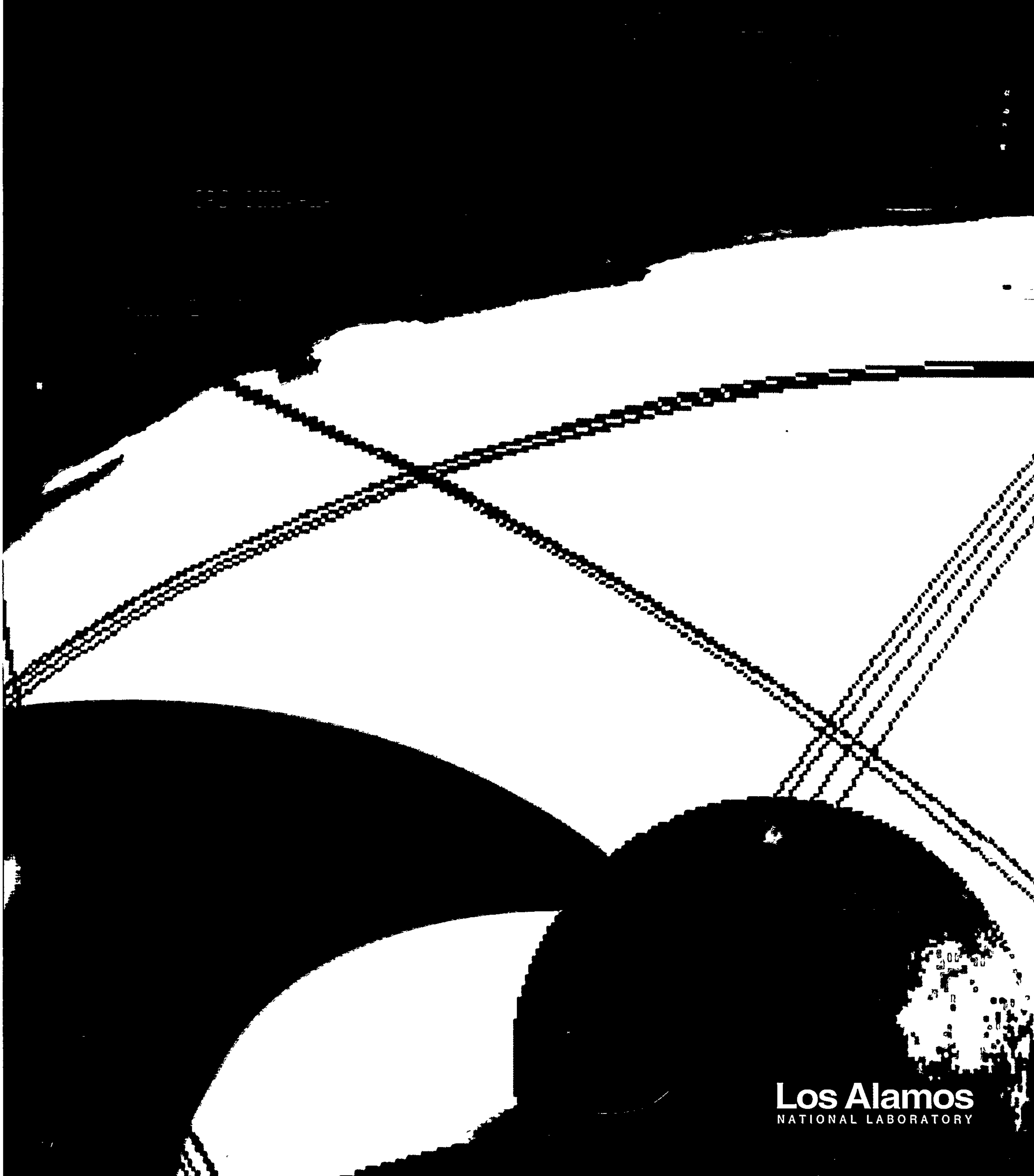
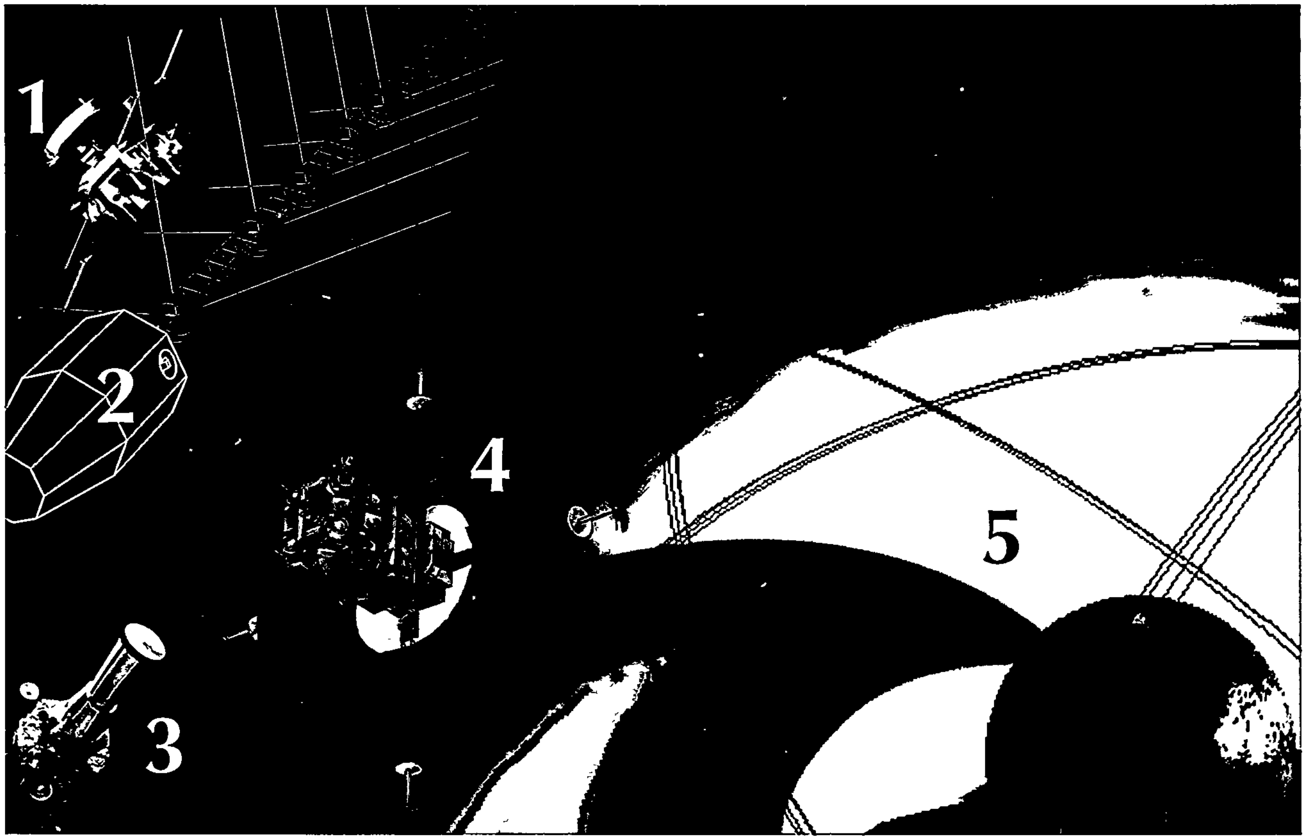
INSTITUTIONAL PLAN

