it has now evolved to funding only scientific thrusts. We intend this component to be the one most guided by the longer-term Laboratory strategy and most influenced by the Laboratory's scientific management. Focusing on scientific thrusts has become a strategic tool used by the Laboratory to make a conscious and deliberate investment in innovative science and technology to achieve identified institutional benefit. The intent of this strategy is to allow market-driven, science-driven, and capability-driven scientific thrusts—all of which are institutionally important.

The differences between the three types of thrusts are subtle but distinct. Market-driven thrusts are those in which the program offices have identified significant opportunity for new programs if particular areas of science and technology are strengthened. Science-driven thrusts are those in which the technical divisions see significant scientific opportunity for new ways of addressing our mission by investing in particular areas of science and technology. Capability-driven thrusts are those in which divisions can identify a science or technology area that needs strengthening to either enhance or preserve a key mission capability.

The CD component receives approximately half of the total LDRD funds. Thrusts are generally multidivision efforts that vary in size from single-project activities funded at \$250,000 for 1 year to more-comprehensive activities that are funded at \$1 million per year for up to 5 years and comprise more than one project.

Program Development

The PD component is intended to fund projects that are generally of short duration (typically 1 year but occasionally longer) that are intended to bring a science or technology to a point where a direct-funding sponsor (such as a DOE program) is persuaded to invest further. The funds for program development are divided among the eight program offices based on the strength of a strategy proposal submitted to the Science and Technology Base Program Office (STB) for review. The program offices are the Los Alamos Department of Defense, Environmental Management, Energy Technology, Industrial Partnerships, Los Alamos Neutron Science Center/Energy Research, Nonproliferation and International Security, Nuclear Materials and Stockpile Management, and Nuclear Weapons Technology. Once the program offices are given a budget target by STB, they each begin an internal process in which they target organizations and ask directly for proposals in specific research and development areas. PD funds support a

very broad range of science and technology—from the more fundamental to the very highly applied.

Selection of LDRD Projects

LDRD is a formally managed program at the Laboratory that imposes accountability in the selection, execution, and reporting of projects. All projects are selected through competition and review by peers or scientific management. Innovation and scientific excellence are key criteria for selecting projects for funding. All projects must be in science and technology areas that support the Laboratory mission.

The annual LDRD proposal cycle begins in February with a formal call for new proposals for LDRD projects. Along with the calls for each of the three LDRD components, the LDRD Office provides detailed guidance on component funding for planning purposes and the research and development areas that will be supported. Though some projects may be multiyear projects, a statement of work must be submitted for each project on a yearly basis (projects are generally funded for a maximum of 3 years). The review process utilized is contingent on the LDRD component the project falls within and whether a project is a new start or a continuing project. In addition, all projects are required to obtain appropriate ES&H approvals.

IP proposals for new starts are reviewed by 1 of 9 LDRD technical category teams. Each technical category team consists of 8 to 12 technical staff members who are selected for their expertise in that technical category. The teams evaluate and rank proposals based on their scientific and technical merit. The highest-ranked and most-relevant ones are selected for funding. Continuing IP projects are subject to scientific management review, and funding is extended into the subsequent fiscal year if the projects were previously approved for multiyear funding and if adequate progress toward stated objectives was achieved.

For the PD component, directed calls for proposals are issued by Laboratory program directors. These calls are generally targeted at specific subject matter and organizations. Program directors institute a review process, usually using program managers in their offices, to select the most innovative projects for funding that match the longer-term strategies of the program offices.

The selection process for new CD thrust proposals also begins with directed calls. The LDRD Office issues a call for proposals that outlines a strategic vision for both the Laboratory (written by the Laboratory Director) and the major programs (written by the program directors). A limited number of ranked proposals are then submitted by the technical divisions in general response to the call for proposals. These proposals are reviewed by appropriate core competency teams and program offices, as well as the STB Program Office. The STB Program Office integrates the reviews and makes a recommendation to the Director, who makes the final decision for thrust funding. To give an idea of the success rate, in FY96, 48 thrust proposals were submitted. Of these submissions, a total of 13 (27%) received funding—4 that comprised several projects were funded at \$1 million for 5 years, 3 were funded at \$1 million for 3 years, 1 was funded at \$750,000 for 1 year, and 5 were funded at \$500,000 for 1 year. In FY97, continuing scientific thrusts were reviewed by scientific review panels to measure the extent of progress toward targeted objectives. This type of review will be continued in the future for continuing scientific thrusts.

The Success of LDRD

The key Laboratory strategies are to ensure a strong defense core that has a nuclear focus, to maintain the vigor of those programs by emphasizing their scientific foundations, and to selectively target civilian research programs to maintain the multiprogram character of the Laboratory. LDRD is a vital tool to support those strategies.

The high quality of science supported by all components of the LDRD Program is attested by the number of related scientific publications, patents, and awards. In 1996, LDRD projects generated 27% of all of the Laboratory's publications, 39% of our patent awards, and half of our R&D 100 awards—with only 5.5% of the Laboratory budget. In addition, the LDRD Program is a significant testing ground for the talent attracted to the Laboratory through our postdoctoral program. In 1996, 150 postdoctoral staff members participated in LDRD projects. Of these postdoctoral students, many go on to become permanent Laboratory employees and contribute to our core scientific missions.

LDRD projects tend to be cutting-edge research and development, and they contribute broadly to the underpinning science and technology supporting our mission. In particular, they contribute substantially to capabilities in nuclear weapons science and technology; nonproliferation, counterproliferation, and arms control; nuclear materials characterization and defense waste disposal; and other national security areas such as materials, detectors, and computational tools for military applications. The following projects have been chosen to highlight just a few significant contributions to national security areas.

Nuclear Weapons Science and Technology

Because of the ban on nuclear testing, we must increase our fundamental understanding of the underlying science of nuclear weapons performance. LDRD researchers are developing new ways to make some of the measurements we need for stockpile certification and for improving the modeling capability of our nuclear weapons codes.

- LDRD researchers are exploring a promising new approach for using energetic protons to make high-resolution radiography. The work is aimed at attaining a fundamental understanding of the processes involved and assessing the ultimate resolution achievable. Ultimately, this technology will enable high-speed imaging of rapid events in dense materials.
- The tendency of adjacent but dissimilar liquid layers to interpenetrate and mix together (interface instability) is a problem of central importance to nuclear weapons performance and simulation. In particular, interfacial instability of a thin fluid layer driven by shock compression is a fundamental issue in understanding turbulent mixing in nuclear weapons. LDRD researchers are developing a new measurement technique to obtain "snapshots" of the evolving instability, leading to more-accurate simulation models and improved computational results.
- Understanding the effects of aging on nuclear weapon components, particularly plutonium and polymers, is a very important aspect of science-based stockpile stewardship. LDRD researchers are making substantial contributions to this understanding through theoretical, computational, and

experimental analyses. LDRD researchers are using transmission electron microscopy, small-angle neutron scattering, and other advanced techniques to investigate alpha-decay-generated helium-bubble formation and distribution in aged plutonium metal. They are also developing the computer simulation tools to evaluate the effect of this and other aging phenomena on properties that are germane to nuclear weapons safety and performance.

- Degradation of polymers as they age is probably the most important factor in limiting the lifetimes of stockpiled weapons. LDRD researchers are using both experiment and theory to link the large span of size scales of polymers to accurately predict how changes in chemical structure, physical structure, and state of stress impact the mechanical properties of the materials. While some aspects of each of the size scales (atomic, molecular, mesoscale, microscale, and macroscale) have been studied in the past, the LDRD work is one of the first attempts to link this wide range of size scales into a coherent picture that can be used to understand the fundamental behavior of polymeric elastomers.

Advanced Manufacturing Processes Relevant to the Weapons Program

- LDRD researchers have developed a new fabrication process called directed-light fabrication (DLF), and they are exploring its application to nuclear weapons fabrication (beryllium, uranium, and plutonium components). The DLF process is an automated, rapid, one-step method of making complex metal parts by fusing metal powder in the focal zone of a laser beam. The resulting parts are fully dense, have excellent structural properties, and are shaped to within a few thousandths of an inch of final tolerance without the use of a mold, pattern, or forming die. The process is ideal for low-volume production of precision parts for both defense and civilian applications.
- LDRD researchers have developed and benchmarked computer simulation programs to predict distortion, residual stress, and thermal management in cast plutonium parts. Advances in these areas will benefit both the Advanced Design and Production Technology and the Accelerated Strategic Computing Initiative efforts of the DOE.

Advanced Computational Capability and Nuclear Weapons Simulation

In the absence of nuclear testing, the ability to predict with confidence the performance of nuclear weapons based on computer simulations is one of the key requirements for maintaining a safe, secure, and reliable stockpile. Computer simulations of the complex phenomena that occur in a nuclear explosion continue to tax available state-of-the-art computational capabilities and simulation techniques.

- Past LDRD activities have resulted in the development of the discrete-ordinates method for radiation transport, the particle-in-cell method for hydrodynamics, and other computational tools that are now used widely in both military and civilian applications. Today, LDRD researchers are providing the technology to implement these tools on the new generation of massively parallel supercomputers. The researchers are also extending the capability of these tools through new developments such as a complex geometric representation common to both the Monte Carlo and the discrete-ordinates codes.
- Computer simulations of nuclear weapons require not only the most powerful computers available but also the ability to transfer huge amounts of computational data and the capability to display these data in forms that can be more easily digested and analyzed. LDRD researchers have advanced the state-of-the-art in fast, data-transfer network technology by inventing the high-performance parallel interface (HIPPI), which supports local networks at data-transfer rates of 800 million bits per second (equivalent to one-hundred 250-page books per second). HIPPI has been adopted as a standard by the American National Standards Institute. HIPPI has been implemented in many vendors' equipment and is currently the high-speed interface of choice for supercomputers. Building on this LDRD work, a synchronous optical network gateway has been developed that uses HIPPI to link supercomputers over very large distances. LDRD researchers are currently exploring technology to extend the network bandwidth to a range of 5 to 10 gigabits per second.

Table 23. Projected Funding for Laboratory-Directed Research and Development (\$M).¹

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Operating Cost	54.9	63.6	65.0	65.0	65.0	65.0	65.0	65.0
Capital Equipment	2.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Total	57.2	65.6	67.0	67.0	67.0	67.0	67.0	67.0

¹Projected amounts subject to approval in accordance with DOE Order 413.2. FY96 data reflects actual amounts for the fiscal year.

- Develop applications as a driver for and a partner in the development of high-performance computing and communications environments. Grand Challenge problems are a particular subset of the suite of applications that are driving and stretching the limits of the environment necessary to make progress in simulation technology.

Advanced Computing Programs

Los Alamos high-performance computing and communications efforts are all motivated by a firm commitment to meeting DOE mission responsibilities and to maintaining national leadership in predictive modeling and simulation and high-end computing and communications technologies. Los Alamos researchers are hard at work in three major DOE advanced computing programs: the Accelerated Strategic Computing Initiative (ASCI), the High-Performance Computing and Communications (HPCC) Program, and the Computer Hardware, Advanced Mathematics, and Model Physics (CHAMMP) Program.

A key aspect of our strategy for the future, already being implemented today, is to leverage the hardware and software infrastructural investments as well as the complex applications problems that these three programs bring with them. The objective of this strategy is not only to accelerate progress in meeting the goals of the programs themselves but also to address other chronic and emerging problems important to the nation that the private sector alone will not or cannot address. For example, supported by institutional funding, researchers in our Crisis Forecasting initiative (described later in this section) are applying the predictive modeling and simulation capabilities and resources developed in weapons programs like ASCI and in the HPCCE efforts in order to model and simulate, and thereby predict, the behavior—in terms of the outbreak and spread—of crises such as wildfires and influenza.

Accelerated Strategic Computing Initiative

Because the ASCI Program has been described in Section II.A.1. Stockpile Stewardship, this section will focus mainly on the high-performance-computing infrastructure component of the program. The three participating laboratories—Los Alamos, Lawrence Livermore, and Sandia—have received their initial ASCI computer systems and have begun installing and testing them. In December 1996, Los Alamos took ownership of the initial delivery system of Blue Mountain, an SGI/CRI Origin2000 supercomputer. This initial system can perform more than 100 billion calculations each second (more than 100 gigaflops per second) and store the equivalent of more than 7 billion words (52 gigabytes) in memory. A second system, Nirvana Blue, has been delivered for our Advanced Computing Laboratory (ACL).

These two initial systems have 256 processors each. Over the next 2 years, additional, faster processors and other components will be added to both the Blue Mountain and Nirvana Blue computers. The final ASCI system, with 3,072 processors, and the final ACL system, with 1,024 processors, can be combined and configured as a single distributed shared-memory system. The combined performance will be more than 4 trillion calculations per second (4 teraflops per second aggregate peak), making it the fastest computing system in the world and a cornerstone of DOE's computing initiative.

Responsibility for the high-performance computing and communications environment at Los Alamos resides primarily with CIC Division, whose mission includes providing the Laboratory with reliable, efficient, state-of-the-art computing and communications resources. Laboratory divisions such as Applied Theoretical and Computational Physics, Engineering Sciences and Applications, and Materials Science and Technology, to name just a few, depend to varying degrees on the facilities and infrastructure provided by CIC Division. The competency-related responsibilities of CIC Division are as follows:

- Provide hardware and software architects who work closely with applications scientists in developing next-generation capabilities, including hardware and systems design.
- Develop the algorithms, libraries, and languages for early-access computer systems. We will also develop new ways to use these systems.
- Design, develop, and implement the integrated environments that make these systems useful. Examples include the High-Performance Storage System (HPSS) for managing previously unimaginable amounts of data at very high speeds and network interfaces such as the now-standard high-performance parallel interface (HIPPI) communications capability.

Although the two supercomputers may be linked for unprecedented power, the computer at the ACL will be used chiefly in an open, unclassified environment to support advanced research in climate modeling, materials science, molecular biology, crisis forecasting, and other critical simulation experiments that cannot be performed with less advanced computers. The ASCI machine, which resides in the secure, classified partition of the computing network, is expected to be ready for performing stockpile stewardship calculations in April 1997.

In addition to the delivery of the Blue Mountain computer at Los Alamos, a high-speed, secure network linking Los Alamos with Lawrence Livermore and Sandia national laboratories is in daily use. We are developing a set of software libraries—known as Parallel Object-Oriented Methods and Applications (POOMA, described below)—which is part of a toolkit that DOE is preparing for advanced computational testing and simulation. This toolkit will provide an integrated set of software tools, algorithms, and environments to accelerate the adoption and use of advanced computing to improve researchers' ability to solve increasingly complex scientific problems.

See Figure 29 for the schedule for implementing the ASCI hardware.

High-Performance Computing and Communications

As discussed in Section II.B.1.c. Energy Research, the OER-sponsored HPC Program supports research and development in the computational and communications sciences to enable the solution of the important Grand Challenge problems. The five Grand Challenge research projects in which Los Alamos researchers are involved are described in the Energy Research section.

Computer Hardware, Advanced Mathematics, and Model Physics

CHAMMP is a DOE program supported by OER. Its goal is to simulate and predict the long-term global and regional climate variations that lie at the heart of the U.S. Global Change Research Program. CHAMMP is described in more detail in Section II.B.1.c. Energy Research.

Parallel Object-Oriented Methods and Applications

Scientific application codes such as those that will run on ASCI supercomputers are extremely large, complex computer programs that previously had to be painstakingly rewritten whenever hardware or software changed significantly. The POOMA framework, developed at Los Alamos, is a software infrastructure designed to simplify the development of scientific applications codes on parallel computer architectures.

Application codes written with POOMA are capable of running—with no changes to the code—on serial, distributed, or parallel computer architectures. Application developers express the fundamental scientific content and numerical methods of their problem using high-level language constructs similar to simple mathematical notation; thus, developers do not need to be familiar with the details of C++ object-oriented programming.

This framework is not only easy to use but is extremely agile and portable across rapidly evolving high-performance parallel computing architectures. It can be used on parallel supercomputers such as ASCI Blue Mountain and on common scientific workstations. Los Alamos researchers are currently using the POOMA framework in several ASCI and Energy Research applications, including multimaterial, three-dimensional hydrodynamics; three-dimensional simulations of turbulence in tokamak fusion plasmas; Monte Carlo neutronics; and global ocean modeling.

Figure 29. The implementation schedule for Nirvana Blue and Blue Mountain supercomputers.

High-Performance Storage System

Los Alamos is an integral member of a partnership of developers and collaborators who have joined together to produce the next-generation data storage system required to meet the demands of high-performance applications on current and future supercomputers. The development team consists of IBM, Los Alamos, Sandia, Oak Ridge, and Lawrence Livermore national laboratories, and other collaborators. The resulting product, the HPSS, is a scalable, parallel storage system for highly parallel computers, as well as for traditional supercomputers and workstation clusters.

A major impetus for Los Alamos participation in developing HPSS was the need for a distributed, high-speed storage management system that could meet the demands of high-performance applications, including Grand Challenge and ASCI applications. The HPSS architecture provides for scalability in several dimensions, including data-transfer rate, storage size, number of namespace objects, size of objects, and geographical distribution. Using software striping as a parallel input-output mechanism, HPSS is designed to scale as necessary.

HPSS will be deployed in the Los Alamos Central Computing Facility in 1997 to serve users whose requirements for storing massive amounts of data generated during simulation runs are not being met by existing storage systems. Typical applications include three-dimensional hydrodynamic and radiation transport codes that will generate many files in the 20- to 50-gigabyte range, hundreds of files in the 1- to 5-gigabyte range, and special graphics and visualization files that can be as large as several gigabytes.

While users will be able to transfer data between their workstations and HPSS via their Fiber Distributed Data Interface or Ethernet networks, the high-speed transfers between supercomputers and HPSS will take place over the HIPPI network, which is already in place. HPSS can transfer data over any socket connection and, thus, has the potential of being used over a variety of networks. The Los Alamos HPSS configuration will include a variety of worker machines ranging from a large symmetric multiprocessor to small workstations that will be served by HPSS via different network paths.

The Laboratory received a 1997 R&D 100 Award for HPSS. *R&D Magazine* presents these annual awards to the top 100 technical innovations. The awards are highly regarded by industry as a measure of excellence.

Crisis Forecasting

The ability to forecast the progress of crises would significantly reduce human suffering, loss of life, destruction of property, and federal expenditures for mitigation. Computational science is now at a point where such predictive simulations of crises may be performed. We have established an effort, funded internally by Laboratory-Directed Research and Development, to address this national challenge. Our goal is to develop the capability to predict the course of an evolving crisis, thereby gaining an understanding of the effects of the emergency on lives and property.

With respect to forecasting crises, there are at least two kinds of challenges. The first and more difficult challenge is predicting the occurrence of a specific emergency such as an outbreak of wildfire, infectious disease, or terrorism. The second challenge is forecasting the spread of the outbreak.

Los Alamos has had tremendous success in simulating dynamic, physical processes. The results of these efforts have been qualitatively correct and have indicated that quantitative prediction is now within the realm of possibility. Such modeling and simulation efforts constitute one of the traditional core competencies of the Laboratory. Los Alamos has also been one of the pioneers in data-driven modeling and simulation—that is, models that are inductively derived from available data sets by employing techniques such as dynamic systems, neural nets, genetic algorithms, and cellular automata. Examples of successful forecasting using these techniques include predicting ice ages, predicting the flooding of Venice, and detecting tax fraud.

The notion of using high-performance computing along with modeling and simulation to forecast the effects of evolving crisis and emergency situations presents Los Alamos, along with our partners at the Los Angeles Fire Department, the Fish and Wildlife Service, NASA, the U.S. Air Force, the Forest Service Fire Research Labs, and the Centers for Disease Control and Prevention, a unique opportunity to test whether computational forecasting might become, in time, an invaluable tool for managing future crises.

Because many crises are strongly linked to weather forecasting, we are working to develop an atmospheric dynamics code for high-resolution and strong-gradient (HIGRAD) applications. This new model is run in conjunction with an established mesoscale model, the Regional Atmospheric Modeling System, to address the problem of predicting weather-related crises. HIGRAD uses advanced numerical techniques and parallelization schemes that take full advantage of multiprocessor technologies to improve the model's forecast accuracy and computational speed. These developments will enable us to achieve a high-resolution forecasting capability on clusters of workstations.

To predict the unfolding of events associated with natural disasters requires more than a fast, accurate weather forecast. The weather prediction capability must be used in conjunction with other crisis-specific models and statistical procedures to achieve a full understanding of an event. Wildfire prediction is a prime example. To predict the course of a wind-driven fire in a small mountain valley, both wind and fire behavior over the terrain must be resolved. To do so, we have coupled our high-resolution weather prediction model to a simple fire-behavior code in preparation for linking to a more sophisticated wildfire code. The combined modeling system is being used to study and predict the constantly evolving interaction of the atmosphere with the wildfire fuels.

Los Alamos researchers have successfully simulated several small fires, including a 1-kilometer $\times$ 1-kilometer area of the October 1996 Calabassas Fire in Los Angeles County, where wildfire overtook several firefighters. In the spring of 1997, in partnership with NASA and the U.S. Air Force, Los Alamos used sophisticated sensing and diagnostic equipment to obtain critical information on a controlled burn at the Kennedy Space Center in Florida. The data are being used to validate our models. In the summer of 1997, we partnered with the County of Los Angeles Fire Department to conduct similar tests.

Falcon: Advanced Software for Simulating Oil Reservoirs

Simulations that predict the flow of oil and gas in underground reservoirs are used by all major oil and gas companies to determine the best recovery strategies. However, because current simulations run on small, slow, single-processor computer systems, they cannot model the large fields that produce over half of the world's oil and gas. Through a cooperative research and development agreement, Los Alamos joined with Amoco Production Company, PGS Tigress, Inc., and Cray Research, Inc., (CRI) to develop Falcon, a commercial-quality, three-dimensional oil reservoir simulation software. Falcon was developed to run on massively parallel processors such as the the CRI T3D, but it is portable enough to run on traditional vector supercomputers and even high-performance workstations and clusters of workstations. In the summer of 1996, PSC Tigress released a commercially available version of Falcon. The Laboratory received a 1997 R&D 100 Award for Falcon.

Falcon provides oil and gas companies with an accurate, fast, and cost-effective tool for finding new, large oil reserves; developing existing, nonproducing fields; and managing production fields. Falcon can model the flow of oil, gas, and water in three dimensions. To perform a simulation, Falcon uses a mathematical

model that solves the equations that govern fluid flow in permeable materials such as the reservoir rock. A geological description that includes data such as depth, thickness, permeability, and porosity of the reservoir rock is entered into the simulation. In addition, Falcon also considers the flow of chemical materials that were originally in the reservoir as well as additives that were injected into it.

In a recent study, Amoco concluded that Falcon will redefine reservoir modeling by enabling engineers to use these simulations in two, new significant ways: (1) entire fields can be simulated, and (2) probabilistic rather than deterministic predictions are now possible. Probabilistic predictions are based on the multiple, accurate geologic interpretations provided by Falcon, whereas deterministic predictions are based on single, inaccurate interpretations.

The Falcon showcase study is the largest reservoir study completed by Amoco. Falcon simulated a multibillion-dollar oil field's production activity over a 25 year period for 1,039 wells. The simulation consisted of 2.3 million cells—approximately 10 times the scale of previous simulations. Falcon simulated the entire field with 9 different geological areas, allowing interactions between the 9 depositional settings. With conventional simulations, each area would have been simulated separately, resulting in significantly reduced accuracy.

D. New Initiatives

Initiatives in this section are either new initiatives or developments of activities already in progress. They are provided for consideration by DOE, and inclusion in this plan does not imply Department approval of, or intent to implement, an initiative.

Because some Los Alamos initiatives span mission areas, the following descriptions are organized by the office in which the initiative resides. In particular, one initiative, the long-pulse spallation source (LPSS), spans two elements of the Laboratory mission: Stockpile Stewardship and Civilian National Missions.

Nuclear Weapons Technology Program

Accelerated Strategic Computing Initiative

Computers have played a fundamental role in the design and analysis of nuclear weapons since the Manhattan Project. Assuring the safety and reliability of weapons in an aging stockpile without nuclear testing will require us to develop an even more significant computing capability. The Accelerated Strategic Computing Initiative (ASCI) is a DOE initiative that will drive advanced three-dimensional (3-D) code development and aggressively exploit advances in computing technologies. Computing hardware initiatives planned for ASCI will involve partnerships between the national laboratories and U.S. computer companies.

Advances required for weapons simulations include 3-D codes for modeling the behavior of full weapon systems, algorithms for parallel computing, and a unified design and aboveground-testing capability for weapon-related experiments.

The 3-D safety and performance calculations for weapons demand significantly increased computing power, represented by

- scalable computing (for example, massively parallel processors) for a 100- to 1000-fold improvement in capability;
- clusters of commodity multiprocessors to provide cost-effective capacity;
- 100-fold improvement in archival storage technology (to be developed through collaboration with industry);
- high-speed, secure networks to move massive amounts of data; and
- software infrastructure for computing effectiveness.

Enhanced Surveillance

Enhanced surveillance is an element of science-based stockpile stewardship. The goal of enhanced surveillance is to anticipate stockpile defects in time to enable corrective-action production capability before any significant reductions in safety or reliability occur. The incremental steps to achieving this goal follow.

1. Quantify deviations from the design parameters that were controlled in the underground test program and manufacturing process.
2. Understand the science behind why changes are occurring and what parameters affect the changes.
3. Develop numerical analysis tools that can predict component and system changes and assess changes in performance.
4. Establish thresholds in parameters that can be measured in a small destructive sample nondestructively, above which performance will be acceptable.

The five key elements of the enhanced surveillance program are

- hydrotesting for surveillance;
- flight-test research and development (R&D);
- materials aging R&D;
- nondestructive evaluation; and
- modeling.

Atlas

When complete in FY99, Atlas, a major pulsed-power facility, will provide the means for conducting materials and hydrodynamic experiments under conditions in which large volumes of near-solid-density materials are at least partially ionized. For hydrodynamic experiments, Atlas will be capable of achieving a pressure exceeding 30 Mbar in a volume of several cubic centimeters. With the development of a suitable opening switch, it will be capable of producing more than 30 MJ of soft x-rays.

The capacitor bank design consists of a 36-MJ array of 240-kV Marx modules. The system is designed to deliver a peak current of 45 to 50 MA with a 4- to 5- μ s risetime. The Marx modules are designed to be reconfigured to a 480-kV configuration for opening-switch development. The capacitor bank is resistively damped to limit fault currents and capacitor voltage reversal. An experimental program for testing and certifying prototype components is under way.

See Table 24 for projected funding for Nuclear Weapons Technology (NWT) new initiatives.

Los Alamos Neutron Science Center

Dynamic Experiment Laboratory

Los Alamos is exploring the possibility of building a dedicated facility for dynamic experiments at the Los Alamos Neutron Science Center (LANSCE). The dynamic experiment laboratory, which will host contained dynamic experiments, will demonstrate the viability and performance of advanced radiographic techniques for science-based stockpile stewardship tasks. Proton and neutron beams will

Table 24. Projected Funding for NWT New Initiatives (\$M).¹

Funding Area	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Accelerated Strategic Computing Initiative (DP101) ¹	17.3	31.0	48.1	46.1	49.1	49.1	49.1	49.1
Atlas (DP102)	1.5	0.7	0.0	1.1	7.0	7.0	7.0	7.0
Enhanced Surveillance (DP0401017)	3.9	9.3	11.0	5.0	19.0	19.0	19.0	19.0
Total	22.7	41.0	59.1	52.2	75.1	75.1	75.1	75.1

¹This table does not include any funding for the Blue Mountain machine procurement. In addition, the funding shown for FY98 and FY99 is at the target level.

function as unique noninvasive diagnostic probes to characterize dynamic systems of importance to the nuclear weapons program. Measurement of basic parameters such as temperature, density, and velocity—not only on the surface but within the bulk of a dynamically evolving device—will contribute to a fundamental understanding of the physics underlying the performance of conventional explosives and nuclear weapon primaries.

A dynamic experiment laboratory could be quickly and cost effectively constructed to provide near-term benefits to the weapons program, complementing existing facilities at LANSCE, including the Manuel Lujan Jr. Neutron Scattering Center (the Lujan Center) and the Weapons Neutron Research Facility. The laboratory would use the existing LANSCE infrastructure, including the 800-MeV proton linear accelerator, the proton storage ring (which will provide the short pulses needed for sequenced imaging of dynamic events), and operations personnel.

The dynamic experiment laboratory would directly contribute to an understanding of key stockpile stewardship and management issues important to DOE and also to the ultimate customer, the Department of Defense (DoD). The ability to benchmark computational simulations using experimental data from facilities such as LANSCE will be essential to the success of the Stockpile Stewardship and Management Program. The fundamental scientific research performed at the dynamic experiment laboratory will help to address key outstanding issues, some of which have remained intractable for over 50 years because of the lack of adequate experimental and computational capabilities.

See Table 25 for projected funding for the dynamic experiment laboratory.

Long-Pulse Spallation Source

Los Alamos proposes to install the LPSS, a new 1-MW spallation neutron production target, in an existing building at the end of LANSCE's 800-MeV accelerator. The LPSS will substantially enhance the Laboratory's neutron radiographic capabilities for stockpile surveillance. With the large neutron flux available from LPSS, both high-energy and low-energy (cold-neutron) tomography will be possible. The LPSS will also provide the U.S.

neutron science community with critically needed capabilities for neutron scattering using cold neutrons, a field of research that underpins many of today's advanced materials technologies in areas such as polymers and ceramics. The LPSS will provide a cold-neutron capability that is as much as four times that of the world's best facility—the research reactor at the Institut Laue-Langevin in France. Cold-neutron scattering capabilities will directly benefit stockpile stewardship in areas such as the study of safety-related defects in high explosives and measurements of corrosion, adhesion, and other near-surface structures. Early experience with the LPSS 1-MW spallation target will also contribute significantly to the design of the National Spallation Neutron Source. In addition, LPSS will be able to generate beams of ultracold neutrons that are between one and two orders of magnitude greater than those currently available worldwide.

The LPSS will be complementary to the existing LANSCE short-pulse spallation source (SPSS). Together, they will produce neutrons over a uniquely large range of energies and provide the U.S. neutron science community with capabilities that rival or surpass the world's leading facilities. Like the SPSS, the LPSS will be operated as a national user facility and will be open, on a peer-reviewed basis, to scientists from federal laboratories, universities, and industry.

The proposed LPSS facility has been reviewed and endorsed by international accelerator experts, a panel sponsored by the Basic Energy Sciences Advisory Committee, and an external team of experts. The LPSS is the Laboratory's highest-priority new research facility over the next 5 years. DOE's Office of Energy Research (OER) has recognized its mission need for an LPSS to support U.S. neutron science. DOE's Office of Defense Programs (DP) also views this proposed facility as highly valuable to the Stockpile Stewardship Program. Funding for the facility would be provided by both OER and DP. Los Alamos has proposed that the LPSS project begin after completion of the accelerator portion of the SPSS enhancement project is completed.

See Table 26 for projected funding for the LPSS through FY03.

Table 25. Projected Funding for Dynamic Experiment Laboratory (\$M) (TEC).

Program Office	Funding Area	Actual		Projected		BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
		Cost FY96	Cost FY97	Cost FY98	Cost FY99						
NWT/DP	LANSCE Dynamic Experiment Laboratory	0.0	0.0	0.0	4.0	21.0	5.0	10.0	10.0		

Table 26. Projected Funding for the Long-Pulse Spallation Source (\$M) (TEC).¹

Program Office	Funding Area	Actual		Projected		BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
		Cost FY96	Cost FY97	Cost FY98	Cost FY99						
NWT/DP	LANSCE Long-Pulse Spallation Source	0.0	0.0	0.0	0.0	0.0	10.6	20.0	36.0		
STB/OER	LANSCE Long-Pulse Spallation Source	0.0	0.0	0.0	0.0	0.0	4.0	5.0	15.0		
Total		0.0	0.0	0.0	0.0	0.0	14.6	25.0	51.0		

¹The Construction Table in the Appendix provides only the DP funding portion of the project. The OER funding portion of the project is recent and has not been incorporated in the Construction Table.

Isotope Production Facility

The high energy and high current of the linear accelerator proton beam at LANSCE make it well suited for producing rare and exotic isotopes that are difficult to produce by more conventional means. The existing Los Alamos isotope production facility, located at the end of the 800-MeV accelerator, has produced unique isotopes that cannot be obtained anywhere else in the world.

However, with the redirection of the mission of the LANSCE accelerator complex from nuclear physics to neutron scattering, the current isotope facility is no longer compatible with long-term LANSCE operational plans. Obstacles to continued operation of the current facility include availability of the high-power beam and conflicts with planned LANSCE upgrades. Consequently, the capability to irradiate targets at LANSCE for isotope production will be lost unless action is taken. Since LANSCE is the only source of irradiated targets, inaction may result in the end of the Los Alamos Medical Radioisotope Program.

To develop a long-term capability for producing critical isotopes in a mode compatible with LANSCE's neutron scattering mission, the Laboratory proposes to construct a new isotope production facility. The facility will be driven by a 100-MeV proton beam, a portion of the main LANSCE beam which will be diverted before it enters the final stage of the accelerator and directed to a new target area dedicated to isotope production. The proposed project will include installation of a beam-switching device at the point where the beam is diverted, construction of a short beam line, and construction of a target-handling facility with a beam stop. The project will be funded by the DOE Office of Nuclear Energy (NE). An affirmative critical decision one was issued by DOE for this facility in January 1997, and the Laboratory is currently preparing a conceptual design report. The proposed schedule calls for a critical decision two and the start of detailed design activities in September 1997; a critical decision three and the start of construction in July 1998; and a critical decision four and the commencement of operations in February 2000.

See Table 27 for projected funding for the isotope production facility.

High-Power Target Test Facility

The development of molten heavy-metal target technology is critical to the development of high-power (greater than 1 MW) spallation neutron sources. Liquid-metal targets are called for in

the National Spallation Neutron Source being designed by Oak Ridge National Laboratory, the European Spallation Source, and the SINQ project at the Paul Scherrer Institute. The accelerator-driven transmutation technology program at Los Alamos is proposing accelerator-driven transmutation of waste systems that depend heavily on molten lead or lead bismuth eutectic (LBE) fluids for neutron production as well as for cooling. In addition, molten targets have been suggested as advanced concepts for the Accelerator Production of Tritium project.

As a first step in the development of this technology, the Institute for Physics and Power Engineering (IPPE) at Obninsk in Russia is building an LBE spallation target. The IPPE research group has considerable experience in LBE technology, based on their work in the design and construction of LBE-cooled submarine reactors. IPPE target development is funded by the U.S., Sweden, and the European community through the International Science and Technology Center. When completed in 3 years, the target will be tested at LANSCE at a power level of 1 MW. The primary purpose of this test will be to demonstrate the integrated operation of the target at high power levels. Although many aspects of the target can and will be tested before the target is placed in the beam, such integrated operation is crucial to developing this technology.

In order to support the Russian target test, Los Alamos proposes to construct a high-power target test facility at LANSCE. This facility will be constructed in an existing building at the end of the accelerator and will be designed to be compatible with the proposed LPSS facility. The high-power target test facility will include the necessary proton-beam transport system, shielding monolith, and test instrumentation. Capabilities will include testing for radiation damage, material compatibility, and corrosion. In addition to testing the Russian target, the facility will provide long-term capabilities for testing high-power targets such as those planned for both the National Spallation Neutron Source at Oak Ridge and the LPSS at LANSCE. The LANSCE linear accelerator currently produces the highest-power proton beam in the world. Access to this beam will become of paramount importance as high-power spallation targets are increasingly used in future projects.

See Table 28 for projected funding for the high-power target test facility.

Table 27. Projected Funding for LANSCE Isotope Production Facility (\$M) (TEC).

Program Office	Funding Area	Actual Cost	Projected Cost	BA	BA	BA	BA	BA	BA
		FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
ET/DOE-NE	LANSCE Isotope Production Facility	0.0	0.0	6.5	2.2	1.3	0.0	0.0	0.0

Table 28. Projected Funding for the High-Power Target Test Facility (\$M) (TEC).

Program Office	Funding Area	Actual Cost	Projected Cost	BA	BA	BA	BA	BA	BA
		FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
EM/EM	LANSCE High-Power Target Test Facility	0.0	0.0	0.0	5.0	12.0	8.0	5.0	5.0

Nonproliferation and International Security Program

Reducing NBC Proliferation and Terrorism

More than 20 countries are suspected of some form of nuclear, biological, or chemical (NBC) proliferation. In addition, subnational, organized crime and other terrorist groups that could gain access to NBC materials are of growing concern. Events such as the terrorist use of chemical weapons in the Tokyo subway heighten the gravity and seriousness of the situation and highlight the vulnerability of U.S. civilians and interests. Adding to this chemical and biological warfare (CBW) threat is the danger of low-technology nuclear devices and radioactive material dispersal weapons. The proliferation of weapons of mass destruction is the most urgent and direct threat to national security. This threat is real, and the political, societal, economic, and psychological impacts are potentially devastating. The consequences of failure in countering the threat could be catastrophic.

Weapons of mass destruction are easily developed from smuggled nuclear materials, from biological/chemical agents (as demonstrated by the Aum Shinrikyo cult's attack), and by using increasingly available biotechnology. The genetically engineered agents that result may be capable of thwarting current protective countermeasures. Therefore, U.S. government activities must focus on reducing vulnerabilities across the NBC threat spectrum. This goal can be accomplished by preventing acquisition, reducing existing capabilities, deterring their use, and developing effective response plans and capabilities to mitigate the impact of their use.

The Nonproliferation and International Security (NIS) Program is responsible for accomplishing the following Laboratory tactical goal—Reducing NBC Proliferation and Terrorism Threats—in partnership with the DoD Programs Office. During FY96, Los Alamos helped establish a national agenda for reducing the threat of NBC weapon proliferation and terrorism that encompassed broadening DOE's role to include the CBW threat areas. This effort positioned DOE and Los Alamos as major resources for the DoD, the Intelligence Community, and other federal agencies. NIS is strengthening the Laboratory's science and technology base and applying it to reducing the NBC proliferation and terrorism threat. We have had the international leadership role in nuclear safeguards for more than 30 years. We now have a major role in the new DOE CBW program.

The U.S. needs timely warning (intelligence) and advanced detection technology (monitoring). Adequate intelligence and monitoring require the application of leading-edge science and technology across a broad spectrum. At Los Alamos, our multidisciplinary staff is active in the international scientific arena. NIS is leading a multidivisional Laboratory effort, using both programmatic and Laboratory-Directed Research and Development (LDRD) Program funding, to develop remote-sensing science into a Laboratory core competency. Capabilities in this field are at the core of the nation's ability to detect the proliferation of NBC weapons. However, many of these capabilities truly provide dual benefits—for example, they have both environmental science and nonproliferation applications.

When combined with other sources of information such as export controls, this knowledge base can identify important overseas trends. We are a center for expert analysis of potential nuclear

dual-use technology exports. For example, we maintain for the DOE the Proliferation Information Network System, which links DOE and the national laboratories so that expert analysis of nuclear-related exports is available in a timely fashion. The Nuclear Suppliers' Group Information Sharing System—also centered at Los Alamos—currently provides export-control information to more than 20 countries.

To address the national CBW threat, DOE, with support from Los Alamos and the other national-security laboratories, developed a program to integrate the physical and life sciences with system-engineering and arms-control regimes to complement ongoing programs and to initiate research in new areas. This program, initiated in FY97, builds upon the over \$1 billion worth of existing complementary programs currently funded within the DOE laboratories. After a survey of the intelligence and defense communities to determine areas in which DOE can most effectively contribute to countering the CBW threat, four DOE mission areas were defined:

- intelligence/assessment;
- policy and treaty support;
- incident response; and
- support to military operations.

These four mission areas support the national priorities of preventing, detecting, reversing, and responding to the threat of weapons of mass destruction.

The DOE CBW program identified seven thrust areas—integrated through a system architecture to support the four mission areas—by which the DOE can provide significant contributions to reducing the CBW threat to national security. These seven thrusts are the following:

- biological informational resource on priority organisms;
- point sensors (local and remote);
- standoff detection;
- threat assessment;
- chemical and biological agent transport, efficacy, and effects;
- decontamination; and
- training, planning, and facilities.

Nuclear Smuggling

The control of nuclear materials and technologies has been a cornerstone of the international nuclear nonproliferation regime. Advanced nations determined to acquire nuclear weapons can produce the materials indigenously in dedicated production facilities (the route to proliferation taken by all known and suspected nuclear states), or they can divert nuclear materials from civilian nuclear programs. Less advanced states and subnational groups are likely to be limited to a third route: acquisition of nuclear materials by theft. This more unconventional proliferation path has become a focus of increased attention following the breakup of the former Soviet Union, the attendant breakdown of that federation's nuclear materials protection, and actual cases of nuclear material trafficking in Europe. Efforts to deal with this long-recognized, but newly increased, threat to nonproliferation have been termed "counter nuclear smuggling" or "counter nuclear trafficking." However, it is important to view preventing or deterring unconventional proliferation in the general context of the overall nonproliferation regime and in the particular context of global nuclear materials control initiatives.

The DOE Office of Nonproliferation and National Security (DOE-NN), with significant support from Los Alamos, has developed an integrated nuclear smuggling program as the DOE effort to counter one pathway—the theft and trafficking of special nuclear materials—to nuclear proliferation or terrorism. While most elements of the program (for example, material protection, control, and accounting [MPC&A] and the Nuclear Emergency Search Team [NEST]) represent well-established parts of other DOE missions, there are activities specifically tailored to countering nuclear smuggling. Experience over the past 2 years has revealed some gaps in the overall program and in support to other agencies. DOE-NN has developed a new initiative that, beginning in FY98, will appreciably increase funding specifically tailored to nuclear smuggling while simultaneously increasing funding for the DOE/DP NEST program. This initiative aims to close these gaps and to address DOE and executive-branch policies in a more comprehensive and corporate manner.

NIS will play a leadership role in the DOE-NN nuclear smuggling program. To this end, Laboratory LDRD and Program Development funds will be expended in FY97 to

- plan and host a critical pathways workshop;
- develop a nuclear smuggling program plan;
- perform a customer survey/needs analysis for deployable instrumentation;
- develop innovative radiation sensors;
- develop active interrogation methods;
- enhance nuclear forensics capabilities;
- design a deployable analysis system;
- develop absorption corrections for deployable radiation detectors; and
- develop processors for deployable radiation detectors.

See Table 29 for projected funding for the NIS new initiatives.

Energy Research

New Neutrino Initiative

Los Alamos is proposing the construction of a new neutrino experiment, the Booster Neutrino Experiment (BOONE), at Fermi National Accelerator Laboratory (Fermilab). BOONE would verify the antimuon neutrino to antielectron neutrino oscillation signal demonstrated by the Liquid Scintillation Neutrino Detector (LSND) experiment. In addition to observing neutrino oscillations, BOONE would offer the first sensitive test for charge conjugation/parity inversion (CP) violation in the lepton sector (by comparing the antimuon neutrino to antielectron neutrino oscillation rate with the muon neutrino to electron neutrino oscillation rate). The experiment would also make precision measurements of Δm^2 , the difference of neutrino masses squared, and $\sin^2(2\theta)$, the neutrino-mixing angle. Furthermore, motivated by

the atmospheric neutrino problem, BOONE would search for muon neutrino disappearance and be able to observe a signal from muon neutrino to tau neutrino oscillations for values of Δm^2 greater than 0.05 eV^2 .

The BOONE detector would be based on the LSND and would consist of two double-wall cylindrical tanks approximately 12 meters in diameter and 12 meters high. Each tank would be covered on the inside by 3,500 8-inch photomultiplier tubes (15% coverage) and filled with 1,000 tons of pure mineral oil. The outer volume of each tank would serve as a veto shield for identifying particles both entering and leaving the detector. The two tanks would be situated approximately 500 meters and 1,000 meters, respectively, from a neutrino beam line fed by the 8-GeV proton booster at Fermilab. The neutrino beam line would consist of a target followed by a horn-focusing system and a 20-meter pion decay volume. One advantage of using the Fermilab booster is that it is capable of running at 15 hertz (5×10^{12} protons per pulse and 15 pulses per second), whereas the Fermilab main injector requires only half that number of pulses. Therefore, BOONE would be able to take data even with the collider running.