FY 1999–FY 2004



Los Alamos
NATIONAL LABORATORY



About the cover: During the past 40 years, Los Alamos has played a significant role in the nation's space program by uniquely combining national security missions with leading-edge investigations of space science and space technology. In 1997 alone, for example, more than two dozen Los Alamos instruments traveled into space on satellites and space probes. On the cover, we highlight a few of Los Alamos' recent accomplishments in space research. (1) The Advanced Composition Explorer is a NASA satellite carrying a Los Alamos plasma composition spectrometer for measuring the solar wind. (2) The Fast On-orbit Recording of Transient Events (FORTÉ) satellite is an experimental satellite developed at Los Alamos and launched in August 1997. It features a 35-foot antenna attached to a 7-foot-long spacecraft and is collecting radio-frequency and optical data associated with atmospheric electrical events such as lightning. (3) Ten Los Alamos instruments are carried on-board the Defense Support Program (DSP) satellite, shown emerging from the bay of the space shuttle. (4) Another Los Alamos experimental satellite, the Array of Low-Energy X-Ray Imaging Sensors (ALEXIS), was launched in April 1993 and continues to measure celestial low-energy x-rays and radio-frequency emissions of atmospheric electrical events. (5) This Air Force Research Laboratory model shows the relativistic electron fluxes trapped in the Earth's Van Allen Radiation Belts. Illustrated are both the outer shell (yellow tinged with green) and a cross-sectional slice (multicolor) of a particular belt. Also shown in this model are the spacecraft trajectories for the Global Positioning System (GPS) satellites. In addition to the Los Alamos-built sensors to detect nuclear explosions, both the GPS and DSP satellites carry Los Alamos sensors to measure conditions in the space environment that can adversely affect spacecraft operations and mission performance.

LALP-98-66
OCTOBER 1998

INSTITUTIONAL PLAN
FY 1999–FY 2004

Los Alamos
NATIONAL LABORATORY

Los Alamos, New Mexico 87545

DISCLAIMER

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PREFACE

The Institutional Plan is an integrated, single-document summary of Los Alamos National Laboratory's internal plans and their connections to the plans of the Department of Energy (DOE). The links among the Department plans, institutional plans, the program plans, and the infrastructure and support plans are more clearly visible because they are summarized in one document.

This is the first Institutional Plan produced under the present Laboratory Director, John C. Browne. Doctor Browne became the Director of the Laboratory in November 1997. Since then, the Director has taken several actions to help ensure that Los Alamos carries out its mission using effective leadership and management systems. Including the Director, a seven-person senior executive team will be responsible for institutional performance and planning in all areas. Three Deputy Directors oversee all areas of the Laboratory. They are the Deputy Director for Science, Technology, and Programs; the Deputy Director for Operations; and the Deputy Director for Business Administration and Outreach. In addition, there are three Associate Laboratory Directors who manage the science and technology programs and activities.

To support the Laboratory focus on integrating its planning and performance-related activities, the Institutional Plan has been organized to reflect the new management system.

In Section I of this plan, we set forth our vision, mission, core competencies, guiding principles, key focus areas, and goals. We address how we measure our performance through the contract between the University of California and the Department. This section illustrates integration with the vision, mission, priorities, core businesses, and the Strategic Goals and Objectives of the DOE's Strategic Plan of September 1997. Through these links, we illustrate that our programs support the Secretary of Energy's 1998 Agreement with the President of the United States.

Section II describes the plans that fall under the administration of the Deputy Director for Science, Technology, and Programs. They are sorted according to the three Associate Laboratory Directorates, which are Nuclear Weapons, Threat Reduction, and Strategic and Supporting Research. Programs within each Associate Directorate present their plans accompanied by a funding table. Section III.A contains the plans and activities that are the responsibility of the Deputy Director for Operations, including plans of the Integrated Safety Management Program; institutional Environment, Safety, and Health; Site and Facilities; and Security and Safeguards. Section III.B presents the plans for areas that are the responsibility of the Deputy Director for Business Administration and Outreach. These areas are Human Resources, Business Operations, Community Involvement and Outreach, Public Affairs, Information Management, and Audits and Assessment.

This Institutional Plan is used increasingly as both a planning reference and an overview of the Laboratory by DOE and other funding agencies, the University of California, other national laboratories, local governments, corporate consultants, mangers at the Laboratory, and the public.

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DIRECTOR'S STATEMENT

When I became the Director of Los Alamos National Laboratory in November 1997, it was again brought home to me that the Laboratory has two great strengths, a strong core mission—to reduce the global nuclear danger—and dedicated employees.

First let me address the mission of the Laboratory and the management structure I have instituted to strengthen our approach to performing this mission. The national security objective to ensure the safety, reliability, and performance of the nuclear stockpile remains unchanged from previous years. However, the conditions under which this objective must be accomplished have changed a great deal since the early 1990s. The Laboratory is meeting this stockpile challenge through enhanced surveillance of the stockpile, advanced subcritical and nonnuclear experiments, and computer simulations in place of nuclear testing.

The threat reduction part of our national security mission addresses the need to provide scientific and technical solutions to the broad range of problems that threaten our national security. This element of our mission will continue to grow in importance as a new nuclear test ban treaty is put in place and the proliferation of chemical, biological, or nuclear weapons remains a significant threat.

In addressing our national security missions, we have developed a strong foundation of technical capabilities that we use to address complex, nondefense-related national problems for which science and technology can help produce a solution. Addressing such problems provides a dual benefit. We not only leverage the national investment in defense by applying the capabilities developed for our national security mission to other national problems, but we also enhance our scientific edge and strengthen our capabilities for addressing our national security mission.

To provide strong leadership and focus in these three broad areas of our mission, I have placed each one under the leadership of an Associate Laboratory Director. The three Associate Laboratory Directors (Nuclear Weapons, Threat Reduction, and Strategic and Supporting Research) report to me and to the Deputy Laboratory Director for Science, Technology and Programs.

As I have mentioned, we have a workforce of dedicated employees. People here care deeply about this Laboratory. Their quality, diversity, and commitment to excellence are what make us successful in our mission. Nothing is more important than the welfare of our

John C. Browne

workforce. For this reason, I have asked all employees to aim for the following *Six Zeros* borrowed from the DuPont Corporation's five zeros program:

- zero injuries or illness on the job,
- zero accidents or illness off the job,
- zero environmental incidents,
- zero ethics incidents,
- zero people mistreatment incidents, and
- zero security and safeguards violations.

The Laboratory is committed to a strong emphasis on safety. We are implementing an Integrated Safety Management Plan (ISM) to ensure that our approach to safety, health, and the environment becomes ingrained in our culture, meets all laws and regulatory requirements, and results in a safer and more environmentally acceptable workplace. We are also committed to being a good neighbor. The Laboratory is in a unique position to assist in the economic development of northern New Mexico and to have a positive effect on education in this region.

The emphasis on operational excellence was underlined in the contract between the Department of Energy and the University of California. That contract requires the Laboratory to undergo a special assessment to ensure that it is progressing in three specific areas. The first is the implementation of ISM, the second involves evaluation of our environmental restoration and waste management programs, and the third pertains to regional involvement, that is, how we function within our region. It is this Laboratory's goal to excel in those three areas. In addition, we intend to excel in all our other performance requirements. Laboratory leadership has been restructured to ensure that we can apply the focus needed to achieve this goal. In addition to the Deputy Laboratory Director for Science, Technology and Programs, there is a Deputy Laboratory Director for Operations and a Deputy Laboratory Director for Business Administration and Outreach. These three deputies are working together with the workforce to develop and integrate a strategy for meeting our mission, operational, and business and outreach goals.

I will also be implementing major changes in how we manage projects at the Laboratory. These changes will address systemic problems that have been identified in recent project reviews. In addition, security (including physical, personnel, materials, and computer security) is another major focus area for improvement. It is my intention that we aim for operational excellence in all these areas.

As you read through this document, you will notice that we have produced material such as a Laboratory vision statement, a list of key areas on which we intend to focus, guiding principles, and some high level goals and objectives. These are to be regarded very much as work in progress. They are even now in the process of being molded and tuned with input from the employees. In the months shortly after the publication of this Institutional Plan, we hope to have finalized that part of our strategy development and be ready to move on to developing specific plans to address our objectives.

All these activities and rearrangements are intended to lead us to excellence not only in our scientific and technological achievements and in meeting our customers' needs, but also in our operations, our management of the Laboratory's business, in the quality of the institution as a workplace, and in our relationship with our neighbors.

I. LABORATORY OVERVIEW

A. VISION

In November 1997, the new Laboratory Director announced his vision for Los Alamos National Laboratory: *Los Alamos will be the premier laboratory in the world applying science to the solution of technical problems critical to national and global security.* This vision reflects our role as a national laboratory, our mission to reduce global nuclear danger, and our determination for excellence. Through the years of performing our mission, we have developed both breadth and depth in scientific and technological capability. A broad array of disciplines, unique facilities, and operational expertise in specialized areas allow us to address extremely complex problems to meet the needs of our nation. We strive for scientific, programmatic, operational, and managerial excellence.

The vision of the Laboratory, which is operated by the University of California (UC) as a Federally Funded Research and Development Laboratory under contract to the Department of Energy (DOE), has embedded within it our contribution to DOE's vision.[1] The Department's vision is that *the Department of Energy, through its leadership in science and technology, will continue to advance U.S. energy, environmental, economic, and national security by being*

- A key contributor to ensure that the United States has a flexible, clean, efficient, and equitable system of energy supply and end-use with minimal vulnerability to disruption;
- A vital contributor to Reducing the Global Nuclear Danger through its national security, nuclear safety, and nonproliferation activities;
- A world leader in environmental restoration, nuclear materials stabilization, waste management, facilities decommissioning, and pollution prevention;
- A major partner in world-class science and technology through its National Laboratories, research centers, university research, and its educational and information dissemination programs; and
- A safe and rewarding workplace that is recognized for business excellence, nurtures creativity, is trusted, and delivers results.

Through our vision, mission, scientific programs and supporting activities we contribute to all appropriate areas of the DOE vision.

[1]As recorded in the DOE Strategic Plan, September 1997.

B. MISSION

Los Alamos has a well-defined and nationally important mission: to *reduce the global nuclear danger.* This central national security mission consists of four main elements: stockpile stewardship, nuclear materials management, nonproliferation and arms control, and cleanup of the environmental legacy of nuclear weapons activities.

The Laboratory provides support for and ensures confidence in the nation's nuclear stockpile without nuclear testing. This challenge requires the Laboratory to continually hone its scientific acumen and technological capabilities to perform this task reliably using an interdisciplinary approach and advanced experimental and modeling techniques.

In the last two National Defense Authorization Acts, Congress identified the need to protect the nation from the proliferation of weapons of mass destruction, which includes nuclear, chemical, and biological weapons, and their potential use by terrorists. At Los Alamos, we are also applying our multidisciplinary science and engineering skills to address these problems.

In addition, the Laboratory's critical programmatic roles in stockpile stewardship and threat reduction are complemented by its waste management operations and environmental restoration work. Information on specific programs is available in Section II of this document.

In Figure 1, the Laboratory mission is depicted by three concentric circles with the national security mission in the center. As illustrated in the outer ring of Figure 1, we apply our expertise to additional key programs that are

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.

synergistic with our core mission. The Laboratory highly values its participation in research programs outside our national security mission. Such research allows us to enhance the science and technology that underpin our core mission. Our performance in open and competitive civilian research helps sustain our scientific edge and our credibility, while strengthening capabilities essential to the national security mission. Our participation in this research also leverages the national investment in defense by applying the capabilities to other problems of national importance and helps the Laboratory attract and retain the highly capable science and technology personnel that we need for our core mission.

The Laboratory's mission is aligned with and incorporates DOE's mission,[2] which is *to foster a secure and reliable energy system that is environmentally and economically sustainable, to be a responsible steward of the Nation's nuclear weapons, to clean up our own facilities, and to support continued United States leadership in science and technology.* The technical and scientific programs at Los Alamos address the strategic goals and objectives of the DOE Strategic Plan in accordance with the Government Performance and Results Act of 1993. These relationships are described in Table 2 at the end of Section I. The Secretary of Energy's Agreement with the President is built upon DOE's Strategic Plan. Thus, Los Alamos' programmatic activities also address this agreement.

In achieving our mission, safety is the first priority. A program of Integrated Safety Management (ISM) is in process to promote a culture of attention to safety at all levels of activity. For more information on ISM and ESH support at the Laboratory, see Section I.E.2. Special Assessments and Sections III.A.1. Integrated Safety Management and III.A.2. ES&H Laboratory-Wide Support.

C. CORE COMPETENCIES

The Laboratory's distinguishing competency is the ability to solve extremely complex problems that require the integration of scientific and technological expertise—an array of disciplines and diverse capabilities—with highly specialized facilities and unique operations expertise.

The technical core competencies grew out of the Laboratory's historical mission to develop and maintain the nation's nuclear deterrent, and they are key to meeting the challenges of our present mission to Reduce the Global Nuclear Danger. They contribute to and are sustained by carefully selected conventional defense and civilian programs. Academic collaborations and industrial partnerships are also essential to the vitality of the core competencies.

The identification and subsequent strategic nurturing of specific technical core competencies allows us to respond to a diversified customer base and to respond rapidly to changing national issues. These eight core competencies provide a vehicle for strategic investment and establish a framework for managing change through evolution of the competencies.

Of the eight core competencies, the first three listed emphasize a scientific approach; the last five focus on scientific content.

1. Scientific Approach

a. Theory, Modeling, and High-Performance Computing

Los Alamos has, through 50 years of performing its mission, developed a special ability to formulate and solve some of the nation's most 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 expertise complements the experimental programs with numerical approaches to solving complex, nonlinear problems. It includes the design and engineering of storage systems and networks to manage previously unimaginable amounts of data at very high speeds and the development of sophisticated user interfaces to increase scientists' ability to share the results of multidimensional simulations.

Theory, modeling, and high-performance computing are not only essential to the Laboratory's stockpile stewardship mission; they also provide essential underpinnings for new and emerging missions and programs.

b. Complex Experimentation and Measurements

Los Alamos is internationally known for fielding complex experiments involving the following:

- novel sources such as accelerators, high-power lasers, high explosives, and pulsed-power systems;
- measurement capabilities 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 radioactive, explosive, and hazardous materials and processes.

[2]As defined in the DOE Strategic Plan, September 1997.

c. Analysis and Assessment

Analysis and assessment capabilities are characterized by the ability to

- integrate basic theory and experimental data across multiple disciplines into realistic simulation models;
- validate the models through comparison with experiments and other expert information; and
- integrate the models into computer programs for independent and unbiased analysis and assessment of complex systems.

Examples of such complex systems include those in the areas of weapons performance and surety, energy, the military, transportation, atmosphere and ocean environments, manufacturing and materials processes, nuclear facility performance and safety, and health.

2. Scientific Content

a. Nuclear Weapons Science and Technology

The core competency in nuclear weapons science and technology encompasses key capabilities in the following:

- the physics of nuclear weapons performance includes skills in hydrodynamics of implosions and explosions, nuclear and thermonuclear reactions, transport and interaction of energy, atomic and plasma physics, and properties of materials under extreme pressures and temperatures;
- large-scale calculations of weapons and weapons phenomena incorporates one-, two-, and three-dimensional radiation hydrodynamics calculations, calculations of nuclear safety and performance, and calculations of weapons output, including detailed spectra;
- engineering design, specification, and integration of weapons components draws on skills in development and engineering of components, reliability and performance testing, manufacturing and assembly, disassembly and repair, and safety assessments;
- science of weapons materials and material properties emphasizes energetic materials, nuclear materials, specialized organic and inorganic materials, and processing and joining methods; and
- experimental measurement, testing, and diagnostics encompasses measurement of dynamic phenomena, special test facilities and sites, ultrahigh-speed electronics and electro-optic imaging devices, and pulsed-power and laser facilities for achieving special conditions.