Assuming booster operation at 5 hertz to the neutrino beam line and a total running time of 3×10^7 seconds (one calendar year), we estimate that BOONE would be able to detect approximately 1,000 neutrino oscillation events [depending on the precise values of Δm^2 and $\sin^2(2\theta)$]. With such a large event sample, we would be able to (1) prove that neutrino oscillations are occurring, (2) measure Δm^2 and $\sin^2(2\theta)$, and (3) search for CP violation in the lepton sector. The total cost for the two detectors is estimated to be approximately \$14 million, and the neutrino beam line would cost another approximate \$10 million. The projected budget for the initiative will be included in a future institutional plan.

New Neutron Crystallography Instrument Initiative

Neutron diffraction provides a unique approach to the study of biological systems in that it enables us to determine the location of hydrogen atoms—atoms that are largely unobservable in conventional macromolecular x-ray studies. Hydrogen atoms are critical to structural stability and enzymatic function and play a dominant role in solvent configuration. Besides providing strong neutron scattering of hydrogen, neutron diffraction provides a means of distinguishing hydrogen from deuterium, allowing for specific labeling techniques that are powerful tools in the study and detailed characterization of proteins.

Similar data are currently difficult to acquire, available at only a few facilities such as the Institut Laue-Langevin in France and Brookhaven National Laboratory in New York State. Furthermore, the low flux of existing beams requires large crystals and long data collection times, rendering significant experimentation impractical.

Table 29. Projected Funding for NIS New Initiatives (\$M).

Funding Area	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Chemical and Biological Warfare Program	5.2	5.8	6.1	6.4	6.7	6.7	6.7
Nuclear Smuggling	0.0	3.0	3.3	3.5	3.5	3.5	3.5
Total	5.2	8.8	9.4	9.9	10.2	10.2	10.2

Los Alamos plans to develop a protein crystallography station at LANSCE for the analysis of proteins and membranes using the super Laue technique. The station will be located at the Lujan Center. The project will commence in FY97; completion is expected in FY99. To date, the plan to develop such a facility has undergone peer review with two committees, each of which have validated the user need for such an instrument and the technical feasibility.

Calculations show that the combination of a spallation neutron source coupled with planned improvements in the high-intensity, water-moderator concepts and focusing optics will improve data collection capability by at least a factor of ten. Experiments can be conducted with faster data collection and with less material, rendering this technique very attractive to a broad scientific constituency.

Los Alamos will operate the crystallography station as a user facility for the national and international structural biology community. Laboratory and office facilities will be established for visiting external users. A technical infrastructure and peer-review-based systems will be established to facilitate and oversee operation of the facility.

Energy Technology Programs

Coal Energy and Environmental Partnership

The Partnership for Coal Energy and Environmental Technology Deployment includes Los Alamos, the DOE Office of Fossil Energy's (DOE/FE's) Coal and Power Systems programs, the Federal Technology Center, and industry. The partnership's mission is to provide a viable industry/government instrument to effect the transition of clean coal and environmental technology to full economic viability. The Laboratory's participation in this partnership is expected to bring in \$1 million annually, with a potential increase to \$3 million.

Computational Fluid Dynamics Center

The Computational Fluid Dynamics Center, founded in FY96 with Los Alamos as the lead laboratory, seeks to integrate and develop the resources of industry, government, academia, and professional societies to enable reliable analysis in multiphase computational fluid dynamics. Current programs are in place with the petroleum and chemical industries, and the center has just completed a technology road map for the DOE. The Los Alamos share of this program reaches \$500,000 per year, with the potential to double this amount in the next few years.

Alkali-Silica Reactivity

Researchers at Los Alamos have developed a simple, environmentally friendly test to detect concrete flaws. The test identifies one of the most common causes of concrete degradation, the so-called alkali-silica reaction, even before cracks and other signs of failure become visible. The alkali-silica reaction detection technique gives better results than currently used tests and does not involve hazardous materials. We have submitted a patent application for the new detection technique.

The alkali-silica reaction work, funded by Los Alamos's LDRD Program, is the first step in a more comprehensive initiative to (1) advance the understanding of concrete geochemistry, (2) improve highway pavement performance, and (3) extend pavement lifetimes. Future funding is expected from the Department of Transportation and state transportation agencies at approximately \$500,000 per year.

Mining Communications

We are developing a joint program with the National Mining Association, DOE/FE, and the Department of Labor's National Institute for Occupational Safety and Health to apply Los Alamos expertise in high-temperature superconducting quantum interface device (SQUID) technology to needs in mining operations and safety. The application uses the Laboratory's expertise in thin films to develop low-noise, compact receivers. The effort is part of an LDRD/Program Development project. Funding is expected to reach \$1.5 million over 2 years.

INFRASTRUCTURE AND SUPPORT

III. INFRASTRUCTURE AND SUPPORT

This section describes the plans and initiatives that lead the Laboratory to its vision of a customer-focused, unified laboratory. The four DOE critical success factors of Communication and Trust; Human Resources; Environment, Safety, and Health; and Management Practices underlie every facet of Laboratory operations. All organizations and individuals are responsible and accountable for their stewardship in these areas. In addition, the critical success factors of Human Resources; Environment, Safety, and Health; and Management Practices are represented by 5-year plans coordinated by the respective Laboratory divisions, and those divisions are operated on quality management principles. Responsibility for the fourth factor, Communication and Trust, is owned at the institutional level by the Laboratory Director and Deputy Director, who are assisted by the Public Affairs Office, which has responsibility for employee communications; by the Community Outreach and Information Office; and by managers of divisions, program offices, and groups, who have their own areas of responsibility. Details of how we address Communication and Trust, Human Resources, and Management Practices are available in the Los Alamos Application for the 1997 DOE Quality Awards (see Appendix D for Web site address).

The operations goals of the Tactical Plan and their related success indicators represent immediate tactics for addressing the DOE critical success factors. Table 30 shows the correlation of the operations goals in the Laboratory's Tactical Plan with the four DOE critical success factors.

In addition, the Laboratory uses the performance measures established in Appendix F of the DOE/UC contract to measure progress in the DOE critical success factors. The 10 functional areas of operations for 1997, for which specific criteria and performance measures are established, are

- Laboratory Management,
- Environment Restoration and Waste Management,
- Environment, Safety, and Health,
- Facilities Management,
- Financial Management,
- Human Resources,
- Information Management,
- Procurement,
- Property Management, and
- Safeguards and Security.

These functional areas correspond well with the critical success factors, as illustrated in Table 31.

Table 30. DOE Critical Success Factors and Related Goals in the FY96–98 Los Alamos Tactical Plan.

DOE Critical Success Areas	Related Goals in the Tactical Plan
Communication and Trust	Corporate Citizenship
Human Resources	Embrace Diversity, Corporate Citizenship
Environment, Safety, and Health	Safety First!
Management Practices	Productivity and Strategic Business Development, Corporate Citizenship, Safety First!

Table 31. DOE Critical Success Factors and 1996 Functional Areas Cited in Appendix F of the DOE/UC Contract.

Functional Area	DOE CRITICAL SUCCESS FACTORS			
	Communication and Trust	Human Resources	Environment, Safety, and Health	Management Practices
Laboratory Management	X			X
Environment Restoration and Waste Management	X		X	
Environment, Safety, and Health	X		X	
Facilities Management			X	X
Financial Management				X
Human Resources	X	X		
Information Management	X			X
Procurement				X
Property Management				X
Safeguards and Security			X	X

A. Safety First!

Los Alamos National Laboratory's policy of operation is that while we accomplish our mission, we will perform work safely. To make this policy a workplace reality, we have made Safety First! our number one tactical goal, with the Laboratory Director as champion. We are enhancing safety through a Laboratory-wide program of Integrated Safety Management (ISM). We are also providing environment, safety, and health (ES&H) support for our scientific and technological programs through a coordinated central support system with distributed elements. In Part 1 of this section, we discuss integrated safety management, and in Part 2, we discuss ES&H Laboratory-wide support.

1. Integrated Safety Management

We are incorporating safety into all Laboratory activities through ISM, a process that integrates safety into every work activity at the Laboratory. The integration of safety into work will allow greater productivity in our mission-related work and an injury-free workplace.

Injury free does not mean risk free. ISM is not a method of removing all risk from the workplace. Through the application of resources, risk can be reduced, but at some point the law of diminishing returns takes over. With a large application of resources, the risk can be made to approach (but it will never reach) zero. ISM uses standards-based safety performance management, employee behavior, engineered controls, and other work-tailored hazard controls to bring the workplace risk to an acceptable and reasonable level. This approach will lead us toward a zero-injury workplace.

Increased productivity comes from management's ability to effectively allocate resources to address safety, programmatic, and operational considerations. This ISM guiding principle supports the creative environment that gives rise to the scientific excellence at Los Alamos. The framework for the management discretion given by this principle comes from a standards-based safety management system, and integration of these standards into the work comes through employee involvement and self-assessment.

The basis of ISM is safety standards, and at Los Alamos these are being derived, based on our work and associated hazards, from the hierarchy of federal, state, and local laws and regulations; consensus and industrial standards; and DOE technical directives. From this suite of information, the Laboratory, in partnership with DOE and other stakeholders, is using the necessary and sufficient process to select a set of "work smart" standards that will become the contractual basis for authorizing work at the Laboratory. Using these "work smart" standards, teams of Laboratory employees are writing Laboratory performance requirements (LPRs), implementing requirements (LIRs), and implementing guidance (LIG) that translate the standards into Laboratory safety norms. These norms, combined with the usual project management constraints on cost, scope, and schedule and integrated with workplace behavior and self-assessment, will create a zone of discretion in which work will be performed safely. Creation of these Laboratory safety norms is an ongoing process scheduled for completion at the end of 1998.

Figure 30 shows how the Laboratory norms define a region of operating discretion. Within this zone, organizations can perform work with the assurance that they are meeting the appropriate regulatory requirements; the review of many primary source doc-

uments will be unnecessary. Working outside of this zone can result in unacceptable consequences leading to possible discipline of workers and line managers. Within the framework of ISM, the bounds defining safe work practice are clear.

Figure 30. ISM uses clearly defined operating norms and organizational structure to define a zone of operating discretion in which we can do work safely.

Creation of safety norms is only one of many ongoing activities in support of ISM. Ongoing activities are presently focused on two areas: (1) achievement of over 50 milestones that constitute the ISM implementation plan and (2) engagement of the workforce. The milestones define the completion of significant activities that are intrinsic to the integration of safety and work. In addition to the selection of Laboratory standards, these milestones include facility work control, self-assessment, and safe work practices in performing research. These milestones are distributed over a 2-year period and are all to be completed by December 1998. The value of these activities comes from their use in the workplace, and in parallel with the milestone activities, numerous communication channels are being used to involve the workforce in creating and implementing the elements of ISM.

Work activities at Los Alamos range from standard industrial processes through nuclear materials fabrication to exotic research. ISM brings safe work practices to each of these activities. Although the institutional safety norms (Laboratory performance requirements) are the same for all activities, the hazard controls and formality of operations are tailored to fit the activity and organization performing the work. With tailoring, safe and productive work can be achieved across all of the diverse activities that are performed at Los Alamos.

ISM covers all work at Los Alamos, including work in nuclear and other moderate-hazard facilities. Formality of operations will be based on a Laboratory-developed, DOE-approved operations formality standard. Application of this standard in the workplace will flow from performance and implementation requirements. All facilities will have a facility safety plan that is part of the authorization basis, and specific nuclear and other moderate-hazard facilities will have authorization agreements.

ISM is altering the way in which safety is practiced at Los Alamos. Appropriate behavior of every member of the Laboratory workforce is the key to reduction of injuries. The first guiding principle of ISM is that line management is responsible for safety,

and the second is that the roles of all employees are clear. These principles are simple, but their application in the workplace can be confused by enduring past practices. ISM defines a line-management safety chain that extends from the worker to the Laboratory Director, and the responsibility of each link in the chain is clear. Recent changes in mission and business policies have brought increasing numbers of subcontractors to the University of California into the Los Alamos workforce, and the responsibility for contractor safety is defined by new Laboratory standards. The ISM guiding principles are bringing clarity to workplace relationships, leading to increased employee awareness of safety responsibility.

Implementation of ISM requires a change in the safety culture of the Laboratory. Change is being introduced through continuous, varied communication with the workforce. The Program Manager for Integrated Safety Management has talked about ISM with all Laboratory managers—from group leaders through the Director. The focus of Los Alamos Safety Days 1997 was the use of the five core ISM functions by every worker at Los Alamos in performing all work. During Safety Days, all group leader-level managers used a video based on the November 1996 explosion in the Center for Materials Science Building and a specially prepared support package to talk about the use of the five functions in safely performing the organizations' work. Safety Days was also supported with banners, bumper stickers, and pins. Continued support for implementation of ISM will include further talks on safety by managers to workers and specific training in behavioral safety processes. Implementation of ISM is a process that will extend over a period of years, and the Laboratory is committed to applying the resources necessary for full implementation.

When ISM is implemented, each worker will be fully conscious of work hazards and have confidence in their mitigation. The Laboratory is instituting ISM as the framework that supports safe behaviors, provides clear direction, and provides the tools and knowledge that allow us to do work safely.

2. ES&H Laboratory-Wide Support

The Environment, Safety, and Health (ESH) Division provides the Laboratory with leadership and guidance in worker, public, and environmental protection to ensure that operations are conducted safely and efficiently. To achieve these objectives, groups in the division develop and apply science and technology in concert with laboratory programmatic organizations or as an independent activity to help solve Laboratory or national ES&H problems. Primary responsibility and accountability for ES&H resides with Laboratory line managers, and the Laboratory Director is personally committed to applying the top-down ISM system.

ESH Division's programs complement the Laboratory's science and technology activities through organizational partnering, evaluation and interpretation of regulatory compliance issues, and research and development in ES&H regulations and requirements. The division's organizational structure enables efficient and professional partnering with other organizations. ES&H generalists and specialists operate out of a central core, partner with Laboratory organizations, and become integral to effective and safe operations. The task of the ES&H generalists and specialists is to aid in informed decision-making that helps managers meet program

goals. Over 200 ESH Division personnel have been deployed to line and program operations.

UC Performance-Based Management System

UC and the Laboratory are committed to achieving managerial excellence by meeting world-class operating standards in a way that will facilitate scientific excellence and meet or exceed accountability expectations of DOE and the public. The UC performance-based management system for ES&H helps ensure that Laboratory managers are fully engaged in ES&H processes and have information that leads to proactive management and improvement in related programs.

The contract under which UC operates the Laboratory specifies performance measures that both UC and DOE use in Laboratory oversight. These measures relate to four performance objectives: (1) protection and prevention, (2) compliance, (3) integration and accountability, and (4) risk management and resource allocation. The performance objectives constitute standards against which DOE assesses UC's overall compliance with contract requirements.

An ES&H functional manager implements contract performance measures at the Laboratory, including quarterly and yearly assessments. The Laboratory's ES&H functional manager works with representatives from DOE and UC and with corresponding functional managers at Lawrence Livermore and Lawrence Berkeley national laboratories to revise performance measures and benchmark and improve performance. The ES&H functional managers from the three UC-managed laboratories will continue to work directly with DOE staff at the Albuquerque and Los Alamos offices, as well as with staff at the Oakland Operations Office, to develop a common understanding of performance expectations and to improve the processes by which implementation is evaluated and site-specific expectations are developed. Focus areas for improvement include involving line and facility managers in developing performance measures and in assessing performance.

The Operations Working Group, a group appointed by the Laboratory Leadership Council that comprises division and program directors, will examine progress on ES&H performance measures and take action to improve performance. The Operations Working Group will also evaluate the effectiveness of corrective actions in improving Laboratory performance.

Industrial Hygiene

The Laboratory's Industrial Hygiene and Safety Group works to promote successful and safe operation by partnering with operating divisions. The group also provides support by maintaining institutional health and safety programs using highly trained professional staff. The staff works with operating divisions to establish policies, programs, and procedures that help assure uniformity and consistency of health and safety program efforts.

The group provides support to operating divisions in a variety of areas, including the following:

- Electrical safety—providing institutional guidance in electrical safety program efforts and serving in the capacity of the electrical authority having jurisdiction.
- Materials handling—providing guidance in the use of forklifts, cranes, hoists, rigging, and other related equipment.

- Laser safety—maintaining a program to evaluate and control the use of lasers in the workplace and ensuring that persons using the equipment understand hazards and precautions.
- Hazard analysis and assessment—assisting employees and supervisors in basic concepts of hazard recognition, evaluation, and control.
- Automated Chemical Inventory System (ACIS)—helping maintain a Laboratory-wide computer system for inventorying chemicals. The system provides chemical data for chemical exchange, air quality permits, Superfund Amendment Reauthorization Act reporting, and other ad hoc requests.
- Material safety data sheets (MSDSs)—integrating over 23,000 MSDSs from the Laboratory's World Wide Web server with a program to label the hazard levels of chemicals. Other integration is planned with the chemical inventory in the ACIS, the industrial hygiene safety hazard analysis, and occupational medicine.
- Toxicology support—helping Laboratory staff to write MSDSs and identify chemical hazards.
- Industrial hygiene and safety databases—developing and maintaining databases with access via the Laboratory network.
- Industrial hygiene programs—offering a variety of programs that provide for chemical, physical, and biological hazards sampling and monitoring of carcinogens, confined spaces, nonionizing radiation, and health hazards.
- High-efficiency particulate air (HEPA) filter testing—performing in-place testing of HEPA filters operated at the Laboratory.
- Respiratory protection—performing respirator training, fit testing, equipment procurement, equipment maintenance and quality-control testing, and inventory control.
- Asbestos management—inventorying and rating the hazards of asbestos-containing building materials, identifying appropriate corrective actions, establishing funds for corrective actions, and overseeing contractor activities.
- Facility design and modification support—interacting with facility design organizations, establishing design criteria, developing and evaluating engineering controls for toxic materials, and participating in facility design review boards.

The specific goals of the Industrial Hygiene and Safety Group include

- promoting successful and safe operations through partnering efforts with operating divisions;
- improving loss experience through continued reduction in workplace injuries and illnesses;
- continuing improvement in effective implementation of institutional safety and health programs;
- continuing reduction of Laboratory subcontractor loss experience; and
- working to develop and implement improved UC performance measures.

Industrial Hygiene Research and Development

The Laboratory's industrial hygiene and safety research and development supports the Laboratory, DOE, DOE contractors, other federal agencies, and private organizations in solving problems in respiratory protection, personal protective equipment, and air emissions monitoring and control.

Future areas of work include

- working with an industrial partner to develop an integrated protective ensemble for hazardous materials operations that use liquid air for breathing and cooling, a new design for a totally encapsulating suit, and a built-in communications system;
- evaluating bypass leakage paths in HEPA filter systems used in nuclear facilities;
- developing a multichemical dosimeter for hazardous materials operations;
- upgrading a computer model for predicting the performance of activated charcoal air-cleaning systems;
- miniaturizing photometers used for aerosol monitoring; and
- developing improved data acquisition systems for research projects.

Radiation Protection

The Laboratory's Radiation Protection Program is important to achievement of our programmatic goals. Laboratory operations support a vast range of activities, including

- nuclear weapons research, development, and testing;
- plutonium chemistry and metallurgy;
- fabrication of radioisotope thermoelectric generators;
- explosives testing;
- accelerator-based nuclear physics research and applied technologies;
- tritium research and applications;
- biomedical research using radiotracers and irradiators;
- materials science and testing involving radioactive materials and accelerators;
- nuclear criticality experimentation;
- mixed-fission-product analysis, including hot-cell work;
- decontamination and decommissioning of nuclear and radiological facilities;
- radioactive- and mixed-waste treatment and storage;
- use of x-ray devices, neutron generators, and sealed sources;
- transportation of radioactive material;
- radiochemistry;
- environmental restoration;
- research reactors;
- use of radioactive sources and x-ray machines and devices for examination, calibration, and testing; and
- other research, development, and activities involving ionizing radiation or radioactive materials.

Any one of these operations or activities would require a Nuclear Regulatory Commission (NRC) license if the Laboratory were not statutorily exempt because its work is done under contract to DOE. The exemption requires that DOE and the contractor demonstrate comparable controls to those that would be required by a NRC license. None of the work listed above could be done if the Laboratory's Radiation Protection Program did not help it meet DOE requirements designed to demonstrate this comparability.

The Laboratory's Radiation Protection Program provides relevant support to line managers and workers in organizations responsible for production, operations, and research activities. The Radiation Protection Office (RPO) in ESH Division administers the Radiation Protection Program. This office is headed by the

Radiation Protection Program manager, who is also designated as the Laboratory's radiological control manager. Three Laboratory groups—Health Physics Operations (ESH-1), Health Physics Measurements (ESH-4), and Policy and Program Analysis (ESH-12)—share the major responsibilities of the Radiation Protection Program. At Los Alamos, where facilities, buildings, and work areas are dispersed, we advocate an approach that provides sitewide consistency and dedicated radiological control support for individual facilities. *Consistency of radiological control is critical.*

Several Laboratory organizations contribute efforts to the Radiation Protection Program.

- The RPO provides program direction and oversight. This office serves as the single point of contact for DOE and Laboratory customers, integrates radiation protection into the facility management process, and provides recommendations for investment of institutional resources.
- ESH-1 provides radiological survey, control, and institutional oversight services to the Laboratory. The group works directly with operating groups at the various Laboratory facilities to ensure the presence of necessary radiation protection practices consistent with the goals, procedures, and requirements of the Radiation Protection Program. ESH-1 also serves as the primary focal point and liaison with other participants in the Laboratory's Radiation Protection Program.
- ESH-4 provides Laboratory-wide radiation measurements to support the Radiation Protection Program. The group also provides and processes personnel dosimeters. Other activities include maintenance and calibration of radiation monitoring instruments, laboratory analysis, and in vivo analysis. ESH-4 maintains a radiation measurement improvement program.
- ESH-12 develops and maintains Laboratory-wide radiation protection policies and programs to meet applicable standards. ESH-12 functions as the Laboratory's point of contact for radiation protection policy and procedures. ESH-12 also provides dose assessment, radiological engineering, occupational support for the ALARA (as low as reasonably achievable) dose reduction program, x-ray and source control, data management, and Nevada Test Site support services.