Additional capabilities that support the broader mission relating to the use, control, and understanding of the nuclear component of the nation's defense include the following:

- weapons system analysis and assessment, including vulnerability, lethality, and effects as well as war-fighting applications analysis and collateral damage assessment;
- threat analysis and assessment, comprising intelligence assessment, nonproliferation, and counterproliferation; and
- treaty support/verification and accident response through expert advice, sensor development, and policy analysis.

b. Nuclear and Advanced Materials

The breadth of materials expertise at Los Alamos, in combination with its specialized facilities, make the Laboratory a national resource for the fundamental understanding of complex materials as well as for synthesis, processing, and application of nuclear and other advanced materials.

The Laboratory is applying its expertise in such areas as

- process technology;
- nuclear fuel research and fabrication;
- radioisotope thermoelectric generators;
- waste management, treatment, and reduction;
- chemical and physical characterization;
- environmental protection and behavior of these materials in the environment;
- material control and accountability technologies;
- nuclear criticality;
- preparation of certified reference materials;
- safe storage methodology;
- nuclear facility operations; and
- disposition and destruction technology options.

Laboratory capabilities in nuclear materials draw upon and contribute to the broader range of advanced materials capabilities in the areas of polymers and membranes, ceramics, separations science, sensor development, process modeling, and materials behavior under extreme conditions. These capabilities also support such areas as radiation protection, nonproliferation, international safeguards, and risk assessment.

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c. Earth and Environmental Systems

Earth and environmental systems integrates the Laboratory's broad knowledge of chemical, biological, and physical processes with the environmental and earth sciences to provide new scientific information and create new technologies to solve environmental, energy, and national security problems. Knowledge of the earth and its environment is increasingly recognized as an important element of economic and national security.

The core competency represents a unique mix of embedded expertise in multiple scientific and engineering skills and technologies for creating

- new and more effective means for waste-site characterization and remediation (treatment, storage, and disposal technologies);
- a stronger scientific basis for understanding global change and climate dynamics;
- new knowledge necessary to assess and mitigate the impact of energy production and national defense activities on ecological systems; and
- new means for remotely observing the earth and near-earth environment (including air and water pollution characterization) and for imaging the earth's interior.

d. 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 reflects on our ability to foster

- close collaboration between experimentalists and theorists;
- strong interdisciplinary interactions between the physical sciences, life sciences, and engineering; and
- unique large-scale facilities that support biotechnology research and development at Los Alamos for the biomedical community at-large.

e. Nuclear Science, Plasmas, and Beams

The core competency in nuclear science, plasmas, and beams integrates capabilities and disciplines spanning the study of high-energy-density systems driven by intense beams, including nuclear physics and nuclear chemistry, plasma physics, accelerator technology and beam physics, and a wide range of technology applications involving many scientific disciplines. Because Laboratory capabilities in these areas originated in the nuclear weapons program, they represent strengths in nuclear physics, nuclear chemistry, and engineering, ranging from internationally recognized basic science programs in medium-energy and neutron nuclear physics to reactor safety studies.

3. Core Competency Teams

Associated with each core competency is a team of technical staff members. Among other responsibilities, these teams may provide advice to Laboratory management on building and developing Laboratory capabilities and assist in identifying scientific directions that position the Laboratory to capitalize on future opportunities. The teams play an important role in providing input to the investment strategy for our Laboratory-Directed Research and Development funds (see Section II.D.2. Laboratory-Directed Research and Development).

D. UNIVERSITY OF CALIFORNIA MANAGEMENT OF THE LABORATORY

UC has managed Los Alamos National Laboratory since it was founded in 1943 and has fostered a research environment that has served the nation in unique ways. UC management of the Laboratory contributes to the high level of achievement at the Laboratory, and in return, the Laboratory has proven to be of great value to the overall research strength of the university.

UC manages three laboratories for DOE: the Ernest Orlando Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory in California, and Los Alamos National Laboratory in New Mexico. The university has managed these laboratories as a public service to the nation since their inception.

A strategy for oversight that involves appropriate distribution of responsibility and authority among UC's Board of Regents and Officers has been developed by the university. The Regents Committee on Oversight of the National Laboratories reviews the performance of the university's officers in the operation of the Laboratory and recommends to the full Board of Regents changes with regard to the contract terms and other senior-level policy matters affecting the Laboratory. The UC President retains ultimate authority and responsibility for contract operations as delegated by the Regents. The President is advised in all aspects of Laboratory management and operation by the President's Council on the National Laboratories, which is appointed by the President and comprises senior-level executives from academia, government, and private businesses involved in research and development. The general goal of the council is to improve the effectiveness with which UC discharges its overall responsibilities under the contracts between the university and DOE. In order to carry out its charge more effectively, the council has formed three panels: National Security; Science and Technology; and Environment, Safety, and Health.

The Laboratory Director and Deputy Directors are appointed by the UC President, with concurrence by the Regents and DOE, and are responsible for the day-to-day contract operations, including acting for the UC President in those actions and responsibilities that have been delegated to them. The University of California Provost and Senior Vice President for Academic Affairs, as delegated by the President, is *responsible* for evaluating the quality of the scientific, technological, and engineering research conducted by the Laboratory and for advising the President of notable achievements and areas of concern. The Office of Research, led by the Vice Provost for Research and the Associate Vice Provost for Research and Laboratory Programs, assists the Provost in this regard. The Senior Vice President for Business and Finance, as delegated by the President, is responsible for evaluating the quality of the administrative and operational functions that support the Laboratory's scientific and programmatic effort and for advising the President of notable achievements and areas of concern. The Laboratory Administration Office (UCLAO), led by the Assistant Vice President for Laboratory Administration, assists the Senior Vice President in this regard.

The current contract between UC and DOE for the management of the Laboratory, approved in September 1997, stresses performance-based management measured against objective, mutually agreed-upon standards. DOE considers the university's annual assessments in establishing an overall assessment rating, which is used to set the amount of the fee paid to the university for managing the Laboratory. This assessment process has provided UC with an in-depth view of the capabilities of the laboratories it manages. It has helped to strengthen the existing ties between the university and the laboratories and is fostering new relationships as well.

UC is committed to strengthening the ties among the nine campuses and the three laboratories. The UC Coordination Team at Los Alamos works with the UC Office of the President (UCOP) and the UC system to coordinate programs that foster collaborations. UCOP uses the Complementary and Beneficial Activities fund, derived from the fee paid for managing the laboratories, for such activities as supporting the Institute for Geophysics and Planetary Physics and the Campus-Laboratory Collaborations program. The Laboratory Director receives other funds derived from the fee for research or research-related activities. The Laboratory's UC Coordination Team administers these UC-Directed Research and Development program funds to enhance the Laboratory's collaborations with the UC campuses and to strengthen research collaborations with New Mexico universities.

UC has recognized the need to be more involved in local and regional initiatives and concerns, and in 1996 became actively engaged in developing and implementing a strategy for increased corporate citizenship in northern New Mexico. The University subsequently established, in May 1996, the University of California Northern New Mexico (UCNNM) Office to cooperate as a good corporate citizen with the regional communities and to support strategies in the areas of education, business practices, and technology transfer to stimulate economic growth and diversification within the region. The office has proven to be an effective means of strengthening relationships with these communities and has demonstrated a tangible UC corporate presence and involvement in the region.

The UCNNM Office has a direct reporting relationship to the UCLAO and is supported in its regional operations by a cadre of functional experts frequently visiting the region from Oakland. Use of the UCNNM Office as a base for operations by these UCLAO experts has been key to the office's success over the past 2 years.

E. CONTRACT PERFORMANCE REQUIREMENTS

1. The DOE/UC Contract Performance Assessment

The 1992 contract between DOE and UC for management of the Laboratory pioneered the application of a performance-based management system. The 1997 contract continues to require application and continuing improvement of such a performance-based system in which performance is measured against negotiated objective standards.

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. The latter includes items such as environmental, safety, and health (ES&H); business operations; facilities management; security and safeguards; information management; and human resources.

8 a. Science and Technology Assessment

The Laboratory continues to use external peer reviews to assess the quality of its science and technology. Such peer reviews have taken on added importance as a result of contracts between DOE and UC for management of Lawrence Berkeley, Lawrence Livermore, and Los Alamos national laboratories. At Los Alamos, the principal input to the science and technology assessment is based on reviews conducted by all the peer review committees, one for each technical division. The Laboratory evaluations are submitted to UCOP. The university evaluates the report and submits a report to DOE, which uses this information as part of its overall assessment of the Laboratory. On behalf of the Laboratory Director, the UC Coordination Team 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 UCOP. 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 technical development and operation of major research facilities, and
- programmatic performance and planning.

The DRCs have 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. 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.

b. Administrative and Operations Assessment

Performance measures for the assessment of administrative and operations systems are listed in Appendix F, Section B, of the DOE/UC contract. The administrative and operations section of Appendix F contains specific performance objectives, criteria, and measures (POCMs). These POCMs are renegotiated every year. To enhance consistency and balance, an additional category of POCMs (Learning and Growth) was added for consideration during the negotiation of the FY99 POCMs. This addition resulted in the following four categories of POCMs:

- Operational Effectiveness—managing cost and performance;
- Stewardship—managing compliance to requirements and commitments;
- Customer Satisfaction—performance measures aligned with DOE and internal customer needs; and
- Learning and Growth—managing the workforce in a manner that ensures personnel are qualified and effective.

The POCMs are the basis for the internal quarterly self-assessments and the DOE/UC annual review process.

The Laboratory received performance scores from DOE's FY97 review that continued to show overall improvement, except for the functional areas of Facilities Management (specifically, construction project management), ES&H (specifically as related to nuclear facility operations), and Security and Safeguards. As a result, the Laboratory's short-term improvement plans are focusing primarily on these operations measures and on longer-term plans that will support the Director's goal of achieving excellence in Appendix F scores. Additionally, the internal Appendix F process is being improved.

The Laboratory Deputy Director for Operations has established five goals to improve overall operational performance; two of those goals specifically support improvement in the Facilities Management and ES&H functional areas:

- Practice Integrated Safety Management (ISM) throughout the Laboratory;
- Manage construction projects within approved costs and schedules;
- Ensure an effective Security and Safeguards Program;
- Achieve excellence on Appendix F Operations Measures; and
- Operate Los Alamos National Laboratory in an environmentally sustainable manner.

The strategies behind these goals include making Appendix F performance information more easily understandable, improving our reporting processes, and enhancing mobilization of management at all levels to incorporate needed actions and plans to improve Appendix F performance.

The Facilities, ES&H, and Security and Safeguards functional areas have been designated as part of a "Critical Few" process—a special subset of Appendix F measures on which Laboratory management focuses through a quarterly self-assessment process. An annual screening process has been developed to establish these Critical Few measures. Figure 2 depicts the Critical Few screening process.

Seven Critical Few measures have been selected from ES&H, four from Facilities, and three from Security and Safeguards. To complement the Critical Few process, all Appendix F measures that are not part of the Critical Few are being evaluated by an additional process to identify measures other than the Critical Few that may need special attention.

c. Internal Appendix F Process Improvement

Plans are underway to improve the internal processes that support each step of the annual Appendix F process, including

- increasing involvement of line management in the negotiation process to ensure their perspective;
- posting measures and associated data on-line for expanded access and information;
- crosswalking measures to DOE's Strategic Plan, the Laboratory Director's goals, and special provision requirements, including the ISM milestones;
- expanding the quarterly DOE/UC/Los Alamos review to all functional areas; and
- providing training to functional areas on report writing and graphics presentations.

These planned enhancements will strengthen the Appendix F goal of improved performance for the Laboratory's operations and administration functions.

2. Special Assessments

In addition to the regular performance assessment required in the DOE/UC contract, DOE will conduct special assessments of the Laboratory as described in clause 5.14 of the contract (Special Assessment). The purpose of these reviews is to determine whether the overall level of performance achieved is satisfactory with regard to the performance objectives in Appendix F of the contract, and whether substantial progress has been made in meeting the special requirements of clause 5.14.

The requirements for these special assessments, or special provisions, fall into three categories: ES&H; environmental restoration and waste management; and regional involvement.

The special assessment will be conducted in the first and second year of contract performance by personnel of the Albuquerque Operations Office in consort with such additional DOE personnel as the Contracting Officer deems appropriate. In conducting the reviews, the assessment team may consider, but is not limited to, information developed in the conduct of the regular annual performance assessments as provided by clause 2.6 (Performance-Based Management) of the contract. The results of the special assessments will be provided to the

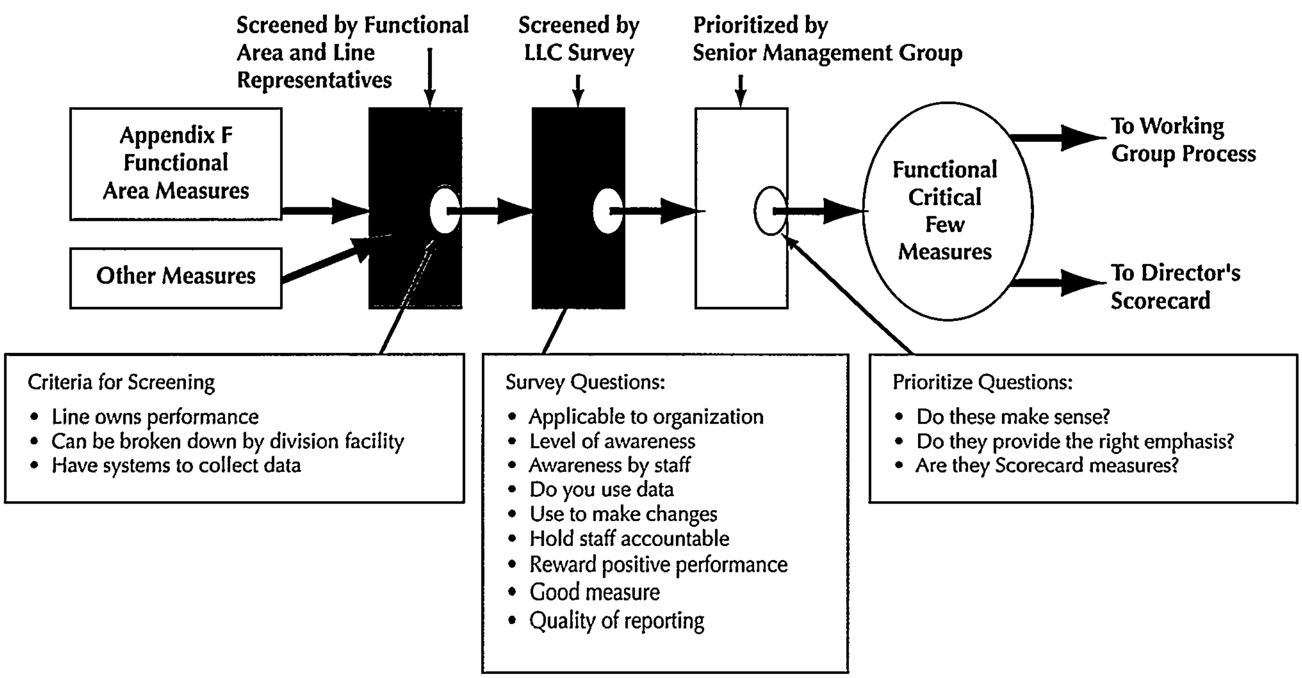


Figure 2. Appendix F "Critical Few" selection process.