Other organizations also contribute to ES&H activities.

- The Emergency Management and Response Office (EM&R) oversees and implements the full range of activities necessary for mitigating, preparing for, responding to, and recovering from emergency incidents at the Laboratory. EM&R prepares emergency response plans commensurate with operations.
- The Occupational Medicine Group (ESH-2) provides examinations and evaluations of employees for the respiratory certification program. ESH-2 is also available to consult with female employees who have declared pregnancies and those who are planning pregnancies. The attending ESH-2 physician and staff from ESH-12 will cooperatively determine whether any temporary work restrictions are required to keep the dose to the embryo or fetus below regulated limits. Accommodation of any recommended work restrictions for the pregnant worker will be made in collaboration with her supervisor, ESH-2, and ESH-12 staff. ESH-2 also may provide special physical examinations or evaluations to employees who are involved in an incident or accident resulting in the actual or suspected exposure to radioactive materials or external radiation.
- The Facility Risk Management Group (ESH-3) provides line and facility managers with expertise in the management and documentation of ES&H hazards and risks. ESH-3 provides risk assessment services, develops programs for risk management, reviews facility modifications for ES&H compliance, and ensures that ES&H design factors are considered for new and modified facilities.
- The Nuclear Criticality Safety Group (ESH-6) provides technical support to those Laboratory groups working with significant quantities of fissile materials. The group assists in developing procedures for operations with such materials, reviewing operations, and training personnel.
- The Occurrence Reporting Group (ESH-7) is responsible for managing the internal reporting and documentation system required for various incidents, as defined in Program Requirements Document PRD120-01.0, Occurrence Investigation and Reporting Program. Under the authority of DOE Order 5000.3B, the group also manages the documentation, sending follow-up reports to the DOE Albuquerque Office and to DOE Headquarters for reportable occurrences at the Laboratory.
- The Hazardous Materials Response Group (ESH-10) provides safe and effective hazardous-materials emergency-response mitigation services to DOE, the Laboratory, and the surrounding community. ESH-10 provides ES&H expertise for the Accident Response Group and Nuclear Emergency Search Team; participates in Region 4 of the Radiological Assistance Program; conducts research and development for DOE's emergency-response programs; provides training and consultation services in emergency response, nonproliferation, and weapons safety; and supports nuclear safety, security, and dismantlement activities in the former Soviet Union.
- The ES&H Training Group (ESH-13) provides radiological worker training, radiological-control-technician training, general employee radiological training, and other required radiological safety training to Laboratory workers.
- The Air Quality Group (ESH-17), Water Quality and Hydrology Group (ESH-18), Hazardous and Solid Waste Group (ESH-19), and Environmental Assessments and Resource Evaluations Group (ESH-20) provide an ongoing program of environmental measurements and activities to help ensure that Laboratory operations do not adversely affect the public health and environment and that Laboratory conforms to all applicable environmental regulatory requirements. The major objectives of these groups are to develop and implement institutional plans and programs for environmental protection in response to specific federal and state regulatory requirements; assist Laboratory organizations in complying with environmental regulatory requirements; measure, evaluate, and document effects of Laboratory operations on public health and the environment; and provide emergency-response support by evaluating and responding to releases of radioactive and toxic materials.

- ESH Division administers the Laboratory's waste minimization program in addition to its other activities. This program has been established in accordance with the Laboratory's fourfold plan for implementing federal requirements and for managing all types of liquid and solid waste generated at the Laboratory. The plan addresses abatement and substitution, segregation and housekeeping, reuse and recycling, and personnel education.
- The Analytical Services Group (CST-3) and the Inorganic Trace Analysis Group (CST-9) conduct an ongoing program of chemical measurements in support of regulatory compliance, environmental and workplace monitoring, and research programs. The staff provides state-of-the-art expertise in sampling requirements, analytical chemical measurements, interpretation of chemical data, analytical quality assurance, National Institute of Standards and Technology traceability of chemical measurements, and experimental design. In addition, the groups conduct an active research program in analytical chemistry and environmental measurements.
- The Chemical Science and Technology (CST) Division ensures that radioactive and chemical liquid and solid wastes, other than sanitary wastes, generated at the Laboratory are processed and disposed of appropriately. Division personnel manage all liquid and solid wastes, other than sanitary wastes, generated at the Laboratory.
- Facility managers oversee ES&H activities in their facilities. The facility managers have ES&H teams composed of line and ES&H Division personnel. These on-site ES&H teams are very effective because they are intimately familiar with the day-to-day ES&H issues in their facilities.
- The Operations Working Group, which is composed of Laboratory senior managers, provides oversight of ES&H activities at the Laboratory.
- The Laboratory's Legal Counsel provides legal support for ES&H programs and compliance issues.

Sitewide Environmental Impact Statement

ESH Division established the Los Alamos Sitewide Environmental Impact Statement (SWEIS) Project Office to provide a single point of contact within the Laboratory to support DOE's preparation of a new environmental impact statement (EIS) for the Laboratory. DOE announced its intention to prepare a new SWEIS in May 1996. The Laboratory's role in DOE's process is to provide base-line data about the Laboratory's current environment, facilities, ongoing programs and activities, and likely future programmatic activities. The SWEIS Project Office is responsible for helping to identify the types of data that may be required for the SWEIS, determining what is available, determining the characteristics of existing data, organizing the information in databases, and submitting it to DOE. The EIS will then be prepared by an independent contractor.

The scope of the Laboratory's effort involves providing base-line information for the SWEIS; facilitating access to existing data; assisting in the DOE Albuquerque Office's development of additional data; reviewing documents for accuracy and liability; and reviewing the mitigation action plan for viability and accuracy. In compiling the information about base-line data that exist at the Laboratory, the SWEIS Project Office will develop a base-line information document that addresses programs, facilities,

and operations; ES&H; cultural resources; socioeconomic factors; and new projects appropriate to the EIS. Over the next several years, this documentation will also support future National Environmental Policy Act requirements and other environmental protection requirements. During the preparation of the SWEIS, the SWEIS Project Office will support an internal information program for Laboratory employees and subcontractors to heighten their awareness of the SWEIS process.

Toward the end of the process, the DOE will generate the mitigation action plan, which will contain commitments that are the basis for the DOE's record of decision. The mitigation action plan will also describe a plan for implementing commitments made in the SWEIS to mitigate adverse environmental impacts associated with the selected alternative.

Occupational Medicine

The Laboratory's Occupational Medicine Program provides a full range of core occupational medicine services.

- Medical evaluations (routine, prescribed fitness-for-duty, surveillance, and certification) as part of an ongoing program for monitoring the effectiveness of initiatives to protect the health of workers and ensuring that employees are physically and emotionally fit for their job assignments.
- Evaluation, triage, managed care, and rehabilitation of workers with work-related injuries and illness.
- Emergency response/decontamination capabilities.
- Medical evaluations for fitness-for-duty referrals from management and disability case management.
- Medical support for the Laboratory worker's compensation and early return-to-work programs.
- Preventive medicine and Wellness Center programs, health promotion and enhancement counseling, and education programs.
- Employee Assistance Program support for the mental health component of employee health and wellness and support for Laboratory human reliability programs and drug-free workplace initiatives.
- Short-term, limited, nonoccupational medical care for employee health problems not ordinarily requiring a private physician.
- Teaming with the industrial hygiene and safety program staff to provide field support, worksite evaluations, and site-specific occupational medicine support to Laboratory employees, programs, and organizations.
- Institutional support in developing/implementing Laboratory health-related policies and programs.
- Confidential employee medical records and medical systems database, health surveillance, tracking, and trending activities.
- Research in the areas of health effects of occupational exposures.

Major accomplishments of the Occupational Medicine Program include, in addition to enriching the core occupational medicine programs, the following:

- substantive success in developing ongoing working relationships with industrial hygiene staff;
- development of the occupational medicine presence in health research;

- integration of Employee Assistance Program and Wellness Center activities in support of employee health education and preventive medicine;
- support of Laboratory programmatic activities through assistance with occupational health requirements of subcontractor labor; and
- heavy involvement of nursing and physician staff in Laboratory policy development (violence in the workplace, fitness-for-duty program, Department of Transportation drug and alcohol testing program, site substance-abuse policy, Family and Medical Leave Act implementation, health-care management, and disability issues).

Facility Risk Management

ESH-3 provides tools and analytical services to facility and operations managers that enable them to make informed decisions about managing ES&H risks. Real-time assessment and maintenance tools include the following:

- ESH Identification—a computer-assisted process that provides guidance to line management in assessing ES&H risks during the planning and scoping phases of new projects, programs, processes, modifications, and construction.
- Preliminary Work Hazard Identification tool.
- Hazard classification database—identifies moderate- and low-hazard facilities and includes a list of the nuclear facilities at the Laboratory;
- Solid-waste-management-unit review—characterizes data and identifies building and project hazards for environmental restoration and new construction projects.
- Excavation review—identifies hazards associated with excavation and groundbreaking activities for ES&H review.

Services provided by the group include the following:

- scheduling and projecting costs of ES&H requirements for new or modified science projects and proposals;
- identifying and analyzing work hazards;
- analyzing the hazards, safety, and risk of operations and facilities;
- helping identify safety operating requirements;
- analyzing change control (such as unreviewed safety question determinations);
- assessing operational readiness;
- supporting risk management; and
- integrating ES&H guidance, risk assessment services, and documentation for new and modified projects and processes.

Quality Assurance

ESH-14, along with other organizations such as the Quality and Planning Program Office, provides quality management support to Laboratory organizations in several areas.

- *Quality Management System (QMS) Assessment.* ESH-14 uses QMS assessment to evaluate the current status of operations-related management systems. The purpose is to determine what system development activities would be beneficial and to document a base-line against which progress can be assessed. The results of the assessment are also useful for benchmarking purposes.

- *QMS Development Support.* This function assists line management in establishing and implementing an appropriate QMS. It also assists management in applying quality tools and concepts to improve performance; defining an organization's performance base-line; employing quality tools and methods; and maintaining compliance.

- *Operational Support.* Operational support activities focus on helping client organizations get their work done.

- *Operational Assessment.* Operational assessment looks at whether organizations are following their defined methods and procedures for accomplishing their work. It also assesses the adequacy of procedures for ensuring safe, reliable operations.

- *Procurement Support.* In organizations for which procured products or services are important to safe and effective operations, mechanisms are needed to ensure that whatever is being purchased meets requirements.

- *Quality Training.* ESH-14 designs and delivers training on several quality topics as well as contributes quality experts to participate in training developed by others. The group regularly delivers training in two areas: quality guidebook training and suspect/counterfeit material training.
- *Clearinghouse for Quality Information.* ESH-14, along with other organizations, provides information on quality tools and methods to Laboratory employees or refers them to appropriate resources.
- *Policy Development and Coordination.* The group is the Laboratory's office of primary responsibility for implementing operational quality improvements. In this role, ESH-14 develops and interprets requirements for Laboratory operational quality programs.

ES&H Training

ESH-13 is exploring new and more efficient ways to accommodate its customers by offering training in various delivery modes—classroom training courses, self-study courses, computer-based training courses, and on-line training via the Internet. The group is reexamining training requirements, streamlining training plans, and working with other training organizations to prevent redundancies.

Currently, the group coordinates all Laboratory-wide ES&H training, following Laboratory training standards, policies, and procedures established by the Training and Development Group in the Human Resources Division.

In FY96, Laboratory workers participated in more than 180,000 hours of ES&H training in such areas as electrical safety, radiation protection, chemical hazard communication, hazardous waste management, emergency response, general employee training, and ES&H management training.

Technology Development, Evaluation, and Application

The Laboratory, working with the DOE, must achieve its ES&H goal by developing new technologies and implementing innovative approaches that cost effectively improve ES&H protection. In FY95, ESH Division initiated a Technology Development, Evaluation, and Application Program, allocating approximately 0.5% of its annual budget to technologies that

would ameliorate Laboratory ES&H problems. Program priorities are to benefit Laboratory workers and the public; support Laboratory mission objectives; employ the unique expertise at the Laboratory; achieve success within 3 years; and transfer technology to other DOE sites. The program's focus on the Laboratory's needs makes it a necessary part of the Laboratory's overall ES&H programmatic effort.

In FY96, ESH Division supported seven small projects (less than \$100,000 each for a total program cost of \$400,000) in neutron dosimetry, exposure assessment, engineering controls, personal protective equipment, and environmental impacts. In FY97, six of these seven projects were continued, and four new programs were initiated. The new projects focus on protective clothing, respiratory protection, aerosol resuspension, and ecological assessment methodology.

Early accomplishments of these projects include

- improving methods for estimating worker neutron exposure, especially exposure of worker extremities to neutrons;
- evaluating the effectiveness of worker exposure assessment using continuous air monitors (CAMs);
- identifying procedures to locate CAMs;
- defining the performance of respirators that protect against exposure to nitric acid;
- developing improved plutonium analytical procedures to better protect worker health and meet new, more stringent regulatory requirements; and
- implementing prototype animal-tracking methodologies to assist in ecological studies.

Current early success indicators are the following: (1) one project has received matching funds from the Nuclear Materials Technology Division, (2) the neutron dosimetry study has in-kind beam-time support at the Los Alamos Neutron Science Center, and (3) supplemental funding has been provided by the Laboratory's capability maintenance and improvement project. A pilot field study to evaluate the neutron extremity meter is in progress, implementation of the new plutonium bioassay procedure has occurred on a pilot basis, and criteria now exist permitting the use of simplified respiratory protection for nitric-acid exposure situations. Tentative plans are in place to apply the CAM study results to the design of a new facility at Los Alamos.

ESH Division's future plans for the program include redefining priorities with more input from line organizations, increasing ESH Division funding commitments by 1% to 3% by FY00, and seeking additional funding outside ESH Division. ESH Division also hopes to extend this effort to support Laboratory-wide line organization interest in developing ES&H technologies.

B. Site and Facilities/Safeguards and Security

For the past few years, Los Alamos has been working on a revitalization initiative with the object of obtaining adequate funding for our infrastructure needs. The Tri-Laboratory Revitalization Program that had been defined and endorsed by the three Defense Laboratory Directors, as described in last year's Institutional Plan, has been redirected to focus upon the specific needs of individual Laboratories. To coordinate this activity at Los Alamos, the Director formed the Project Office for Infrastructure and Facilities Revitalization in January 1997. The project leader for this activity works very closely with the Director, the Facilities, Security and Safeguards (FSS) Division, and with program and line organizations throughout the Laboratory. Part 1 in this section describes the purpose and goals of this office.

Facilities planning, documentation, databases, and daily operations, as well as safeguards and security operations are consolidated in FSS Division. FSS Division has both central and distributed functions at the Laboratory. In Part 2, we discuss the plans, strategies, data, and functioning of FSS Division, including its progress in developing the site master facilities plan referred to in Part 1.

1. Infrastructures and Facilities Revitalization Project

Los Alamos shares the mission assignment of Reducing the Global Nuclear Danger with the other Defense Programs (DP) laboratories. However, Los Alamos has a number of unique facilities and capabilities that make us unique among the laboratories for addressing this mission assignment. The unique facilities and capabilities include the following:

- tritium handling, processing, and research;
- the plutonium processing, pit surveillance, and pit and fuels production activities;
- highly enriched uranium processing and fabrication activities;
- nonnuclear component fabrication requirements;

- high-explosives synthesis, characterization, and fabrication at S-Site;
- detonator research development and production; and
- a host of experimental activities directly concerned with stockpile stewardship and management.

Because we have such specialized facilities and capabilities and because many of our facilities are old, dating to the 1950s, the infrastructure revitalization and facility replacement needs at Los Alamos are greater than those at the other DP laboratories and will require greater sustained capital expenditures (see Figure 31). As well as being essential to our mission, having up-to-date facilities that meet current standards is also essential for safe and reliable operations.

The purpose of the Infrastructure and Facilities Revitalization Project is to define, prioritize, and obtain the funding needed to undertake a sustained long-term program in infrastructure and facilities revitalization. The Laboratory has identified three basic components of this effort. These components are as follows:

- Obtain sustained line-item capital-funding support aimed specifically at infrastructure revitalization. This activity is envisioned to last a minimum of 7 years, with an average funding level of \$20 million per year.
- Continue to obtain line-item capital-funding support for specific buildings and experimental facilities necessary to conduct the Laboratory mission assignments. Examples of such buildings and facilities include the proposed light laboratory/office buildings for Nonproliferation and International Security (NIS) Division that have been proposed by the DOE Office of Nonproliferation and National Security (DOE-NN) and the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility supported by DP.
- Allocate appropriate operating funds in an ongoing way to ensure that maintenance and noncapital line-item projects are properly supported to meet the Laboratory's central mission assignment of Reducing the Global Nuclear Danger.

Figure 31. The blue areas mark Los Alamos TA-3 sites built during the 1950s, which had a design life of only 5 to 10 years. These sites are still in use.

The Laboratory has dedicated more than \$2.3 million of FY97 operating funds for the specific purpose of identifying, prioritizing, and developing the necessary documentation for proceeding with specific Conceptual Design Plans (CDPs) for infrastructure upgrades at the Laboratory. Specific projects currently in the CDP stage include the following:

- waste water collection lines at TA-3 and TA-16;
- 100-psi natural gas distribution line;
- equipment transportation and access road (firing line road);
- traffic safety upgrades;
- relocation of the Laboratory Emergency Operations Center;
- Centralized Records Storage Facility; and
- TA-3 steam condensate lines.

In addition to the infrastructure projects listed, we are currently engaged in the preparation of a Comprehensive Master Plan for the TA-3 central core area. This TA-3 plan is the first step toward the preparation of the Comprehensive Site-Wide Master Plan for the Laboratory.

For more information on the Site Master Plan, see Part 2 in this section. The initial investment will be used to develop the rationale and appropriate documentation for proceeding with main infrastructure improvements. A critical portion of the path forward includes partnership with DOE to develop more cost-effective processes for defining, designing, and constructing capital infrastructure and facilities projects. The partnership will lead the Laboratory and DOE to the adoption of industrial standards and codes when such standards are appropriate.

2. Facilities, Security and Safeguards

Los Alamos is situated on approximately 27,800 acres of land (43 square miles) owned by DOE. Only about 30% of this land is developable because of topographic environmental, operational and buffering constraints. About 7,500 Laboratory employees (including full-time, part-time, visiting, and casual-status employees) and an additional 3,275 contract employees, vendors, members of the protective guard force, and contractor personnel are housed in approximately 5.1 million occupiable square feet (over 8.0 million gross square feet) of floor space. These building facilities have an estimated replacement cost of \$2 billion (see Table 32); this figure increases to over \$4.2 billion when utilities and capital equipment are included. Figures 32 and 33 show the net usable-area distribution by utilization and building type.

Although the Laboratory seeks to efficiently reuse and reallocate present facilities, this objective must be weighed within the reality that 30% of Laboratory facilities are more than 40 years old. More importantly, some 80% of these facilities are more than 20 years old, the age at which major building systems begin to fail and maintenance and operating costs increase. As a result, an increasing percentage of Laboratory facilities will need replacement or major rehabilitation in the near future (see Figures 34 and 35).

Figure 32. Gross space utilization by function.

Figure 33. Gross space by construction type.

Figure 34. Gross space by condition.

Figure 35. Gross square feet by year built.

Table 32. Replacement Costs for Laboratory Buildings.

Use	Number of Structures	Space (Square Feet)	Acquisition Cost (\$)	Replacement Cost (\$)
Administration	474	2,016,576	98,304,455	310,109,467
Housing	2	26,864	365,569	3,397,013
Laboratory	232	3,706,381	272,113,049	1,215,455,671
Other	35	53,914	2,360,272	11,460,197
Production	71	467,676	28,971,719	157,594,695
Service	340	904,757	50,846,555	223,302,265
Storage	332	786,315	50,536,580	149,618,782
Temporary Storage	849	170,754	-	-
Total	2,335	8,133,237	503,498,199	2,070,938,089

Comprehensive Planning

Los Alamos published its first long-range Site Development Plan (SDP) in the spring of 1983, and made available, in early 1991, a completely updated SDP, the SDP-Technical Site Information (TSI). The SDP-TSI deals with long-range land use, population and facilities, transportation and circulation, safeguards and security, utilities, and environmental, safety, and health issues. The document was designed to be adapted and updated as conditions change. It has been continually updated in the geographic information system, an automated format that allows SDP-TSI data to be updated and maintained more efficiently and cost-effectively.

In 1991, DOE established requirements for preparing an SDP Annual Update, a brief document that presents and updates annual site development issues that require resource commitments. The *FY 1996 Site Development Plan-Annual Update* reports the following:

- a short overview of Los Alamos, including existing mission and workload, site and regional context, and projections and resource requirements;
- a future master plan divided into core elements of land use, facilities, transportation/circulation, security/safeguards, utilities, safety, and environment. The plan describes, for each element, objectives that have major site and facilities impact or requirements as well as facility and land requirements (any single construction project may address one or more of these categories); and
- a special consideration section examining potential land transfers, the proposed development of a research park, and related land-use development and management issues.

The changing mission of the Laboratory in the 1990s has brought about the need to develop a new, integrated comprehensive planning process. This process, sponsored by the Laboratory Planning Council, will integrate and coordinate diverse types of plans into a new Site Master Plan for the Laboratory. The resulting Site Master Plan will incorporate individual program-sector plans, planning support documents, and Laboratory-wide core planning elements. In addition, the process will continue to allow for Technical Area (TA) master plans such as the recently completed TA-63 Master Plan and the proposed TA-3 Master Plan. Master plans for Facility Management Units (FMUs) will lay out the Laboratory's program of distributed facility management and will also become unit plans within the new Site Master Plan. The long-range goal is to maintain the Site Master Plan as a comprehensive database for conducting up-to-date physical planning activities and to serve as the foundation for the comprehensive planning process as required by DOE's Land- and Facility-Use Policy and Life-Cycle Asset Management Order.