contractor for review and comment before they are finalized and submitted to the Secretary of Energy. This first year's special assessment is a preliminary assessment of the contractor's performance status and its progress in achieving the requirements of this clause. However, if, upon completion of the second-year special assessment, DOE determines that the contractor's performance is unacceptable with respect to the objectives set forth in paragraphs (b), (c), or (d) of the special assessments clause, or that the contractor's overall performance level at the Laboratory is not sufficiently satisfactory as measured in accordance with Appendix F, DOE may, upon direction of the Secretary of Energy, terminate the DOE/UC contract in whole or in part. In the event that unsatisfactory performance or failure to make progress is determined solely in the area of environmental restoration and waste management, the right of termination is limited to that portion of the contract related to such work. A decision to terminate this contract in whole, or in part, is solely that of the Secretary of Energy consistent with the Secretary's determination of whether the public interest is served thereby

Accordingly, for the Director's key focus areas of operational excellence and integration of science, technology, programs and business, the 2-year goals include receiving excellent ratings during DOE's annual evaluations.

The Deputy Director for Operations is the champion for two of the special provisions, ES&H and environmental restoration and waste management (ER and WM), while the Deputy Director for Business Administration and Outreach is the champion for the special provision on regional involvement.

In order to ensure that the Laboratory is heading in the right direction to accomplish the requirements of these provisions, quarterly assessments with DOE and UC have been established. Discussions about the nature of the assessments and interpretation of the requirements are designed to clarify the definition of success and to measure ongoing progress relative to the requirements.

The Laboratory is addressing the special assessment using project management techniques. The Deputy Directors are developing cascading goals and measures for operations that tie to the special provisions and are incorporated into the employee performance appraisal system.

The three elements of the assessment are discussed in the remainder of this section.

a. Integrated Safety Management

The special assessments clause requires the Laboratory to meet certain performance expectations in the definition, implementation, and ongoing execution of ISM. All of the actions required in this clause are consistent with the actions defined in the existing ISM Description Document and the ISM Implementation Plan. The clause focuses on a few important aspects of ISM: work control, Laboratory standards and requirements, self assessment, management commitment to formality in operations, and actions to be taken by UC in support of the implementation of ISM at Los Alamos. The Laboratory and UC are taking actions to meet the expectations of all elements of this clause of the contract.

We have completed many of the ISM actions that are tied to the special assessments clause. A few important actions are underway and are scheduled to be complete by the end of CY98. However, success requires more than mere completion of these specific actions; it requires sustained execution of the principles of ISM by all managers and employees at Los Alamos. This means, for example, that facility work and research must be performed in accordance with the relevant Laboratory requirements; we must assess our performance and make improvements where necessary; and managers and employees must integrate the principles of ISM into the planning and execution of all work performed at Los Alamos.

ES&H metrics found in Appendix F of the contract will be used to determine success in sustaining the execution of ISM actions over time. These metrics will be reduced in number and focused to allow us to understand how well we are meeting the requirements of the special assessments clause and the Director's goals for working safely and operational excellence. Over the past 18 months, we have created the framework for a sound ISM system; the challenge is now to execute what we have created and to sustain this execution so that safety becomes a truly integral part of the planning and execution of work. The evidence of our success will be improved performance on our Appendix F ES&H metrics.

The ISM system is described in more detail in Section III.A.1. Integrated Safety Management.

b. Environmental Restoration and Waste Management

The work of ER and WM at Los Alamos is also included in the special provisions of the contract between DOE and UC. In addition to emphasizing satisfactory achievement of several performance measures outlined in Appendix F of the contract, this special provision requires that a "make/buy" analysis be conducted for ER operations with life-cycle costs greater than $5 million and for certain specific activities in WM.

The purpose of the make/buy analysis is to formally examine the costs for conducting specific operations to determine whether or not these operations can be performed more cost effectively by contracting with an organization other than UC. As a part of our ongoing efforts to be cost competitive, significant portions of both the ER and WM budgets are already assigned to competitively awarded subcontractors. Approximately two-thirds of the ER budget is spent by subcontractors doing the hands-on work of cleaning up the environment. In WM, many of the tasks are conducted by the Laboratory subcontractor and Johnson Controls Northern New Mexico, as well as other, more specialized task-order contractors.

KPMG Peat Marwick completed the make/buy analysis in waste management for both the Radioactive Liquid Waste Treatment Plant (RLWTP) and the Solid Waste Management Transuranic Waste Inspectable Storage Project (TWISP). With the recent streamlining in the RLWTP, it was determined that the Laboratory was better off "making" both of these services rather than "buying" them. DOE has concurred for the RLWTP report, but the TWISP report is still under review.

The Laboratory's goal is to continue to improve its performance for ER and WM and to manage the program as efficiently as possible with an optimal mix of contractor tasking and university management and oversight.

c. Regional Involvement

The third special assessment category, regional involvement, requires that the Laboratory and UC enhance community relations, educational outreach, and enhance regional economic development. The Laboratory is seeking to build trust among its customers, employees, and the community. Through the community relations, educational outreach, and regional économic development initiatives, the Laboratory aims to attain a position of community leadership.

Defined in the special assessment clause of the DOE/UC contract are six specific regional involvement requirements, which are as follows:

1. establishing a foundation and initiating giving,
2. developing and implementing a regional education plan,
3. taking a survey of the community,
4. increasing regional procurement,
5. UC donating 500 hours of time, and
6. producing an investment commitments report.

In June 1998, DOE agreed that the requirements pertaining to the foundation and the 500 hours of UC time had been implemented on schedule. The remaining four requirements are also on schedule for completion. In addition, three appendices of the contract provide drivers for the Laboratory regional involvement initiatives. They are Appendix J (Regional Purchasing), Appendix M (Technology Commercialization), and Appendix N (Corporate Citizenship). The initiatives, which are enabled by these appendices, address the special provisions as illustrated in Figure 3.

In addition, specific performance measures in Appendix F of the contract relate to the three initiatives as illustrated in Figure 4.

Community Relations

Specific goals for the community relations initiative are to have the Laboratory considered the premier employer of choice and to have local communities consider the Laboratory a good and valued neighbor. Information about the implementation of the community relations initiative is available in Section III.B.3. Community Involvement and Outreach and in Section III.B.4. Public Affairs.

Educational Outreach

The Laboratory is uniquely capable of assisting in the enhancement of and providing support for regional education. Helping provide assistance for regional students to be more prepare for employment at the Laboratory and surrounding businesses creates a diverse and capable workforce and aids in the development of the regional economy. The Laboratory's specific educational outreach goals are that the quality of regional schools help the Laboratory to recruit a diverse and excellent workforce; northern New Mexico students are successful in competing for all types of jobs at the Laboratory; and northern New Mexico students are

Figure 3. Appendices J, M, and N are drivers for the Laboratory's three regional involvement initiatives. Through these initiatives, we address the special provision requirements.

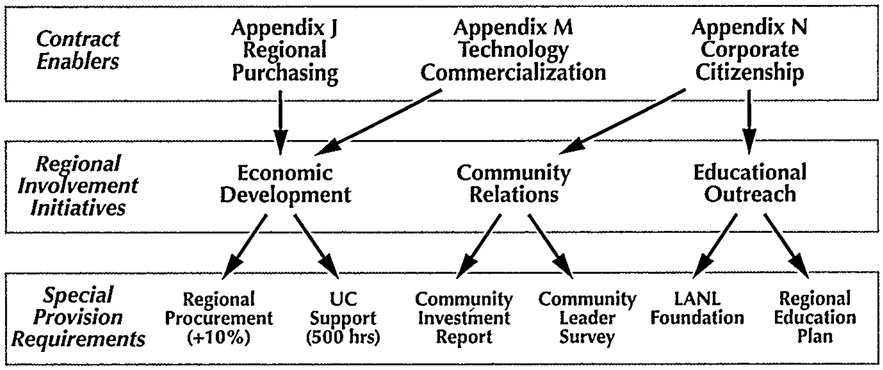
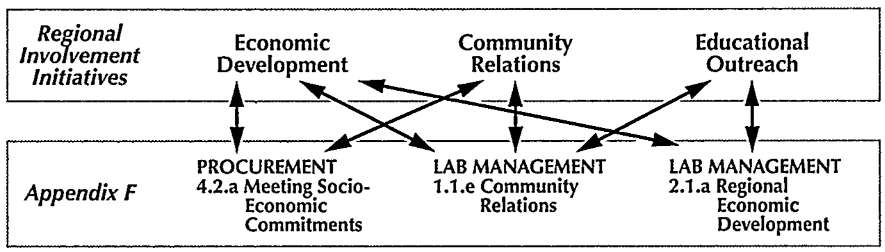


Figure 4. Three Appendix F measures address our regional involvement initiatives.



successful in competing for the new jobs created by our economic development initiatives. Additional information about the Laboratory's educational outreach programs is available in Section II.D.1. Science and Math Education.

Regional Economic Development

Because of its position as the largest employer in northern New Mexico and in light of its requirements for a broad range of services and contracts, the Laboratory is able to leverage its business to foster the development of the regional economy. The Laboratory's regional economic development goals are the creation of jobs; a diversified economy; significant investment in the region; and a more robust infrastructure. More information on this initiative is available in Section III.B.2. Business Operations and in Section III.B.3. Community Involvement and Outreach.

F. LABORATORY GUIDING PRINCIPLES, KEY FOCUS AREAS, AND GOALS

In a recent testimony,[3] the Director of the Laboratory said,

> We have a well-defined and nationally important mission to carry out. It is my intention that we apply best-management principles during my tenure as Director to ensure that we succeed in carrying out this mission.

To ensure that the mission is carried out and that best-management principles are applied, the Laboratory has begun the process of revisiting its long-term and near-term goals.

1. Guiding Principles

As a guide in setting its strategic direction, the Laboratory has adopted the following guiding principles.

- Public Service—*We are motivated to serve our nation and the people of the world.*
- Leadership—*We are people-oriented. We are empowered at all levels to push the horizons of our work but always with strong regard for safety and operational principles.*
- Quality and Diversity—*The diversity of our science, of our people, of our programs, and of our facilities contribute to our quality.*
- Pride—*We have pride in who we are and what we do.*
- Openness—*We demonstrate openness to our employees, to the community, to each other, and to change. We have open minds.*
- Trustworthiness—*We consider the interests of others in our decisions and we do what we say.*

[3]Subcommittee on Strategic Forces, the Senate Committee on Armed Services, March 1998.

- Management—*We measure our performance continually.*
- Accountability—*We hold ourselves accountable for our actions; we hold others accountable for their actions.*

The Los Alamos guiding principles provide a background for developing our key focus areas and related goals.

There is a strong correlation between the Laboratory guiding principles and the DOE core values. DOE has chosen the following core values to serve as its guideposts and conscience in fulfilling its mission and attaining its vision.

- We are customer-oriented.
- We value public safety and respect the environment.
- We believe people are our most important resource.
- We value creativity and innovation.
- We are committed to excellence.
- We work as a team and advocate teamwork.
- We recognize that leadership, empowerment, and accountability are essential.
- We pursue the highest standards of ethical behavior.

Table 1 illustrates the relationships using the descriptive text of both the guiding principles and the core values as the basis for comparison.

2. Key Focus Areas

The Laboratory has also defined six key areas on which to focus its goals to ensure that the Laboratory can carry out its mission using effective leadership and management systems. The Director has created a new management structure designed to address these focus areas. There will be a senior executive team of seven people who will be responsible for institutional performance in all programs and operations and in the focus areas. See management structure in Appendix A.

The key focus areas are as follows:

- Quality in our science and technology;
- Integration of our science and technology programs, our business, and our operations;
- Quality and diversity in our workforce;
- Operational excellence;
- Community relationships; and
- Customer and stakeholder relationships.

DOE's three corporate management areas identified as factors for success are as follows:

- *Environment, Safety, and Health*—How we will ensure the safety and health of workers and the public, and protect and restore the environment.
- *Communication and Trust*—How we will communicate information and build trust within the organization and with our stakeholders and customers.

Table 1. The Relationship between Los Alamos Guiding Principles and Related DOE Core Values.

	Los Alamos Guiding Principles							
DOE Core Values	Public Service	Leadership	Quality and Diversity	Pride	Openness	Trustworthiness	Management	Accountability
We are customer-oriented.	X			X	X	X	X	X
We value public safety and respect the environment.	X	X		X	X	X	X	X
We believe people are our most important resource.		X	X	X	X	X		X
We value creativity and innovation.	X	X	X	X	X	X		
We are committed to excellence.	X		X	X			X	X
We work as a team and advocate teamwork.		X	X			X		
We recognize that leadership, empowerment, and accountability are essential.	X	X		X	X	X	X	X
We pursue the highest standards of ethical behavior	X	X		X	X	X		X

- *Management Practices*—How we will manage our workforce; allocate, spend, and account for resources; procure, produce, and contract for goods and services; streamline and continuously improve our operations and facilities; and manage our information technology systems—the tools we use to get it all done.

The Laboratory's key focus areas may be represented as a subset of the DOE success factors that are particularly applicable to the Laboratory at this time. Using the descriptive text of both the DOE success factors and the Los Alamos key focus areas as the basis of comparison, the relationships appear as in Figure 5.

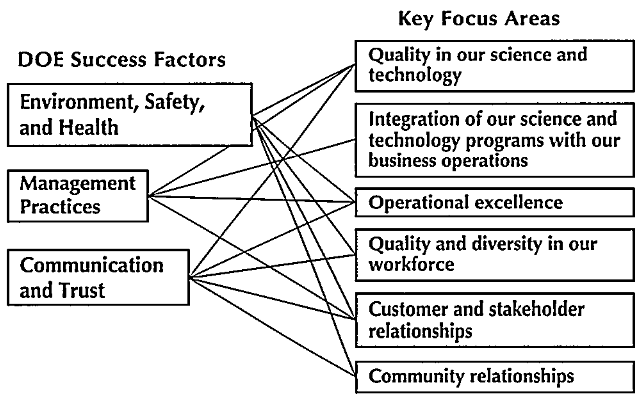


Figure 5. The connections among the current Los Alamos key focus areas and DOE Success Factors.