Institutional planning estimates and strategies for future program activities form the basis for the Laboratory's site-planning documents. The new planning process will address Laboratory planning and growth issues by providing a flexible foundation and framework for Laboratory decision-makers, who work in an atmosphere of constant change. Specific recommendations and plan maps translate long-range goals into day-to-day action plans for managing the Laboratory's physical infrastructure in a flexible, efficient, and cost-effective manner.

Potential Land Transfers and Related Land-Use Issues

In the past few years, the DOE Los Alamos Area Office (LAAO), Los Alamos National Laboratory, Los Alamos County, San Ildefonso Pueblo, and, to a lesser extent, the U.S. Forest Service and the National Park Service have discussed the possible transfer of Laboratory land in exchange for the elimination or reduction of DOE assistance payments to the county and in support of Pueblo land claims. LAAO supports release of parcels of DOE land to the county and the Pueblo. The parcels could be subject to deed restrictions limiting uses to technology transfer from the Laboratory, Laboratory-related economic development, affordable housing, or other uses deemed appropriate to foster self-sufficiency. In addition, deed restrictions could prevent activities that could negatively affect program operations at the Laboratory.

Any land disposition must follow established General Services Administration rules and procedures, relevant DOE orders, other federal or state laws, the Atomic Energy Community Act of 1955, and additional special legislation. During the summer of 1997, special legislation was put before Congress outlining a process and schedule for transferring the land. The legislation requires a DOE recommendation to Congress about which tracts of land are to be transferred to whom, a National Environmental Policy Act (NEPA) review, and transfer as appropriate. Generally, the whole process is to be handled within 3 years from approval of the legislation. Allowance for special needs as identified, such as an action resulting from the NEPA process, may be made.

Since October 1995, the process for transferring property has been carefully refined to identify tract boundaries to ensure that all parties agree on the land to be considered for transfer. This process allowed the Laboratory to conduct detailed review of each parcel to identify concerns and constraints related to the potential transfer. The Laboratory Planning Council submitted a detailed tract-by-tract land transfer recommendation to DOE in June 1996. The Laboratory identified operational impact and noted both utility easement requirements and NEPA compliance requirements for all tracts.

It is expected that some tracts and parts of several tracts will not be transferred because either the transfers will have unacceptable impact on the programs at the Laboratory or regulatory compliance issues must be completed first. The Environmental Assessment for part of the DP Road and the research park tracts are near completion. Because of possible Laboratory requirements, the research park tract is being considered for lease rather than transfer.

Coordinated planning and participatory decision-making processes involving the DOE Albuquerque Operations Office, LAAO, the Laboratory, Los Alamos County, San Ildefonso Pueblo, the U.S. Forest Service, and the National Park Service are key to finding workable solutions to land-transfer and related land-use issues. Specifically, the following actions should continue to take place to find workable solutions:

- involve the Laboratory Planning Council in land-transfer discussions and decisions with DOE and the potential recipients of land;
- follow the Laboratory Planning Council's strategic planning guidance that evaluated the programmatic and land-use impact of transferring land and follow the prescribed DOE National Environmental Policy Act process;

- consider transferring parcels that are no longer needed by DOE and the Laboratory and are consistent with current and projected uses of land adjacent to the parcels.
- Continue support and involvement in the development of the research park;
- incorporate deed restrictions to ensure present and future compatibility and utility easement provisions with DOE and the Laboratory; and
- follow the government process for land transfer.

Facilities Resource Requirements

Funded and Proposed Line-Item Construction Projects

The Laboratory and DOE have improved coordination and consistency among Laboratory planning processes and documents. Previously, the ongoing and dynamic nature of construction projects produced variations in construction project lists throughout the year, resulting in inconsistencies in documents that have different due dates. These inconsistencies are being reduced through coordination and consistency among various planning efforts. Table 36 in the Appendix summarizes funded and proposed line-item construction projects from the current fiscal year through FY03.

The funded and proposed line-item construction projects are consistent with the *FY98 DOE Capital Asset Management Process (CAMP)* report and the *FY 1996 Site Development Plan-Annual Update*. The Laboratory's construction program is dynamic, and updates to the planning status of line-item construction projects are conducted quarterly.

General Plant Projects

DOE Order 2200.6 (page VI-20, paragraph 2h) defines general plant projects as miscellaneous, minor, new construction projects of a general nature, the total estimated cost of which may not exceed the congressional authorization of \$2.0 million per project. Such projects are necessary to adapt facilities to new or improved production techniques, to effect economies of operations, and to reduce or eliminate health, fire and security problems. They provide for design or construction (or both), other capital alterations and additions, and improvements to land, buildings, and utility systems. They may include construction of small, new buildings, replacements of or additions to roads, and general area improvements. Total funding for general plant projects at Los Alamos in FY97 is \$2.7 million and for FY98, \$3.8 million is budgeted.

Facilities Maintenance and Repair

In FY97, the total allocation for the maintenance and repair of institutional property at the Laboratory was \$68.5 million, approximately \$20 million more than the FY96 allocation. This total includes activities such as management and technical support, snow and waste removal, custodial services, and landscaping. The increase in funding reflects the implementation of distributed facility management (FM).

The Laboratory began to move toward a distributed FM model during FY94. In this model, there are 18 full-time facility managers who have the funding and responsibility for the maintenance of their facility. The FM model included transition, when

appropriate, to direct funding of maintenance by Laboratory programs instead of the former space-recharge method. The transition to direct funding of maintenance at several large facilities is the primary source of the funding increase above the FY96 level. The FM model is also helping to identify the true cost of facility maintenance by capturing maintenance and support costs that were previously funded from sources other than the space-recharge budget. This accurate reflection of maintenance costs also accounts for some of the increase from FY96.

Table 33 lists the components of the maintenance budget as projected for FY97. The maintenance and repair cost (\$47.2 million) is the amount projected for preventive and corrective maintenance. The custodial support cost (\$9.8 million) is the amount projected for janitorial services and trash removal. The management, engineering, design, inspection, and technical support cost (\$7.7 million) is the amount required to direct and coordinate the support services contractor. The cost for other (\$3.8 million) is the amount projected for landscaping and snow removal.

A small amount of new construction as well as the aging facilities at the Laboratory necessitate increases in the maintenance budget through the year 2000. Therefore, an approximate 1% annual increase has been projected through FY02 based on expected growth as well as the reality of overall declining budgets.

Distributed Facility Management Program

The Facility Management Program at the Laboratory established a decentralized system for managing facilities across the Laboratory. Within the program, Laboratory divisions own facilities and are accountable for maintenance of the buildings' operational safety envelopes and maintenance management. The intent of the institutional program is to ensure that the Laboratory's physical infrastructure supports programmatic requirements and facility needs and to assure that formality of operations is consistent and appropriately applied across all facilities.

The Facility Management Program has been defined and approved by Laboratory leadership. Implementation continues at the various distributed facility management units. An FY97 effort is focused on assessing facility unit implementation based on a set of facility expectations. This assessment will identify the level at which the distributed function has been implemented and will assist in the identification of functional areas that require further development to achieve adequate management of laboratory facilities. The Infrastructure and Facilities Revitalization Project Of-

fice will administer and monitor the institution's achievement of the facility expectations and requirements.

Implementation efforts to date have helped facilities and technical operations to manage with greater emphasis on safety and with improved formality of operations. Additional work is proceeding in these areas as facility management organizations mature. Future efforts include completing the actions from the implementation assessment and developing improved standards for facility activities. Institutional systems and organizations are changing form and culture in support of the Facility Management Program.

Fire Protection

The Laboratory Fire Protection Plan and program are conducted in accordance with the DOE Fire Protection Program and the DOE order on fire protection. Laboratory Director's Policy DP-118 provides program direction and assigns appropriate responsibilities. FSS Division and assigned organizations provide other documents.

FSS Division has requested a \$10 million complete upgrade to the Los Alamos sitewide fire alarm system. The proposed system will be a "stand-alone" system that meets UL Listing requirements. The current contract between DOE and the County of Los Alamos will terminate in November 1997, and the Laboratory has the responsibility for drafting the proposed new statement of work and managing the new contract after it is in effect. New fire protection standards necessary for the protection of the Laboratory will be defined by a team of fire protection professionals and facility management users.

Safeguards and Security

Safeguards and security operations are conducted to ensure effective protection of national security interests, proprietary information, personnel, property, and the general public. Program strategies are based on a graded approach utilizing threat analysis, risk assessments, and cost benefit analysis. Safeguards and security management programs, outlined below, are designed to enhance the safeguards and security operations providing effective and efficient quality service and support to Laboratory programs.

The Laboratory ensures that all safeguards and security interests, including classified and sensitive unclassified material and information, nuclear material, and other U.S. government property, are protected against threats defined by a DOE-designed basis.

Table 33. Facilities Maintenance and Repair (\$M).

	FY97	FY98	FY99	FY00	FY01	FY02
Maintenance and Repair	47.2	47.7	48.1	48.6	49.1	49.6
Custodial Support	9.8	9.9	10.0	10.1	10.2	10.3
Management, Engineering, Design, Inspection, and Technical Support	7.7	7.8	7.9	7.9	8.0	8.1
Other Maintenance Services	3.8	3.8	3.9	3.9	4.0	4.0
Total	68.5	69.2	69.9	70.6	71.3	72.0

The threats include compromise, loss, theft, diversion, espionage, sabotage, erosion, and other malevolent or inadvertent acts that may cause unacceptable risks to national security, employee or public health and safety, and/or the environment. The Laboratory provides protection in a graded manner that is consistent with potential risks. It ensures effective safeguards and security operations by maintaining comprehensive programs in physical security (including protective forces), nuclear material control and accountability, property protection, personnel security assurance, computing and communications, and personnel/information security.

The intrusion detection system employed at Los Alamos is anticipated to be upgraded and ultimately replaced over the next 5 years. The current control system serves as both a fire alarm and a security-intrusion detection system. The new control system will employ state-of-the-art technology and will be capable of supporting the projected missions of the laboratory well into the 21st century.

The Laboratory has initiated and is committed to quality management practices to ensure

- innovative, creative, safe, and credible safeguards and security programs;
- consolidation (and where practical, reduction) of safeguards and security interests;

- increased use of technologies such as automated access and automated validation systems that promote cost-effective, efficient, and reliable safeguards and security operations;
- standardized protection systems, including weaponry, alarm hardware, and computer hardware, for cost savings and consistent protection application; and,
- emphasis on training that ensures that safeguards and security personnel are well qualified and knowledgeable.

The Laboratory is committed to partnering with DOE safeguards and security managers and staff through jointly sponsored initiatives (working groups, task forces, and self-assessments) and continuous quality improvement efforts to achieve and maintain credible safeguards and security operations that promote the DOE and Laboratory ideals of openness, customer satisfaction, efficiency, and cost-effectiveness. Safeguards and security strives to "Far Exceed" all performance measures as outlined in Appendix F, Part X, of the UC contract with DOE.

C. Human Resources

Los Alamos National Laboratory continues to be the major employer in north-central New Mexico. Just as the Laboratory has had to redefine its mission and role in society in this post-Cold War era, so has the Laboratory's Human Resources (HR) Division needed to adapt its role to enable the Laboratory to accomplish its near- and long-term goals. This is reflected in the HR mission:

The Human Resources Division provides leadership and support that unifies and strengthens the ability of our workforce to support the Laboratory's mission of delivering science and technology to serve society. Human Resources accomplishes this mission by being simultaneously an advocate of the workforce and the community and by being highly business oriented.

To ensure that HR Division does in fact support the Laboratory's mission, HR is centered around the Laboratory's strategic and tactical goals. To ensure that we are an advocate of the workforce and the community and are highly business-oriented, we use several review processes.

We continue to use the Appendix F performance measures established in the DOE/University of California contract, and the attendant evaluations against those measures, to not only mark our progress toward our mission but also to set "stretch" goals that encourage progress. The measures themselves are reviewed annually and modified, reinforcing the concept of continuous quality improvement (CQI). For instance, having obtained in FY96 an overall rating of "Exceeds Expectations" in the Human Resources portion of Appendix F, we have expanded the areas upon which we will focus our efforts. For FY97, we modified an existing performance objective—Performance Objective #1, Cost Effectiveness—to include measures for process improvements, and we added two new performance objectives—Performance Objective #4, Customer Needs, and Performance Objective #5, HR Leadership in Deploying Mission/Business Strategy.

We are employing the use of an external advisory committee composed of senior leadership and HR experts from benchmark companies and academic institutions. The committee reviews current HR operations, ascertains what the expectations of HR's customers are by reviewing HR-collected data, such as the Voice of the Customer input discussed in the next section, and by meeting with customers. In its 1997 report, the committee

- approved of HR's partnering efforts;
- advised a review of the HR staff's skills mix to ensure that the right skills will be available for current and future operations;
- agreed with the division's direction in applying technology such as the PeopleSoft software discussed in the next section;
- emphasized that the Training Integration Office and the Training and Development Group must change managers;
- recommended expanding the role of the HR generalists;
- pointed out that the distinction between HR policies and HR guidelines is not always clear;
- recommended increased employee involvement in policy generation; and
- encouraged improved communication, including the division's vision.

As a result of these reviews and other planning activities, HR has established the following priorities:

- Workforce planning;
- Management tools for alignment with the Laboratory direction, including rewards and recognition, performance management, and customer satisfaction management;
- Workforce for the future, including strategic recruiting, skills assessment, career development, and health care; and
- Cultural change leadership, including training and accountability for safety and treatment of others.

Workforce Management Tools for Alignment with Laboratory Direction

A key responsibility we have assumed in Human Resources is to create an environment and the tools to promote the alignment of all workforce activities, including HR activities, with Laboratory goals. Of course, fundamental to our ability to do this is having a workforce that is informed of and understands Laboratory goals. In 1994, we instituted an annual employee survey that clearly identified this as an area for improvement. Senior management responded by incorporating communications as a Laboratory tactical goal. After 3 years of survey data, we have seen a statistically significant increase in favorable responses to the following survey statements:

- I am sufficiently informed about the Laboratory's tactical plan.
- I am sufficiently informed about the Laboratory's mission.
- I have a clear understanding of the goals and objectives of the Laboratory as a whole.

We use the employee survey as a mechanism for identifying and marking employee perception of progress in a broad range of workforce issues, from performance evaluation to employee pride and morale. Although, generally, questions remain the same on the survey to track trends, items will occasionally be added as the institutional focus changes or other workforce issues become manifest so that the resulting data is pertinent.

To make sure that HR, as a support organization, is enabling Laboratory organizations to support Laboratory goals, we have utilized "Voice of the Customer" techniques to identify and prioritize HR process improvements. First, focus groups were conducted to solicit opinions about HR services. Issues were gathered, categorized, and then used to develop a survey that was sent to all Laboratory managers. Managers were asked to rate HR services and processes according to (1) their satisfaction with each service and process and (2) the level of importance they give to each service or process.

After survey responses were received and items were scored, HR processes and services were grouped into four categories: High Importance/Low Satisfaction; High Importance/High Satisfaction; Low Importance/High Satisfaction; and Low Importance/Low Satisfaction. Naturally, the High Importance/Low Satisfaction group contains the issues that HR needs to address first. From the response data, we have added the following nine process improvements to our quality improvement efforts:

- Job Evaluation/Pay Structures
- Professional Development Program
- Institutional Recruiting
- Student Program Administration

- Workforce Planning Tools Development
- Performance Management
- Major HR Process Linkage Communication
- Employee Complaint Process
- Community College Involvement in Employee Training & Education

Before the "Voice of the Customer" survey was conducted, HR had already identified most of the same issues the Laboratory workforce had given as priorities. Performance Management is a good example. This is a workforce management tool we have focused on since 1993. Lessons learned from a performance assessment pilot were incorporated into a major redesign of the performance assessment process, the Performance Management System. We are completing Phase I implementation of the Performance Management System in selected division and program offices, and next year we plan to begin Phase II, expanding the use of the system Laboratory-wide.

In the Performance Management System, employees work with their managers to determine their own "Individual Expected Results" that will further the organizational objectives stated in each employee's Individual Performance Plan. These organizational objectives are directly linked to higher-level strategic Laboratory objectives. At the end of the review period, employees are evaluated based upon the results achieved and the impact made upon their organization's objectives.

We understand that how a result is achieved is as important as what is achieved. That is why employees are also rated on how well they exhibit behaviors that support Laboratory values. To obtain a well-rounded picture of these behaviors in our employees, input is solicited from their peers, customers, managers, subordinates, and others they interact with in an official capacity. These two aspects of employee performance are used to determine an overall performance rating that will later be a factor in managing the employee's salary increase.

We are also looking at other aspects of performance management. Our system for job evaluation and pay structure is being streamlined to allow the workforce greater mobility among projects while enabling timely response by the Laboratory through prompt allocation of resources to projects. We will also be investigating other reward mechanisms such as nonmonetary awards and variable pay.

We have recently purchased and installed PeopleSoft, a commercial software package for human resources management, to centralize and integrate as many of our local HR systems as possible. This software will allow us to streamline many of our processes and will greatly reduce redundant data entry. The software contains modules for position management, recruiting, career and succession planning, salary administration, and more. We intend to take full advantage of the extensive capabilities of this package in our future planning and process improvements.

Workforce Planning/Workforce for the Future

To position the Laboratory to meet its goals, we need to implement workforce planning for the near term as well as look forward to how we will develop our workforce for the future. Certainly, one way to do this for the near term is to maximize the potential of the current workforce.

Last December, a Career Development Advisory Council (CDAC) was established to advise management on Laboratory career development issues and to help define our career-planning process. Although the Laboratory already has some career development activities in place, such as workshops offered by the Training and Development Group in interviewing skills, job search, and résumé writing, CDAC's function is to ensure a coordinated approach to career development through implementation of a career development system designed by a Laboratory Leadership Council Action Team.

Each organization conducts staffing assessments to highlight the organization's development needs. Information on the Laboratory's development needs is used to guide our employees in developing the necessary skills for our programmatic needs. We are in the process of providing other mechanisms such as an online skills database to support the career development system. We intend to take full advantage of the career development, mentoring, and succession planning modules in the PeopleSoft software mentioned earlier. Full implementation requires workforce planning that identifies needs that can be addressed through mobility, recruitment and hiring, and staffing assessments.

We understand how crucial mentoring is in career development. The Laboratory sponsored "Mentoring Week" at the beginning of the year to raise employee awareness of mentoring activities and the importance of mentoring. The event was not only used to recruit mentors from our workforce but also to solicit input on how Laboratory staff can become more effective mentors. Award programs for mentoring have been established through the Science Education Office in the Science and Technology Base Program Office (STB/SE) and through the Women's Diversity Working Group.

In addition, we have modified our Community Service Leave policy to allow time off for activities directly related to the Laboratory's Science Education programs. We are also emphasizing the educational aspect of assignments given to student employees and guests of our student employment programs. We now require all organizations that request student employees or guests to assign each student a mentor who will create a focused work plan suited to the student's interests and skills. We recognize that our student employment programs are an excellent resource for our future workforce—both in the near- and long-term. For instance, we retain approximately one-quarter of the employees that work in our postdoctoral program.

Clearly, workforce planning would be incomplete without aggressive recruitment of the very best employees we can find. To this end, we have appointed an institutional recruiting coordinator whose role it is to increase our college recruiting activities. Because many of the best candidates are offered jobs six months before they graduate, it is important to have a presence on campus and to identify and attract new graduates who have the greatest potential to contribute and succeed at the Laboratory.

HR has also been working with the Diversity Office as well as STB/SE to increase the diversity of the pools of applicants from which we draw our future employees. We intend to have a direct effect on that pool through the Laboratory's science education programs and mentoring activities that encourage young people to enter careers in science and math, frequently giving them hands-on experience and providing sophisticated equipment for their use.

See Table 34 at the end of this section for composition of the Laboratory workforce.

Last year, the point-of-service health care plan offered to Laboratory employees dramatically showed the effects of rising medical costs combined with increased plan utilization. Health coverage in 1997 involved both a premium increase and some form of benefits reduction, the amount of each determined by the negotiated plan design. To help determine plan design, we went to the plan customers—Laboratory employees and retirees. We solicited input through e-mail, focus groups, and a survey instrument, all of which helped us to prioritize plan benefits and balance premium and co-payment increases.

We have already established a Health Care Advisory Committee to develop alternatives and make recommendations to the University of California for a new health care plan in 1998. The committee is composed of members of the Laboratory's workforce and retiree population as well as representatives from the Benefits Office, the Employee Advisory Council, and Concerned Citizens for Health Care, a local health care advocacy group. Additionally, the Laboratory will be piloting a Health Promotion Program designed to improve the health of the health care participants while reducing health-related expenses.

Leadership in Cultural Change

As a result of the end of the Cold War and the coincidental reduced emphasis on security and defense as national priorities, the Laboratory has reengineered and developed ways to become competitive and more business oriented. This competitive focus will require a unified approach to institutional values.

HR began leadership in this area by establishing values and guiding principles that HR employees use in supporting HR's mission and performing their duties. These values and guiding principles are aligned with the behaviors on which employees are rated in the Performance Management System. The principles and values focus on increased customer/stakeholder satisfaction and improved HR products and services.

Most importantly, we want to reinforce a deep respect for safety. Safety is the first item on the list of behaviors used to rate employees in the Performance Management System and is the first HR guiding principle. The Laboratory is also implementing Integrated Safety Management, a system that, among other things, specifies that safety involves every worker and gives every worker the authority and responsibility to stop work deemed unsafe. All new employees are required to undergo safety training with additional mandated training, when applicable, specific to each employee's workplace and job assignment.

We also want to foster a culture where employees feel safe in identifying issues and problems pertaining to their work environment so that the workforce can be as productive as possible. Realizing that many problems can be resolved in a nonescalating fashion through facilitation and other communications techniques, the Laboratory has added two more resources for employees. Both the Employee Relations Group and the Ombuds Program provides informal assistance to employees for work-re-

lated issues. The Employee Relations Group in HR now offers mediation services using a collaborative, informal approach to conflict resolution. The Ombudsman listens to employees, assists them in developing options, provides information and referrals, and may occasionally mediate informally between parties.

Finally, not only are we continuing to mandate Individual Development Plans for our employees, we are also, as part of the Performance Management System, improving the quality and consistency of these plans, encouraging employees to work with their managers to identify specific actions they can take to improve current job performance as well as their overall professional growth and development.

Figure 36 portrays the HR system through which the Laboratory's workforce priorities will be addressed. It illustrates the three primary activities of the Human Resources function—People Intake, People Maintenance, and People Outgo. These activities are guided by HR's Mission, Vision, and Guiding Principles (MVGP); are supported by Planning and Management, and Infrastructure; and are shaped by the environment in which the system must operate. This environment includes the Laboratory's strategic mission and tactical goals, contractual and stakeholder requirements, and customer input. The HR function at Los Alamos is an adaptive system that will change to meet the needs created by this dynamic environment.

Figure 36. Human Resources—a systems view.

Table 34. Affirmative Action and Equal Employment Opportunity.**Regular Employees (including personnel on leave)¹**

Occupational Category	Total		Minority		White		Black		Hispanic		American Indian		Asian	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Officials and Managers														
Managers	368	70	40	8	323	61	1	0	31	7	5	0	3	1
Supervisors ²	722	202	145	65	572	137	2	2	124	56	4	2	15	5
Professional														
Scientists and Engineers	1,936	303	241	45	1,670	256	11	1	133	23	22	1	75	20
Administrative	321	442	114	151	205	288	1	1	106	135	5	9	2	6
Technicians	902	280	506	128	391	150	3	0	475	115	25	7	3	6
Office and Clerical	69	622	58	411	11	209	0	0	55	387	3	20	0	4
Crafts	98	7	49	4	48	3	0	0	43	4	6	0	0	0
Operatives	13	12	11	12	2	0	0	0	11	11	0	1	0	0
Total	4,429	1,938	1,164	824	3,222	1,104	18	4	978	738	70	40	98	42

Limited-Term Employees (including casual employees)³

Occupational Category	Total		Minority		White		Black		Hispanic		American Indian		Asian	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Officials and Managers														
Managers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supervisors	2	3	1	0	1	3	0	0	1	0	0	0	0	0
Professional														
Scientists and Engineers	141	19	18	3	121	15	2	0	3	2	0	0	13	1
Administrative	6	17	1	4	5	12	0	0	1	4	0	0	0	0
Technicians	30	19	22	7	8	12	0	1	21	4	1	0	0	2
Office and Clerical	2	42	2	21	0	21	0	0	2	21	0	0	0	0
Crafts	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operatives	1	8	0	0	1	8	0	0	0	0	0	0	0	0
Total	182	108	44	35	136	71	2	1	28	31	1	0	13	3

Special Employment Program Employees (including casual employees)⁴

Occupational Category	Total		Minority		White		Black		Hispanic		American Indian		Asian	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
High School Co-op	9	8	3	3	6	5	0	0	2	3	1	0	0	0
Undergraduate	341	250	167	152	174	98	3	1	130	123	16	13	18	15
Graduate Research Assistant	330	185	77	65	253	120	3	4	34	29	4	2	36	30
Postdoctoral	264	59	81	15	183	44	3	0	6	4	0	0	72	11
Total	944	502	328	235	616	267	9	5	172	159	21	15	126	56

¹Totals include 43 male and 10 female employees who choose not to declare their ethnicity.²"Supervisors" have responsibility for other employees but are not classified as managers.³Totals include 2 male and 2 female employees who choose not to declare their ethnicity.⁴These figures do not include employees who choose not to declare their ethnicity.

D. Information Management

Information Management (IM) at Los Alamos includes computing resources and software both for telecommunications and for scientific and administrative functions; printing, library services, photography, and writing and editing; and records management and document control. These activities fall under the purview of the Computing, Information, and Communications (CIC) Division. The mission of CIC is to provide reliable, efficient, state-of-the-art computing and communications resources and information services for the Laboratory's many and varied activities. The goal of CIC is to provide Laboratory managers and technical and administrative staff with improved computing and communications capabilities to handle information in a faster and more effective manner. Virtually every Laboratory organization depends on the availability of these critical resources and services to meet program obligations, support day-to-day operations, and manage the information for which the organization is responsible.

Integrated Management Planning Process

Although the planning process that provides a framework for IM operations has improved each year, it became apparent during the spring of 1996 that the planning process should be a component of a larger, integrated management process for running the division. Previously, CIC Division had treated the elements of the planning process as discrete units. Information, such as tactical goals, flowed from one element to the next, but the elements themselves were planned and carried out in relative contextual isolation from each other. A rapidly changing work and technological environment highlighted the need to focus leaders' attention at a higher level; for example, leaders spent too much time resolving operational problems and not enough time pulsing the external environment for future trends and directions. As a result, CIC Division developed an approach that would integrate division-wide processes, strengthen the transition to management by fact, and enable decision-making at the lowest possible level.

The result is depicted in Figure 37, a schematic diagram of how the various CIC division-wide processes (assessment, strategic planning, business planning, and operations) should be integrated into a continuous process that cycles through the fiscal year.

In time, this integrated approach will be replicated at group and team levels so it becomes the way CIC Division conducts all IM operations. Tactical goals at one organizational level will become the strategies at the next organizational level. An oversight subteam will ensure that all operations are linked to mission objectives in the Institutional Plan, the Laboratory Strategic Overview, and the Tactical Plan.

Underpinning this initiative is an extensive education and communication plan that will ultimately help all CIC employees understand how their individual work fits into the overall strategies and goals of the division and the Laboratory. The integrated management planning process will take at least 3 years to implement to the point at which it is an ingrained process that includes yearly self-assessment and improvement.

Information Architecture Project

The Information Architecture (IA) project is a Laboratory-wide effort to develop the framework for the selection, imple-

mentation, and support of computing and communications products and services. Balancing the needs of Laboratory computing customers (computer users) with those of the technology providers (Laboratory employees who provide tools and support services to the computer users), the project reaches out to involve members throughout the Laboratory. Currently, more than 100 employees from 21 Laboratory divisions actively participate on IA project teams.

The IA project establishes Laboratory guidelines and standards for computing, information, and communications hardware and software. It achieves its goal through a process that heavily involves both Laboratory customers and technology providers. By providing a forum for discussion, negotiation, and agreement, the project helps customers and providers resolve issues that continue to surface as a result of external forces (including the market for information technologies, DOE, and the World Wide Web consortium) regarding the selection, implementation, and support of information products and services.

Development of standards is a living process that ensures evolution. The process for developing standards also ensures that customers are included in decision-making; that technical decisions are made by technical experts; that guidelines and standards adapt to changing technologies and are developed in an open, participatory process that includes all interested Laboratory employees; and that there are incentives for adhering to the guidelines and standards.

Since the IA project's conception in 1993, more than 80 IA standards have been issued for comment by Laboratory employees, and more than 50 have been approved and are currently active. Standards cover Macintosh and clone, PC and clone, and UNIX hardware; desktop software; the Internet; and local area networks.

The IA project has been extremely successful in using e-mail and Web technology to communicate with customers and providers throughout the Laboratory. The number of e-mailed

Figure 37. CIC Division is integrating its management processes into a continuous cycle of planning, operations, and assessment.

comments and requests for help averaged around 100–200 per quarter but peaked at more than 400 for those quarters when the project issued desktop and remote-access proposals. From November 1995 to November 1996, the number of times the IA Web pages were accessed each month increased nearly 6-fold, from 2,200 hits to 12,845 hits, and over 12 times more customers accessed the Web pages to review and comment on draft standards.

In 1997, project members will conduct another Laboratory-wide survey to ascertain how many employees are using standard desktop software. This survey will be a follow-up to a base-line survey that was conducted in March 1995 and will include version specifications for standard software. This information will be valuable to our Remote Electronic Desktop Integration (REDI) project as well (see the section on the REDI project). Tracking of new purchases in 1996 showed that only a small percentage of employees (0.2–5.9%) used nonstandard software, except for presentation software, an area in which there is no strong industry leader.

Library without Walls Project

The desire to increase Los Alamos researchers' productivity is driving efforts to integrate and manage digital information. The short-term goal for Los Alamos's Library without Walls (LWW) project is delivery of information to the researcher's desktop from digital library resources, and its long-term goal is creation of a network of knowledge systems to facilitate collaboration among researchers.

The LWW Project has three components: (1) archival of and electronic publishing of all unclassified, uncontrolled LA-series reports; (2) Web access to scientific citation and library databases; and (3) delivery of electronic journals to the desktop. This year the LWW project moved closer toward achieving those goals by offering several new services.

On-Line LA-Series Reports

All the unclassified, uncontrolled LA-series reports issued in paper at Los Alamos since 1943 are now on-line. To date, roughly 11,000 LA-series reports have been converted to portable document format (PDF) files and have been made available on the Web.

Web Access to Scientific Citation and Library Databases

SciSearch® at LANL is an international, multidisciplinary index to the journal literature of science and technology. The database covers 5,200 journal titles and contains 13 million citations, 200 million cited references, 95 million active hyperlinks, 15,000 weekly updates, and customized alerts with individual profiles. The research library developed the SciSearch® at LANL Weekly Alerts Service to help researchers keep pace with the explosion of scientific publications. Weekly Alerts is an automated service that can be used to track the contents of journals or subjects of interest. Users register and create individual profiles (a customized search strategy) that are then checked against the 15,000 citations added weekly to the database. New items matching the researcher's profile automatically generate an e-mail notification of the new item of interest. The LWW project

is now providing access to SciSearch® at LANL to the University of New Mexico, Sandia National Laboratories, Phillips Laboratory, and Stanford University.

The Los Alamos Unclassified Publications (LAUP) Database is a multidisciplinary database containing files of basic and applied scientific and technical literature written by the staff of Los Alamos National Laboratory, its contractors, and its collaborators from 1943 to the present. The database also includes references to other literature about Los Alamos and its history. Abstracts are included for most citations.

The LAUP Database is currently an experimental effort that is being tested by users. The database is updated twice monthly and contains 50,000 bibliographic records for technical reports. This database has been compiled for use by managers and researchers at the Laboratory. Access is currently restricted to employees of Los Alamos National Laboratory and its contractors.

Delivery of Electronic Journals to the Desktop

Building on the technology implemented for Los Alamos technical reports, the next project phase involves experimentation with the delivery of electronic journals. The Laboratory has established two objectives for this phase: (1) integrating full-image, full-text journal articles with the library catalog and (2) integrating full-image, full-text journal articles with science citation databases such as SciSearch® at LANL, the Energy Database, INSPEC, BIOSIS, and the Engineering Index.

We are collaborating with several publishers to provide electronic journals to the desktop in PDF. Publishers working with the LWW project include Academic Press, Elsevier, Institute of Physics, and American Mathematical Society. To date, 255 full-text, full-image journal titles are now available for authorized users through network connections.

The LWW project complements the Research Library's mission by providing 24-hour access to our digital library resources from anywhere our customers can connect to the Laboratory's network.

Office Automation Systems Project

The Office Automation System (OAS) is an application that Los Alamos developed to enhance collaboration among Laboratory employees by automating office processes. The OAS application provides tools for easy storage, sharing, and publishing of information. This application uses Lotus Notes as a front end. Functions include ease of communication, workflow handling, access to forum databases, archival and retrieval of Laboratory records, and access to office tools. OAS provides Laboratory-wide scalability. It supports the PC, Macintosh, and UNIX environments; Windows NT and UNIX servers; and a variety of network protocols, including transfer control protocol/Internet protocol (TCP/IP). OAS provides the following capabilities:

- a central repository from which most information can be quickly recovered using full-text searches;
- methods for
 - handling both electronic documents and images;
 - annotating all images;
 - converting an electronic document to an image for annotation and review;
 - routing documents between people on an ad hoc basis, with automatic reminders sent to people who detain a document too long; and

- editing documents in place (with no need to detach and reattach documents);
- integrated e-mail that can easily handle attachments;
- integrated calendars and scheduling;
- customizable security that selectively limits access to particular classes of documents; and
- business tools, including
 - Los Alamos Memos—a tool for writing and distributing official laboratory memos electronically;
 - Action Tracking—a tool for delegating and automatically following requested work;
 - Virtual Meetings—a method of communicating electronically for brainstorming, collaborative work, and delegation of tasks; and
 - Correspondence Management—e-mail and hard copy.

Because of the limitations of the format of the Lotus Notes database, we require a large object repository for information that must be stored but is not handled well by Lotus Notes. Documentum, which requires a connection between it and Lotus Notes, is the object repository in which we will store archived records and images. Finally, OAS is image-enabled through Adobe Acrobat.

Remote Electronic Desktop Integration Project

The REDI Project is helping to keep the Laboratory productive and competitive by reducing the costs of desktop software and services. CIC Division launched REDI in October 1996 to focus resources on improving productivity and reducing operating costs. More than 10% of the Laboratory's budget is associated with desktop computers. According to industry studies (by the Gartner Group) and Laboratory measures, each desktop computer costs about \$8,300 per year. About 70% of that cost is created by human labor, including support and administration. With well over 13,000 desktop systems in use, the Laboratory's total computer costs are more than \$100 million per year.

The mission of REDI is to reduce Laboratory costs for desktop computer acquisition, management, and support through increased efficiency and labor-saving technologies. The goal of this new effort is to reduce the current annual cost by 20%. The REDI Project is modeled after studies by the Gartner Group, an information-technology consulting firm contracted by the Laboratory. The REDI initiatives fall into three user service areas: Provide, Manage, and Help (see Figure 38).

Provide

REDI is phasing in the following services and strategies.

- The Electronic Software Distribution (ESD) service provides software installation from a remote server to desktop systems. Because nearly 50% of the costs for desktop computers are generated by manual software installation and upgrades, ESD is the cornerstone for cost-effective desktop computer management. ESD also provides on-line purchasing, server-wide virus detection, transaction security, a check of the receiving machine's capacity, auditing for conflicts, user notifications and management reports, and support for IA standard software for desktop systems.

- A volume procurement strategy obtains "best-of-breed" selections at prenegotiated prices. This strategy lowers administrative costs by reducing the number of vendor liaisons and contracts to negotiate.
- Product evaluation provides testing for usability before products are offered Laboratory-wide.

Manage

REDI is implementing software management techniques that will aid acquisition and support decisions and keep software versions current, as described below.

- Revision control will ensure that software remains up to date. Revisions are applied to software already in use and could be performed remotely or at the limited discretion of the end user.
- Hardware and software inventories can be taken remotely. This data on what desktop resources are in use is helpful for managing acquisitions, maintaining interoperability (the ability for Macintosh, IBM PC, and UNIX users to share readable computer files), ensuring legality and regulatory compliance, and making informed decisions regarding future volume purchases and other expenditures.
- Software metering electronically locates the applications in use. The computer support organization can then use this information to make purchasing decisions and to provide training and trouble-shooting assistance.

Help

Rapid problem-solving to increase user productivity will depend on intradivisional collaboration.

- Help Desk Automation will speed problem resolution and will incorporate the following features:
 - problem tracking from submission to resolution,
 - diagnostic technologies,
 - problem-resolution reporting and analysis,
 - problem-status reporting, and
 - a comprehensive-knowledge database.
- Just-in-Time Training (JITT) is an on-demand electronic help package built into a software application. These help packages in applications decrease the need for classroom and informal peer-to-peer training. Because JITT is interactive, self-paced, and applied to an immediate workplace situation, users retain a large amount of the information.
- Remote access overcomes lost work time and frustration by allowing personnel to open user-authorized sessions to other systems in the network in order to run applications, perform diagnostics, and alter and exchange files. Remote access can also provide users with one-on-one instruction.

The REDI Project will collect measurements on all its initiatives to determine technological effectiveness and customer satisfaction. Measures include service usage rates, customer surveys, site visits, and built-in electronic feedback mechanisms. REDI is committed to reducing the operational burdens on individual Laboratory organizations and providing users with the most efficient means of doing business, purchasing software and hardware, and receiving training and trouble-shooting assistance.

Figure 38. The Remote Electronic Desktop Integration Project focuses on metrics and three main service areas: providing appropriate desktop hardware and software, managing and maintaining desktop systems, and helping users by offering training and problem resolution.

E. Business Operations

At Los Alamos National Laboratory, business operations such as accounting, budgeting, procurements, property management, materials management, and transportation are centralized in the Business Operations (BUS) Division. BUS Division enables the Laboratory to accomplish national goals by providing world-class, innovative business services through empowered employees. We have set our sight on the year 2000 by when we expect to be widely recognized as having an innovative and creative workforce, achieving a level of impact and performance that creates a clear competitive advantage for the Laboratory. BUS Division's FY97 goals are aligned with Laboratory tactical goals such as Safety First!, Corporate Citizenship, and Productivity and Strategic Business Development.

Management Framework and Core Functions

Our business operations apply the concepts of empowerment and accountability. Both employees and managers are expected to solve daily operational problems, develop and implement operational changes that will improve effectiveness and efficiency, and develop capabilities to place the Laboratory in a competitive advantage. The management paradigm also includes the use of self-directed work teams. Several self-directed work teams are currently operational within various groups. Some examples include travel reservations, contract accounting, payroll in the Accounting Group, and delivery services in the Materials Management Group.

The core functions of budgeting, accounting, property management, transportation, and procurement are performed by designated groups whose members support effective business operations at the Laboratory by establishing appropriate Laboratory policies and procedures while ensuring compliance with relevant DOE orders and statutory regulations. The Systems Support Group facilitates the use of automated systems, and the Materials Management Group is responsible for operation of the liquid- and compressed-gas facility, materials receipt and distribution, and stores inventory.

Model of Distributed Services

BUS Division was the first support organization to provide distributed services to the Laboratory. The business team leaders are assigned to the field directorates and oversee all business functions (finance, procurement, and property). Customers pay only for the services that they receive by way of a recharge system. BUS Division continued its customer service feedback mechanism through Voice of the Customer (VOC), an initiative that we used to modify the division business plan. Through a series of one-on-one interviews with customers, distributed services employees gather performance information from both internal and external customers. VOC sessions conducted with DOE helped us gain very valuable insight. The information is analyzed to determine the value of the various services that are being provided to both internal and external customers. Phase II of the VOC initiative will use the information as a source in the development of employee performance criteria. By using this method of performance criteria development, we will enable employees to focus on improving the services that customers judge important to their ability to do better science and other important Laboratory technical

work. Because of the inherent desire to help their customers, employees' performance and morale is improved and customers are more satisfied with the distributed service provider. Phase II will also develop information that will map customer input, concerns, and issues onto BUS initiatives and accomplishments.

Financial Management

Financial management at the Laboratory includes accounting and direct and institutional budgeting. The Laboratory's annual budget includes over \$1 billion in operating funds and approximately \$100 million in capital and construction funds. The Laboratory has achieved a high level of compliance with DOE directives, orders, and requirements. The Laboratory has

- continued streamlining the direct-budget formulation process using an on-line budget estimating tool for all proposals;
- continued revising the process for preparing, reviewing, and approving reimbursable proposals;
- continued developing a reimbursable database for transmitting proposal packages electronically;
- documented Work for Others (WFO) policies, which are now available on the World Wide Web;
- provided training courses on WFO policies and budgeting for managers;
- streamlined the indirect-budget formulation and functional cost processes;
- enhanced the financial systems to include the resource planning module; and
- implemented several streamlining initiatives in accounting, such as cashless travel, negotiations with airlines, and other efforts that have reduced the Laboratory's cost of doing business.

Procurement Opportunities for Small Businesses

Procurement has constantly focused on being a good partner to New Mexico businesses, particularly those in Northern New Mexico. The Laboratory's outreach efforts also include active participation in the Rio Grande Minority Purchasing Council and its Northern New Mexico programs.

More than half of the Laboratory's \$1 billion operating budget is for the acquisition of goods and services necessary for operations. The Laboratory focuses on providing subcontracting opportunities to small businesses and businesses owned by women and minorities. The Laboratory has helped these businesses by

- continuing to establish set-asides (at all dollar levels) for small and small disadvantaged businesses and for all types of procurements;
- establishing small distributorships for products previously available only from large businesses;
- initiating a formal business development program that includes training for businesses on various aspects of procurement;
- providing technical assistance to small businesses responding to requests for proposals and preparing bids;
- developing an aggressive outreach program that provides information for access by small businesses; and
- initiating an aggressive outreach program for business development in Northern New Mexico.

Recognition of the Laboratory's small business programs by the U.S. Small Business Administration includes

- a National Award of Distinction in 1994 and 1995;
- an Excellent rating, 1995 Programmatic Review; and
- an Eisenhower Award of Excellence in 1994 for the most outstanding small business subcontracting program in a research and development environment.

Property Management

BUS Division's Property Management Group (PMG) oversees the protection and proper use of the Laboratory's 70,000 property-numbered items, which are worth just under \$1 billion. In FY96, the Laboratory's property management program was rated as one of the highest-performing property groups in the University of California (UC) complex. In FY96, in partnership with DOE, the PMG received two awards: (1) an Excellence Award from the Office of Management and Administration and (2) a Gold Award from the Albuquerque Operations Office Team Quality Award, which is based on the Malcolm Baldrige Quality Award criteria. These awards were for the partnering efforts between DOE and the Laboratory and their efforts and successes in implementing new initiatives which provide continuous improvement in the property management program. Some of these efforts and successes are described below.

- Consolidating all the property functions into BUS Division for effective property management and control.
- Developing a property management manual that includes applicable policies and procedures and a well-rounded property awareness and training program for Laboratory property custodians.
- Creating process improvement teams, which use continuous quality improvement (CQI) methodologies and philosophies.
- Continuously improving the Laboratory's inventory plan and processes. The Laboratory conducted its first statistical sample inventory in FY96, which resulted in the Laboratory locating 100% of its inventory sample. DOE has approved the Laboratory's proposal to conduct a statistical sample for the FY97 inventory. The Laboratory is preparing 3-year and 5-year plans for its inventory program.
- Successfully partnering with DOE to remove property-numbered items costing between \$1,000 and \$5,000 from inventory requirements. The Laboratory also successfully partnered with DOE to raise the threshold on its attractive items from \$300 to \$1,000. These initiatives truly took work off the table and resulted in significant cost savings.
- UC Contract Appendix F property management performance measures were the highest ever. In FY96, the Laboratory received a score of 95.4 from DOE. Recognition for areas of excellence included the vehicle management, management support, and cost-reduction efforts.

Materials Management

Materials management focuses on the efficient flow of inbound and outbound materials at the Laboratory. This function encompasses a variety of activities, including shipping and receiving, warehousing and distribution operations, customer service

center operations, laundry operations, liquid- and compressed-gas operations, transportation operations, and a host of additional logistics-related services.

In FY96, the Materials Management Group's priorities and strategies focused on total quality management and continuous improvement. Examples include

- implementing sweeping changes in the way we conduct business;
- developing customer service plans;
- expanding into new services;
- becoming leaner, quicker, and more competitive by eliminating duplication of effort and implementing best business practices; and
- continually resetting standards for delivering the highest possible quality at the lowest cost and improving operating performance.

UC Performance-Based Management

In concert with Vice President Gore's framework for reengineering the federal government, UC was one of the first contractors within the DOE Complex to incorporate performance-based management. The business operations portion of the Appendix F requirements, which is to be implemented by various functional managers, includes approximately 75 different performance measures to be assessed each year. At the conclusion of each fiscal year, DOE and UC independently evaluate the Laboratory's performance against those measures, and an overall rating is assigned to each area. In FY96, BUS Division led the Laboratory in improving performance in the areas of financial management, procurement, and property management. All three areas have demonstrated improved performance from that of previous years (see Table 35).

Areas of excellence identified in financial management included improving system-wide efficiency and effectiveness, cash and debt management, and processing of revenues.

In procurement, areas of excellence identified by DOE included savings of \$37 million achieved through staff reductions, subcontract negotiations, outsourcing of the cafeteria, and enhancements of procurement operations; management of government-owned property under subcontracts; acquisition planning; meeting commitments to compete subcontracts; implementing a procurement training program; and managing audits and assessments.

In property management, areas of excellence included the accountability of property, inventory of capital property, subcontractor management of government-owned property, and resolving audit findings with applicable corrective actions.

Table 35. UC Contract Appendix F Performance Measures for BUS Division.

Area	FY93	FY94	FY95	FY96
Financial Management	69.0	74.3	80.0	86.0
Procurement	80.0	83.0	88.7	96.0
Property Management	45.0	73.0	87.4	95.4

CQI and Cost Reduction Initiatives

In FY96 and year-to-date FY97, BUS Division effected excellent achievements and performance, reflecting across-the-board improvement to our business. Highlights include the following.

- Revised the Laboratory's Financial Management Information System as follows:
 - changed the methodology of general-and-administrative cost distribution to a "modified-total-cost" method.
 - implemented a time-and-effort system that includes weekly reporting of individual attendance and use of productive time.
 - revised the reporting capability of financial information to allow access to detailed transactions and graphics capabilities.
- Developed an on-line universal budget estimating tool for all Laboratory proposals.
- Negotiated a special airline rate structure for frequent destinations of Laboratory travelers, resulting in an annual savings of \$700,000 to \$1 million.
- Eliminated cash advances for official travel. This effort also included distributing airline tickets via Laboratory mail, providing direct depositing of travel reimbursement checks, and having Laboratory travelers use automated teller machines for cash advances. The total estimated savings is \$500,000.
- Continued implementing the "Fast Fab" procurement process to allow expedited placement of small fabrication purchases. Procurement cycle time was reduced from 28 days to 5 days.
- Continued implementing the Laboratory purchase card program. Issued 750 purchase cards to Laboratory staff, allowing direct purchases up to \$2,500. This effort resulted in an approximate cost savings of \$1 million in both the accounts payable and procurement areas.
- Reduced procurement cycle time by 57% (from 194 days to 84 days) for procurements.
- Implemented a common procurement policy and procedures manual for Los Alamos, Lawrence Livermore, and Lawrence Berkeley national laboratories. This effort enhanced productivity by increasing the small-purchase threshold from \$25,000 to \$100,000.

- Benchmarked various business operations for efficiency and effectiveness. Results indicate that the Laboratory compares very favorably with other similar contractors.

Key future efforts include electronic commerce, outsourcing, developing paperless systems, partnering with suppliers, surveying customers, and consolidating the vendor base. Other major initiatives involve

- developing the Total Integrated Procurement System, which will offer on-line purchase-request generation and approval, stores order placement, catalogs, vendor information, and historical procurement information;
- including a budget-allocation/budget-forecast module with the actual cost data in the Laboratory's Financial Reporting System;
- developing graphical user interfaces for both the property system and the time-and-effort system;
- developing an alternative method for road closures such as scheduling closures during early morning hours and employing unmanned barricades (for an annual projected savings of \$800,000);
- moving hazardous materials packaging and transportation to a BUS packaging and transportation core (for an annual projected savings of \$600,000);
- establishing satellite receiving operations throughout the Laboratory and implementing direct delivery by the United Parcel Service to these locations; and
- notifying requesters electronically of delivered material.

BUS Division also will continue to improve the processes for managing the Laboratory's overhead activities by including the risk/benefit assessment process. This reengineering effort aims to (1) achieve greater efficiency at lower cost for functions performed within the Laboratory and (2) outsource functions when comparable or better services are less costly in the commercial sector. The DOE Contract Reform Task Force, whose recommendations are being closely examined by the Laboratory as it seeks to improve its business operations, embraces both of these means of addressing cost reduction opportunities.

APPENDIX

IV. APPENDIX

A. Organizational Chart

B. Construction Table

Funded and Proposed Line-Item Construction Projects

Table 36 summarizes funded, budgeted, and proposed line-item construction projects for FY97 to FY03. This list is based on the FY98 *Capital Assets Management Process (CAMP)* report, which is updated through June 1997 to reflect the most recent programmatic guidance. It must be noted that the construction planning, budgeting, and funding process is very dynamic and although this table reflects current information, it will change. For each project listed in this table, there is one or more of the following drivers:

Health and Safety, Environmental, Safeguards and Security, and Mission/Investment.

General Plant Projects are not displayed in the table because of the volatility of their funding and large number of projects. In addition, construction funds for the National Ignition Facility and Accelerator Production of Tritium projects are not identified in the table because Los Alamos National Laboratory's share is undetermined.

Projects labeled 1997 and before are funded. Projects labeled 1998 and 1999 are budgeted. Projects labeled 2000 and beyond are proposed.

Table 36. Funded and Proposed Line-Item Project Construction (\$M).

	Total Estimated Cost	Prior Years	1997	1998	1999	2000	2001	2002	2003	2004 Plus
DARHT Facility, 1988	186.7	55.4	26.0	46.3	26.0	20.0	13.0			
Chemistry and Metallurgy Research Building Upgrades, 1992	174.1	52.7	15.0	15.7	27.4	27.0	20.5	15.8		
Atlas, 1996	43.3	8.4	15.1	13.4	6.4					
Fire Protection Improvements, 1996	16.9	1.5	5.0	5.5	4.9					
Water Well Replacement, G1 Thru G4, 1996	16.8	1.0	10.2	4.5	1.1					
Nonnuclear Reconfiguration, 1996	27.8	16.8	11.0							
Nuclear Materials Storage Facility Renovation, 1997	45.3		4.0	9.2	15.2	12.2	4.7			
Capability Maintenance and Improvements, 1999	382.0				22.4	59.6	98.0	102.0	65.0	35.0
Infrastructure and Facilities Revitalization, 1999	20.0				20.0					
Nuclear Materials Safeguards and Security Upgrade Project, 1999	78.3				8.0	18.0	42.0	10.3		
Los Alamos Nonproliferation and International Security Center, 1999	60.0				8.2	35.7	16.1			
Isotope Production Facility at LANSCE, 1999	10.0				6.5	2.2	1.3			
Central Health Physics Calibration Facility, 1999	3.8				3.8					
Tritium Consolidation, 2000	48.0					5.0	15.2	11.8	16.0	
Electrical Infrastructure/Safety Upgrades, 2000	50.0					2.2	13.0	15.0	9.5	10.3
Theoretical Building, 2000	30.0					2.0	23.0	5.0		
Radioactive Liquid-Waste Treatment Facility, 2000	25.0					6.0	12.0	7.0		
System Surrogate Conditioning Facility, 2000	20.0					4.0	12.0	4.0		
Low-Level Waste Volume Reduction Facility, 2000	3.5					1.0	2.5			
Infrastructure and Facilities Revitalization, 2001	20.0						20.0			

Table 36. Funded And Proposed Line-Item Project Construction (\$M). (Continued)

	Total Estimated Cost	Prior Years	1997	1998	1999	2000	2001	2002	2003	2004 Plus
High-Power Detonator Production Facility, 2001	15.0						5.0	10.0		
Trident Upgrade Project, 2001	22.6						2.0	20.6		
Long-Pulse Spallation Source at LANSCE, 2001	100.6						10.6	20.0	36.0	34.0
Dynamic Experiment Laboratory at LANSCE, 2001	30.0						4.0	21.0	5.0	
Infrastructure and Facilities Revitalization, 2002	20.0							20.0		
ES&H Institutional Training Center, 2002	15.0							5.0	5.0	5.0
Security Upgrade for ESA Facilities, 2002	13.0							5.0	5.0	3.0
Administration Building, 2002	30.0							5.0	25.0	
Infrastructure and Facilities Revitalization, 2003	20.0								20.0	
Sanitary Landfill, 2003	10.0								2.0	8.0
Funded (1997 and before)	510.9									
Budgeted (1998 and 1999)	554.1									
Proposed (2000 and beyond)	472.7									
Total	1,537.7									

Figure 39. Construction project status.

C. Resource Projections

This section summarizes Laboratory funding (operating, capital equipment, and construction) and personnel data at various levels. These summary levels include overall funding and personnel (Tables 37 and 38) and breakdown by various Secretarial Officer (Tables 39 and 40) and by major program categories (Budget and Reporting, level 2 [B&R2]) within each Assistant Secretary or office (Tables 41–54). Tables 55 and 56 reflect projections for Work for Others.

The data reflect the actual funding and full-time equivalents (FTEs) for FY96 and the Laboratory's funding and FTE projec-

tions for FY97. The projections for FY98 and beyond reflect the Laboratory's request of new Budget Authority (BA) as of publication of this document. The request also is consistent with the program guidelines received from DOE Secretarial Offices. FY99 constant dollars are used in developing estimates for FY00–FY03.

For the FY98–FY03 period, the Laboratory's planning goals and infrastructure will not allow the execution of all proposals and initiatives. Clearly, if all proposed programs and initiatives are funded during this period, the Los Alamos budget would grow unreasonably. Thus, the resource projections for FY98–FY03 assume that only some Laboratory proposals and initiatives will be funded.

1. Resource Summaries

Table 37. Laboratory Funding Summary (\$M).

Funding (\$M)	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
DOE Funding ¹	904.6	1,002.4	1,059.0	1,105.5	1,179.6	1,207.2	1,227.7	1,227.2
Work for Others	103.0	109.0	81.0	78.0	78.0	78.0	78.0	78.0
Subtotal Operating	1,007.6	1,111.4	1,140.0	1,179.5	1,257.6	1,285.2	1,305.7	1,305.2
Program Capital Equipment	49.5	56.8	53.4	76.5	69.2	67.5	66.6	67.4
Program Construction	34.6	60.3	104.0	161.0	161.0	161.0	161.0	160.0
General Plant Projects	11.0	8.0	5.0	9.0	9.0	9.0	9.0	9.0
General-Purpose Equipment	7.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total Laboratory Funding	1,109.7	1,241.5	1,307.4	1,431.0	1,501.8	1,527.7	1,547.3	1,546.6

¹DOE funding includes net of transfers to other DOE contractors.

Table 38. Laboratory Personnel Summary (FTEs).

Personnel (FTEs)	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Direct								
DOE Effort	2,994	3,091	3,190	3,230	3,350	3,424	3,406	3,341
Work for Others	365	371	306	277	277	277	277	277
Subtotal Operating	3,359	3,462	3,496	3,507	3,627	3,701	3,683	3,618
Program Capital Equipment	14	18	16	16	16	16	16	16
Program Construction	47	51	50	50	50	50	50	50
Total Direct	3,420	3,531	3,562	3,573	3,693	3,767	3,749	3,684
Total Indirect	3,340	3,380	3,380	3,380	3,380	3,380	3,380	3,380
Total Laboratory Personnel	6,760	6,911	6,942	6,953	7,073	7,147	7,129	7,064

Figure 40. Summary of Laboratory funding.

Figure 41. Summary of Laboratory personnel.

2. Resources by Secretarial Officer

Table 39. Funding by Secretarial Officer (\$M).

	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Defense Programs								
Operating	492.0	571.5	595.1	625.3	685.9	689.1	701.9	706.4
Capital Equipment	35.7	42.1	37.2	59.8	53.0	52.1	52.1	52.2
Construction	42.0	64.0	109.0	154.0	154.0	154.0	154.0	154.0
Subtotal	569.7	677.6	741.3	839.1	892.9	895.2	908.0	912.6
Environmental Restoration and Waste Management								
Operating	148.5	135.7	146.7	153.0	169.3	185.5	192.1	185.7
Capital Equipment	4.6	5.9	2.2	2.4	2.1	0.9	0.4	1.1
Construction	3.0	3.0	0.0	1.0	1.0	1.0	1.0	0.0
Subtotal	156.1	144.6	148.9	156.4	172.4	187.4	193.5	186.8
Energy Research								
Operating	65.5	68.9	69.1	70.4	71.7	73.6	74.7	76.1
Capital Equipment	6.2	4.8	11.0	11.3	11.1	11.5	11.1	11.1
Construction	0.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	72.3	75.0	80.1	81.7	82.8	85.1	85.8	87.2
Nonproliferation and International Security								
Operating	87.9	103.8	118.7	125.4	125.3	131.6	131.6	131.6
Capital Equipment	7.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0
Construction	0.0	0.0	0.0	8.0	8.0	8.0	8.0	8.0
Subtotal	94.9	107.8	123.7	138.4	138.3	144.6	144.6	144.6
Nuclear Energy								
Operating	18.0	18.0	16.0	17.0	17.0	17.0	17.0	17.0
Capital Equipment	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0
Construction	0.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0
Subtotal	19.0	20.0	18.0	27.0	27.0	27.0	27.0	27.0
Energy Efficiency and Renewable Energy								
Operating	11.0	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	11.0	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Fissile Materials Disposition								
Operating	9.7	21.6	23.0	23.0	23.0	23.0	23.0	23.0
Capital Equipment	2.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	11.7	24.6	24.0	23.0	23.0	23.0	23.0	23.0
Fossil Energy								
Operating	3.0	3.7	5.2	5.2	5.2	5.2	5.2	5.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	3.7	5.2	5.2	5.2	5.2	5.2	5.2
Environment, Safety, and Health								
Operating	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Chief Financial Officer								
Operating	3.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0
Human Resources and Administration								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Policy, Planning, and Program Evaluation								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 39. Funding by Secretarial Officer (\$M). (Continued)

	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Civilian Radioactive Waste Management								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous DOE Programs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Net Reimbursable DOE Work (Other DOE Facilities)	65.0	63.0	68.0	68.0	68.0	68.0	68.0	68.0
Subtotal DOE Operating¹	904.6	1,002.4	1,059.0	1,101.5	1,179.6	1,207.2	1,227.7	1,227.2
Work for Others								
NRC	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
DoD	52.0	54.0	39.0	40.0	40.0	40.0	40.0	40.0
HHS/NIH	8.0	11.0	6.0	4.0	4.0	4.0	4.0	4.0
NASA	9.0	7.0	5.0	5.0	5.0	5.0	5.0	5.0
EPA	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Other Federal Agencies	19.0	22.0	21.0	21.0	21.0	21.0	21.0	21.0
Private Industry	12.0	11.0	6.0	5.0	5.0	5.0	5.0	5.0
All Other Non-Federal	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Subtotal Work for Others	103.0	109.0	81.0	78.0	78.0	78.0	78.0	78.0
Total Program Funding	1,007.6	1,111.4	1,140.0	1,179.5	1,257.6	1,285.2	1,305.7	1,305.2
Program Capital Equipment	49.5	56.8	53.4	76.5	69.2	67.5	66.6	67.4
General-Purpose Equipment	7.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total Capital Equipment	56.5	61.8	58.4	81.5	74.2	72.5	71.6	72.4
Program Construction	34.6	60.3	104.0	161.0	161.0	161.0	161.0	160.0
General Plant Projects	11.0	8.0	5.0	9.0	9.0	9.0	9.0	9.0
General-Purpose Facilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Proposed Construction ²	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total GPP/Construction³	45.6	68.3	109.0	170.0	170.0	170.0	170.0	169.0

¹DOE Funding includes net of transfers to other DOE contractors.²Proposed Construction is an optional estimate of future construction funding.³Total GPP/Construction is also included in the individual program construction funding.

Figure 42. Summary of funding by Secretarial Officer.

Figure 43. Funding by Secretarial Officer (by year.)

Table 40. Personnel by Secretarial Officer (FTEs).

Description	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Defense Programs	1,752	1,866	1,871	1,916	2,021	2,081	2,071	2,041
Environmental Restoration and Waste Management	351	321	325	325	347	368	367	340
Energy Research	245	236	238	233	226	219	212	205
Nonproliferation and National Security	287	279	347	348	348	348	348	348
Nuclear Energy	42	41	32	31	31	31	31	31
Energy Efficiency and Renewable Energy	36	41	53	51	51	51	51	51
Fissile Materials Disposition	39	78	73	71	71	71	71	71
Fossil Energy	12	17	25	29	29	29	29	28
Environment, Safety, and Health	4	5	4	4	4	4	4	4
Chief Financial Officer	1	1	0	0	0	0	0	0
Human Resources and Administration	0	0	0	0	0	0	0	0
Policy, Planning and Program Evaluation	0	0	0	0	0	0	0	0
Civilian Radioactive Waste Management	0	0	0	0	0	0	0	0
Miscellaneous DOE Programs	0	0	0	0	0	0	0	0
Net Reimbursable DOE Work (Other DOE Facilities)	225	206	222	222	222	222	222	222
Subtotal DOE Programs	2,994	3,091	3,190	3,230	3,350	3,424	3,406	3,341
Work for Others								
NRC	9	7	6	5	5	5	5	5
DoD	149	147	117	105	105	105	105	105
HHS/NIH	39	43	34	31	31	31	31	31
NASA	35	21	17	15	15	15	15	15
EPA	3	3	3	3	3	3	3	3
Other Federal Agencies	64	77	66	59	59	59	59	59
Private Industry	66	69	60	56	56	56	56	56
All Other Non-Federal	0	4	3	3	3	3	3	3
Subtotal Work for Others	365	371	306	277	277	277	277	277
Total Direct Personnel for Program Effort	3,359	3,462	3,496	3,507	3,627	3,701	3,683	3,618
Program Capital Equipment	14	18	16	16	16	16	16	16
Program Construction	42	46	45	45	45	45	45	45
General-Purpose Equipment	0	0	0	0	0	0	0	0
General Plant Projects	5	5	5	5	5	5	5	5
General-Purpose Facilities	0	0	0	0	0	0	0	0
Proposed Construction	0	0	0	0	0	0	0	0
Total Direct Personnel	3,420	3,531	3,562	3,573	3,693	3,767	3,749	3,684
Total Indirect Personnel	3,340	3,380	3,380	3,380	3,380	3,380	3,380	3,380

Figure 44. Summary of personnel by Secretarial Officer.

Figure 44. Summary of personnel by Secretarial Officer. (Continued)

3. Resources by Subprogram

Table 41. Defense Programs (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
DP01 – Stockpile Stewardship								
Operating	234.0	276.1	282.8	264.2	281.5	281.5	281.5	281.5
Capital Equipment	28.0	39.3	30.3	50.0	40.0	40.0	40.0	40.0
Construction	32.0	51.0	73.0	69.0	69.0	69.0	69.0	69.0
Subtotal	294.0	376.0	386.1	383.2	390.5	390.5	390.5	390.5
Direct Personnel (FTEs)	845	878	912	854	883	883	883	883
DP02 – Inertial Confinement Fusion								
Operating	21.0	23.8	22.0	21.9	21.9	21.9	21.9	21.9
Capital Equipment	0.3	0.6	0.2	0.2	0.2	0.2	0.2	0.2
Construction	1.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0
Subtotal	22.3	26.4	23.2	22.0	22.0	22.0	22.0	22.0
Direct Personnel (FTEs)	86	90	86	86	86	86	86	86
DP03 – Technology Transfer and Education								
Operating	37.7	18.6	17.6	13.6	13.6	13.6	13.6	13.6
Capital Equipment	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	38.1	18.8	17.8	13.7	13.7	13.7	13.7	13.7
Direct Personnel (FTEs)	133	86	65	53	51	145	145	145
DP04 – Weapons Stockpile Management								
Operating	192.6	248.8	269.7	322.6	365.9	369.1	381.9	386.4
Capital Equipment	7.0	2.0	6.5	9.5	12.7	11.8	11.8	11.9
Construction	9.0	11.0	35.0	85.0	85.0	85.0	85.0	85.0
Subtotal	208.6	261.8	311.2	417.1	463.6	465.9	478.7	483.3
Direct Personnel (FTEs)	684	807	803	918	996	996	952	922
DP05 – Program Direction								
Operating	0.7	3.6	3.0	3.0	3.0	3.0	3.0	3.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.7	3.6	3.0	3.0	3.0	3.0	3.0	3.0
Direct Personnel (FTEs)	1	5	5	5	5	5	5	5
GB1017 – Stabilization								
Operating	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	2	0	0	0	0	0	0	0

Table 41. Defense Programs (\$M). (Continued)

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
DP – Total Funding for Weapons Activities								
Operating	487.0	571.5	595.1	625.3	685.9	689.1	701.9	706.4
Capital Equipment	35.7	42.1	37.2	59.8	53.0	52.1	52.1	52.2
Construction	42.0	64.0	109.0	154.0	154.0	154.0	154.0	154.0
Total	564.7	677.6	741.3	839.1	892.9	895.2	908.0	912.6
Direct Personnel (FTEs)	1,751	1,866	1,871	1,916	2,021	2,081	2,071	2,041
GG – Worker and Community Transition Program								
Operating	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	1	0	0	0	0	0	0	0
DP – Total Funding for Defense Programs								
Operating	492.0	571.5	595.1	625.3	685.9	689.1	701.9	706.4
Capital Equipment	35.7	42.1	37.2	59.8	53.0	52.1	52.1	52.2
Construction	42.0	64.0	109.0	154.0	154.0	154.0	154.0	154.0
Total	569.7	677.6	741.3	839.1	892.9	895.2	908.0	912.6
Direct Personnel (FTEs)	1,752	1,866	1,871	1,916	2,021	2,081	2,071	2,041

Table 42. Environmental Restoration and Waste Management (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
EW – Environmental Restoration and Waste Management – Defense								
Operating	145.3	134.3	146.7	153.0	169.3	185.5	192.1	185.7
Capital Equipment	4.5	5.9	2.2	2.4	2.1	0.9	0.4	1.1
Construction	3.0	3.0	0.0	1.0	1.0	1.0	1.0	0.0
Subtotal	152.8	143.2	148.9	156.4	172.4	187.4	193.5	186.8
Direct Personnel (FTEs)	349	321	325	325	347	368	367	340
EX – Environmental Restoration and Waste Management – Non-Defense								
Operating	3.2	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.3	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	2	0	0	0	0	0	0	0
Total Funding for Environmental Restoration and Waste Management								
Operating	148.5	135.7	146.7	153.0	169.3	185.5	192.1	185.7
Capital Equipment	4.6	5.9	2.2	2.4	2.1	0.9	0.4	1.1
Construction	3.0	3.0	0.0	1.0	1.0	1.0	1.0	0.0
Subtotal	156.1	144.6	148.9	156.4	172.4	187.4	193.5	186.8
Direct Personnel (FTEs)	351	321	325	325	347	368	367	340

Table 43. Energy Research (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
AT – Magnetic Fusion								
Operating	4.4	3.7	3.3	4.3	4.4	4.5	4.5	4.6
Capital Equipment	0.4	0.3	0.3	0.1	0.1	0.1	0.1	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	4.8	4.0	3.6	4.4	4.5	4.6	4.6	4.7
Direct Personnel (FTEs)	17	12	11	14	14	13	13	12
KA – High-Energy Physics								
Operating	0.7	0.8	0.7	0.7	0.7	0.8	0.8	0.8
Capital Equipment	0.2	0.1	0.1	0.0	0.0	0.4	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.9	0.9	0.8	0.7	0.7	1.2	0.8	0.8
Direct Personnel (FTEs)	3	3	4	3	3	3	3	3
KB – Nuclear Physics								
Operating	11.4	10.7	10.4	10.4	10.6	10.8	11.0	11.2
Capital Equipment	1.4	0.8	0.4	0.4	0.4	0.4	0.4	0.4
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	12.8	11.5	10.8	10.8	11.0	11.2	11.4	11.6
Direct Personnel (FTEs)	44	39	31	30	30	30	30	30
KC – Basic Energy Sciences								
Operating	29.2	19.6	18.3	18.3	18.7	19.1	19.5	19.8
Capital Equipment	2.9	1.9	6.7	6.8	6.8	6.8	6.8	6.8
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	32.1	21.5	25.0	25.1	25.5	25.9	26.3	26.6
Direct Personnel (FTEs)	103	61	62	60	58	56	54	52
KD – Energy Research Analyses								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
KJ – Computer and Technology Research								
Operating	0.0	13.8	13.5	13.3	13.5	14.1	14.1	14.4
Capital Equipment	0.0	0.7	0.8	0.8	0.8	0.8	0.8	0.8
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	14.5	14.3	14.1	14.3	14.9	14.9	15.2
Direct Personnel (FTEs)	0	46	43	41	39	38	36	35
KP – Biological and Environmental Research								
Operating	19.0	20.0	22.9	23.4	23.8	24.3	24.8	25.3
Capital Equipment	1.3	1.0	2.7	3.2	3.0	3.0	3.0	3.0
Construction	0.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Total	20.9	22.3	25.6	26.6	26.8	27.3	27.8	28.3
Direct Personnel (FTEs)	78	75	87	85	82	79	76	73
KT – University and Science Education								
Operating	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Energy Research								
Operating	65.5	68.9	69.1	70.4	71.7	73.6	74.7	76.1
Capital Equipment	6.2	4.8	11.0	11.3	11.1	11.5	11.1	11.1
Construction	0.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Total	72.3	75.0	80.1	81.7	82.8	85.1	85.8	87.2
Direct Personnel (FTEs)	245	236	238	233	226	219	212	205

Table 44. Nonproliferation and National Security (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
GC – Verification and Control Technology								
Operating	54.2	60.1	60.5	63.5	60.3	63.3	63.3	63.3
Capital Equipment	4.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	58.2	63.1	63.5	66.5	63.3	66.3	66.3	66.3
Direct Personnel (FTEs)	182	191	201	201	201	201	201	201
GD – Nuclear Safeguards and Security								
Operating	7.9	6.5	9.0	9.0	10.0	10.0	10.0	10.0
Capital Equipment	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	8.9	7.5	10.0	10.0	11.0	11.0	11.0	11.0
Direct Personnel (FTEs)	26	22	29	30	30	30	30	30
GJ – Export Control, Nonproliferation and International								
Operating	20.2	31.7	41.6	44.9	46.6	49.5	49.5	49.5
Capital Equipment	2.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Construction	0.0	0.0	0.0	8.0	8.0	8.0	8.0	8.0
Subtotal	22.2	31.7	42.6	53.9	55.6	58.5	58.5	58.5
Direct Personnel (FTEs)	56	44	92	92	92	92	92	92
ND – Emergency Management								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
ND – Intelligence								
Operating	5.6	5.5	7.6	8.0	8.4	8.8	8.8	8.8
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	5.6	5.5	7.6	8.0	8.4	8.8	8.8	8.8
Direct Personnel (FTEs)	23	22	25	25	25	25	25	25
Total Funding for Nonproliferation and National Security								
Operating	87.9	103.8	118.7	125.4	125.3	131.6	131.6	131.6
Capital Equipment	7.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0
Construction	0.0	0.0	0.0	8.0	8.0	8.0	8.0	8.0
Subtotal	94.9	107.8	123.7	138.4	138.3	144.6	144.6	144.6
Direct Personnel (FTEs)	287	279	347	348	348	348	348	348

Table 45. Nuclear Energy (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
AF – Nuclear Energy Research and Development								
Operating	13.0	11.0	11.0	12.0	12.0	12.0	12.0	12.0
Capital Equipment	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	14.0	13.0	13.0	14.0	14.0	14.0	14.0	14.0
Direct Personnel (FTEs)	21	15	15	15	15	15	15	15
CD – Uranium Programs								
Operating	0.0	3.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	3.0	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel (FTEs)	0	9	2	1	1	1	1	1
KK05 – Policy and Management – NE								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	1	0	0	0	0	0	0	0
ST – Isotope Production and Distribution Program								
Operating	5.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Capital Equipment	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0
Construction	0.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0
Subtotal	5.0	4.0	4.0	12.0	12.0	12.0	12.0	12.0
Direct Personnel (FTEs)	20	17	15	15	15	15	15	15
Total Funding for Nuclear Energy								
Operating	18.0	18.0	16.0	17.0	17.0	17.0	17.0	17.0
Capital Equipment	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0
Construction	0.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0
Subtotal	19.0	20.0	18.0	27.0	27.0	27.0	27.0	27.0
Direct Personnel (FTEs)	42	41	32	31	31	31	31	31

Table 46. Energy Efficiency and Renewable Energy (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
AK – Electrical Energy Systems								
Operating	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	12	0	0	0	0	0	0	0
AM – Geothermal Systems								
Operating	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	5	0	0	0	0	0	0	0
AR – Hydrogen Research								
Operating	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	1	0	0	0	0	0	0	0
EB – Solar Energy								
Operating	0.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Direct Personnel (FTEs)	0	20	25	26	26	26	26	26
EC – Buildings Sector								
Operating	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
ED – Industrial Sector								
Operating	3.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Direct Personnel (FTEs)	10	7	8	8	8	8	8	8
EE – Transportation Sector								
Operating	2.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	2.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Direct Personnel (FTEs)	8	14	20	17	17	17	17	17
WB – In-House Energy Management								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Energy Efficiency and Renewable Energy								
Operating	11.0	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	11.0	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Direct Personnel (FTEs)	36	41	53	51	51	51	51	51

Table 47. Fissile Materials Disposition (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
GA – Fissile Materials Disposition								
Operating	9.7	21.6	23.0	23.0	23.0	23.0	23.0	23.0
Capital Equipment	2.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	11.7	24.6	24.0	23.0	23.0	23.0	23.0	23.0
Direct Personnel (FTEs)	39	78	73	71	71	71	71	71
Total Funding for Fissile Materials Disposition								
Operating	9.7	21.6	23.0	23.0	23.0	23.0	23.0	23.0
Capital Equipment	2.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	11.7	24.6	24.0	23.0	23.0	23.0	23.0	23.0
Direct Personnel (FTEs)	39	78	73	71	71	71	71	71

Table 48. Fossil Energy (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
AA – Coal								
Operating	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
AB – Gas								
Operating	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	6	4	0	0	0	0	0	0
AC – Petroleum								
Operating	2.0	2.2	4.5	4.5	4.5	4.5	4.5	4.5
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	2.0	2.2	4.5	4.5	4.5	4.5	4.5	4.5
Direct Personnel (FTEs)	6	13	25	27	27	27	27	27
AZ – Innovative Clean Coal Technology								
Operating	0.0	0.4	0.7	0.7	0.7	0.7	0.7	0.7
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.4	0.7	0.7	0.7	0.7	0.7	0.7
Direct Personnel (FTEs)	0	0	0	2	2	2	2	2
CB – Naval Petroleum and Oil Shale Reserves								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Fossil Energy								
Operating	3.0	3.7	5.2	5.2	5.2	5.2	5.2	5.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	3.7	5.2	5.2	5.2	5.2	5.2	5.2
Direct Personnel (FTEs)	12	17	25	29	29	29	29	28

Table 49. Environment, Safety, and Health (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
HA – Environmental Safety and Health								
Operating	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	4	5	0	0	0	0	0	0
HC – Environmental Safety and Health – Non-Defense								
Operating	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel (FTEs)	0	0	4	4	4	4	4	4
HP – Nuclear Safety Policy								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
NR – Radiological Oversight								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
NS – Nuclear Safety Oversight								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Environment, Safety, and Health								
Operating	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel (FTEs)	4	5	4	4	4	4	4	4

Table 50. Chief Financial Officer (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
WN – Cost of Goods Sold								
Operating	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	1	1	0	0	0	0	0	0
Total Funding for Chief Financial Officer								
Operating	3.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	1	1	0	0	0	0	0	0

Table 51. Human Resources and Administration (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
WM – General Administration – Contractual Services								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Human Resources and Administration								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0

Table 52. Policy, Planning, and Program Evaluation (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
PE – Policy Analysis and Systems Studies								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Policy, Planning, and Program Evaluation								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0

Table 53. Civilian Radioactive Waste Management (\$M).

Resources by Subprogram	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
PE – Policy Analysis and Systems Studies								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Total Funding for Policy, Planning, and Program Evaluation								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0

Table 54. Total Program Resources (\$M).

	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Total DOE Reimbursables	65.0	63.0	68.0	68.0	68.0	68.0	68.0	68.0
Direct Personnel (FTEs)	225	206	222	222	222	222	222	222
DOE Totals								
Operating	904.6	1,002.4	1,059.0	1,101.5	1,179.6	1,207.2	1,227.7	1,227.2
Capital Equipment	56.5	61.8	58.4	81.5	74.2	72.5	71.6	72.4
Construction	45.6	68.3	109.0	170.0	170.0	170.0	170.0	169.0
DOE Total	1,006.7	1,132.5	1,226.4	1,353.0	1,423.8	1,449.7	1,469.3	1,468.6
Direct Personnel (FTEs)	2,994	3,091	3,190	3,230	3,350	3,424	3,406	3,341
Work for Others								
NRC	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
DoD	52.0	54.0	39.0	40.0	40.0	40.0	40.0	40.0
HHS/NIH	8.0	11.0	6.0	4.0	4.0	4.0	4.0	4.0
NASA	9.0	7.0	5.0	5.0	5.0	5.0	5.0	5.0
EPA	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Other Federal Agencies	19.0	22.0	21.0	21.0	21.0	21.0	21.0	21.0
Private Industry	12.0	11.0	6.0	5.0	5.0	5.0	5.0	5.0
All Other Non-Federal	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Work for Others	103.0	109.0	81.0	78.0	78.0	78.0	78.0	78.0
Direct Personnel (FTEs)	365	371	306	277	277	277	277	277
Laboratory-wide Program Funding Totals								
Operating	1,007.6	1,111.4	1,140.0	1,179.5	1,257.6	1,285.2	1,305.7	1,305.2
Capital Equipment	56.5	61.8	58.4	81.5	74.2	72.5	71.6	72.4
Construction	45.6	68.3	109.0	170.0	170.0	170.0	170.0	170.0
Total Program Funding	1,109.7	1,241.5	1,307.4	1,431.0	1,501.8	1,527.7	1,547.3	1,546.6
Total Direct Personnel f(FTEs)								
Direct Personnel	3,359	3,462	3,496	3,507	3,627	3,701	3,683	3,618
Capital Equipment	14	18	16	16	16	16	16	16
Construction ¹	47	51	50	50	50	50	50	50
Total Direct Personnel	3,420	3,531	3,562	3,573	3,693	3,767	3,749	3,684

Table 55. Subcontracting and Procurement (\$M).¹

	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Subcontracting and Procurement from								
Universities	11.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
All Others	602.0	575.0	575.0	575.0	575.0	575.0	575.0	575.0
Transfers to Other DOE Facilities	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Total External Subcontracts and Procurements	622.0	594.0	594.0	594.0	594.0	594.0	594.0	594.0

¹Total dollars obligated within each fiscal year.**Table 56. Small and Disadvantaged Business Procurement (\$M).¹**

	Actual Cost FY96	Projected Cost FY97	BA FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03
Total Procurement from								
Small and Disadvantaged Businesses	335.0	262.0	262.0	262.0	262.0	262.0	262.0	262.0
Transfers to Other DOE Facilities	54%	44%	44%	44%	44%	44%	44%	44%

¹Total dollars obligated within each fiscal year.

D. Cited Documents and Web Sites

Cited Documents

Appendix F of the DOE/UC Contract (W-7406-ENG-36)

Los Alamos National Laboratory FY96–FY98 Tactical Plan (LALP-96-51)

Los Alamos National Laboratory Strategic Overview, 1996–2015 (LALP-96-31)

NIS Self-Assessment (NIS-96-078)

FY 1996 Site Development Plan—Annual Plan (published in May 1996)

FY 1997 Capital Assets Management Process (CAMP) (published in May 1996)

FY 1999 Annual Controller's Budget Book

Performance Agreement Between the President and the Secretary of Energy, Fiscal Year 1996

DOE Laboratory Operations Board's Strategic Missions Plan, July 1996

U.S. Department of Energy, Albuquerque Operations Office FY1996 Performance Appraisal of the Los Alamos National Laboratory

Cited Web Sites

Performance Agreement Between the President and the Secretary of Energy, Fiscal Year 1996
(http://www.doe.gov/policy/library/all_pr.html)

DOE Laboratory Operations Board's Strategic Laboratory Missions Plan, July 1996
http://www.er.doe.gov/production/er-07/er-7_cr.html

Strategic Overview
<http://www.lanl.gov/subject/planning/>

DOE Mission Statement
<http://www.doe.gov/html/doe/about/doemissn.html>

Department's Core Values
<http://www.doe.gov/html/doe/about/doevalus.html>

Laboratory's Tactical Plan
<http://www.lanl.gov/subject/planning/>

The role of the Division Review Committees
<http://stb.lanl.gov/P&A/P&A.html>

Descriptions of Integrated Science and Technology Program Technologies
<http://www-emtd.lanl.gov>

Los Alamos Application for the 1997 DOE Quality Awards (LA-UR-97-1233)
<http://iosun.lanl.gov:2001/pdfs/doeqtext/97qaward.pdf>

E. ACRONYMS

ACIS	Automated Chemical Inventory System	FMU	Facility Management Unit
ACL	Advanced Computing Laboratory	FSS	Facilities, Security and Safeguards
ADaPT	Advanced Design and Production Technology	FSU	former Soviet Union
ALARA	as low as reasonably achievable	FXR	flash x-ray facility
ALEXIS	array of low-energy x-ray imaging sensors	GA	General Atomic
APT	Accelerator Production of Tritium	GEANIE	germanium array for neutron-induced excitations
ARIES	Advanced Recovery and Integrated Extraction System	HEPA	high-efficiency particulate air
ARM	Atmospheric Radiation Monitoring	HEU	highly enriched uranium
ASCI	Accelerated Strategic Computing Initiative	HIGRAD	high resolution and strong gradient
ATW	accelerator-driven transmutation of waste	HIPPI	high-performance parallel interface
BR	Burns & Roe Enterprises, Inc.	HPC	high-performance computing
BUS	Business Operations	HPCC	High-Performance Computing and Communications
CAM	continuous air monitor	HPSS	High-Performance Storage System
CAMP	Capital Asset Management Process	HR	Human Resources
CBW	chemical and biological weapon	HSWA	Hazardous and Solid Waste Amendment
CD	Competency Development	HTSC	high-temperature superconductor
CDAC	Career Development Advisory Council	IAEA	International Atomic Energy Agency
CERN	European Center for Nuclear Research	ICF	Inertial Confinement Fusion
CIC	Computing, Information, and Communications	IM	Information Management
CHAMMP	Computer Hardware, Advanced Mathematics, and Model Physics	IP	Individual Projects
CHGS	Center for Human Genome Studies	IPPE	Institute for Physics and Power Engineering
CISA	Center for International Security Affairs	ISM	Integrated Safety Management
CITPO	Civilian Industrial Technology Program Office	JBREWS	Joint Biological Remote Early Warning System
CLC	Campus-Laboratory Collaborations	JGI	Joint Genome Institute
CMR	Chemistry and Metallurgy Research	JITT	Just-in-Time Training
CQI	continuous quality improvement	LAAO	Los Alamos Area Office
CRADA	cooperative research and development agreement	LACEF	Los Alamos Critical Experiments Facility
CRI	Cray Research, Inc.	LANSCE	Los Alamos Neutron Science Center
CTBT	Comprehensive Test Ban Treaty	LAUP	Los Alamos Unclassified Publications
DARHT	dual-axis radiography hydrotest	LBE	lead bismuth eutectic
DLF	directed-light fabrication	LDRD	Laboratory-Directed Research and Development
DNFSB	Defense Nuclear Facilities Safety Board	LIDAR	light detection and ranging
DoD	Department of Defense	LIG	Laboratory implementing guidance
DOE	Department of Energy	LIR	Laboratory implementing requirement
DOE/AL	DOE Albuquerque Operations Office	LLMW	low-level mixed waste
DOE-EE	DOE Office of Energy Efficiency and Renewable Energy	LLRW	low-level radioactive waste
DOE-NN	DOE Office of Nonproliferation and National Security	LPR	Laboratory performance requirement
DOT	Department of Transportation	LPSS	long-pulse spallation source
DP	Defense Programs	LSND	Liquid Scintillator Neutrino Detector
DRC	division review committee	LWW	Library without Walls
DSWA	Defense Special Weapons Agency	MC&A	Material Control and Accounting
EA	Environmental Assessment	MOX	mixed oxides
ESD	Electronic Software Distribution	MPC&A	Material Protection, Control, and Accounting
EIS	environmental impact statement	MSDS	material safety data sheet
EM	Environmental Management	NBC	Nuclear, Biological, and Chemical
EOS	equation of state	NEPA	National Environmental Policy Act
EPA	Environmental Protection Agency	NHMFL	National High Magnetic Field Laboratory
ER	Environmental Restoration	NIH	National Institutes of Health
ES&H	environment, safety, and health	NIS	Nonproliferation and International Security
ET	Energy Technology	NMED	New Mexico Environmental Department
FHWA	Federal Highway Administration	NMSF	Nuclear Materials Storage Facility
FLC	Federal Laboratory Consortium	NMSM	Nuclear Materials and Stockpile Management
FM	facility management	NNMT	Nonnuclear Munitions Technology
		NPT	Nonproliferation Treaty
		NRC	Nuclear Regulatory Commission
		NSF	National Science Foundation
		NWT	Nuclear Weapons Technology

OAS	Office Automation System
OER	Office of Energy Research
OTHER	Office of Health and Environmental Research
ORTA	Office of Research and Technical Assistance
PD	Program Development
PDF	portable document format
PHENIX	Pioneering High-Energy Nuclear Ion Experiment
PHERMEX	pulsed high-energy radiographic machine emitting x-rays
POOMA	Parallel Object-Oriented Methods and Applications
PSR	proton storage ring
QMS	Quality Management System
R&D	research and development
REDI	Remote Electronic Desktop Integration
RF	radio frequency
RHIC	Relativistic Heavy-Ion Collider
RMCS	rotary mode core sampling
SBSS	Science-Based Stockpile Stewardship
SDP	Site Development Plan
SERS	Science and Engineering Research Semester
SME	Science and Math Education
SNL	Sandia National Laboratories
SNM	special nuclear materials
SNO	Sudbury Neutrino Observatory
SPSS	short-pulse spallation source
SRL	special recovery line
START	Strategic Arms Reduction Treaty
STB	Science and Technology Base
SWEIS	Sitewide Environmental Impact Statement
SWP	saltwell pumping
TA	Technical Area
TA-55	Plutonium Facility
TCE	trichloroethylene
TCP/IP	transfer control protocol/Internet protocol
TRANSIMS	Transportation Analysis and Simulation System
TRIPLE	Time Reversal Invariance and Parity at Low Energies
TRU	transuranic
TSI	Technical Site Information
UAV	unmanned aerial vehicle
UC	University of California
UCDRD	University of California Directed Research and Development
UCOP	University of California Office of the President
ULISSES	uranium line for special separation science
VOC	Voice of the Customer
WETF	Weapons Engineering Tritium Facility
WFO	Work for Others
WM	Waste Management
WMD	weapons of mass destruction
WNR	Weapons Neutron Research
WR	War Reserve

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