3. Laboratory Goals

For each focus area, the Laboratory has developed an initial set of 10-year goals aimed at addressing our mission and our operational and administrative imperatives. This set of goals is a work-in-progress; they will be finalized after the permanent Senior Management Team is in place. The 10-year goals, sorted by key focus area, are as follows:

- *Quality in our science and technology.*
  - Our science has allowed us to certify the stockpile without nuclear testing.
  - We have assisted the nation in the management of proliferation crises.
  - New, focused mission areas have been established that address critical national and global issues.
  - Our research has strengthened our programs and has led to new discoveries and opportunities.
  - New major experimental and computational facilities have attracted people and programs.
- *Integration of our science and technology programs, our business, and our operations.*
  - Our business and technical operations perform synergistically and safely.
  - Our business and information systems support technical productivity.
  - Costs are well managed in order to facilitate institutional and customer goals.
- *Quality and diversity in our workforce.*
  - Renowned for the quality and accomplishments of our people.
  - Key leadership positions reflect gender, racial, and ethnic diversity.
  - Recruitment efforts have attracted a diverse and excellent pool of workers for the future.
  - Training and development are valued and integral parts of our work life.
- *Operational excellence.*
  - ES&H is integrated into our everyday work—we are the best of all the labs.
  - Our environmental legacy shows that we respected and cared for the diverse surroundings that make northern New Mexico so beautiful.
- *Community relationships.*
  - The Laboratory is considered the premier employer of choice.
  - Local communities consider the Laboratory a good and valued neighbor.
  - Northern New Mexico students are successful in competing for all types of jobs at the Laboratory.
  - Laboratory economic development activities in northern New Mexico are visible, positive, and valued.
- *Customer and stakeholder relationships.*
  - The President, DOE and other federal agencies, Congress, the New Mexico government agencies, as well as the private sector recognize Los Alamos for our overall excellence in achieving our mission.
  - Our operations are judged as meeting or exceeding all federal and state laws.

The senior managers in the new structure are responsible for organizing the employees in developing associated 2-year goals that align the Laboratory with the 10-year goals and for cascading these goals into the Laboratory organizations.

G. THE FOUR BUSINESS AREAS OF THE DOE STRATEGIC PLAN

DOE has divided its business into four business areas: energy resources, national security, environmental quality, and science and technology. The Laboratory contributes to each of these business areas and addresses all but one of the DOE objectives (nuclear propulsion). Laboratory programs tend to develop their goals and objectives directly with their customers. For example, Laboratory programs funded by DOE Defense Programs (DP) develop objectives and goals directly with DP and participate in the development of the DOE Stockpile Stewardship Plan.

The strength of this Laboratory lies in its ability to address large, nationally important, highly complex problems by integrating a broad array of disciplines and competencies with its specialized, unique facilities. The Laboratory, to successfully fulfill its mission, must address a broad range of synergistic programs; competencies for the core mission are advanced and nurtured, while simultaneously helping the nation solve problems other than national security. Because of the large size of the Laboratory and because of its multiprogram nature, it is only possible to show, at a very high level, how some of the current major activities tie into the DOE Strategic Goals and their Objectives.

Table 2 illustrates that Los Alamos program activities are addressing the DOE objectives.

Table 2. Los Alamos Program Activities Are Addressing the DOE Objectives.[1]

Energy Resources Strategic Goal: The Department of Energy and its partners promote secure, competitive, and environmentally responsible energy systems that serve the needs of the public.

Objective 1 Reduce the vulnerability of the U.S. economy to disruptions in energy supplies.	• Natural Gas and Oil Technology Partnership. (CIT)[1] • Support research to 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. (ER)
Objective 2 Ensure that a competitive electricity generation industry is in place that can deliver adequate and affordable supplies with reduced environmental impact.	• Superconductivity Technology Center. (CIT)
Objective 3 Increase the efficiency and productivity of energy use, while limiting environmental impacts.	• Research Consortium for Multiphase Fluid Dynamics. (CIT) • Fuel Cells for Transportation Applications Program. (CIT) • Alkane Functionalization Catalysis. (CIT) • Environmental Stewardship Office works with Laboratory programs and operations to reduce waste and improve efficiency of all activities. (EM)
Objective 4 Support U.S. energy, environmental, and economic interests in global markets.	• Isotope Production and Distribution Program. (CIT) • Uranium Enrichment. (CIT) • 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. (ER)
Objective 5 Carry out information collection, analysis, and research that will facilitate development of informed positions on long-term energy supply and use of alternatives.	• Los Alamos CO_2 Sequestration Process Program. (CIT)

Table 2. Los Alamos Program Activities Are Addressing the DOE Objectives.[1] (Continued)

National Security Strategic Goal: Support national security, promote international nuclear safety, and reduce the global danger from weapons of mass destruction.

Objective 1 Maintain confidence in the safety, reliability, and performance of the nuclear weapons stockpile without nuclear testing.	• Maintain confidence in the U.S. nuclear weapon stockpile through surveillance, enhanced surveillance, and weapons assessment programs. (NWT) • Respond to surveillance and directed production assignments for stewardship of the enduring stockpile. (NMSM) • Extend the life of stockpiled weapons through the Stockpile Life-Extension Program. (NWT) • Develop the science and technology to sustain indefinitely the science-based stewardship of the stockpile without nuclear testing. (NWT, NMSM) • Conduct certification of the safety and reliability of the stockpiled weapons through Annual Certification and Dual Revalidation. (NWT) • Support DOE's nuclear test readiness (NWT) • Demonstrate that APT Technology is safe, reliable, and unlikely to face significant hurdles; develop and document an efficient and cost-effective design, with the flexibility to scale the plant capacity to meet changing tritium needs; and establish/maintain dependable cost and schedule data.
Objective 2 Replace nuclear testing with a science-based Stockpile Stewardship and Management Program.	• Develop predictive three-dimensional simulation and modeling codes to evaluate the aging stockpile. (NWT) • Pursue the Accelerated Strategic Computing Initiative (ASCI) to enable the development and validation of the necessary computational simulation capability. (NWT) • As part of ASCI, install the Blue Mountain SGI/Cray machine with full 3- to 6-TeraOp operational capabilities by 1999-2000. (NWT) • Train new weapons scientists through such vehicles as the Theoretical Institute for Thermonuclear and Nuclear Studies (TITANS). (NWT) • In order to develop and test models and support weapon assessments, design, conduct, and analyze experiments that include - subcritical experiments at Nevada Test Site, - hydrodynamic testing to study the implosion of mock-up nuclear weapons primaries, - experiments and simulations in the area of high-energy density physics regimes, - the study of high-explosives science and engineering, and - the properties and aging effects of stockpile materials, including experiments at the Los Alamos Neutron Science Center (LANSCE). • Conduct Hydrodynamic Testing to study the implosion of mockup nuclear weapons primary. (NWT) • Perform experiments and simulations in the area of high-energy-density physics regime. (NWT) • Study high explosives science and engineering in support of the Stockpile Stewardship program. (NWT) • Use LANSCE to characterize and understand stockpile materials aging effects. (NWT)

Table 2. Los Alamos Program Activities Are Addressing the DOE Objectives.[1] (Continued)

DOE Objective	Los Alamos Program Activities
Objective 3 Ensure the vitality of DOE's national security enterprise.	• Maintain and restore unique nuclear materials facilities (NMSM) • Improve technologies and processes for future limited-scale manufacturing in the DOE complex. (NMSM) • The Accident Response Group (ARG) will continue to evaluate and validate the capabilities to respond to U.S. nuclear weapons accident worldwide. (NWT) • Develop the science and technology to sustain indefinitely the science-based stewardship of the stockpile without nuclear testing. (NWT, NMSM) • Maintain ongoing contact and interaction on unclassified science and technology. (NWT, NMSM) • Maintain a capability to resume underground nuclear testing. (NWT)
Objective 4 Reduce nuclear weapons stockpiles and the proliferation threat caused by the possible diversion of nuclear materials.	• Dismantle and convert weapons fissile materials; encourage verifiable Russian involvement. (NMSM) • Support disposition option through mixed-oxide fuel technology. (NMSM) • Clean up Cold War production legacies. (NMSM) • Examine the global nuclear future. (NMSM) • Lead the DOE materials protection, control, and accounting (MPC&A) program that is significantly upgrading the security of nuclear materials in the former Soviet Union. (NIS) • Provide all-source evaluations of known and potential foreign nuclear weapons programs. (NIS) • Develop technologies that support international customs agents and law enforcement officials in combating smuggling of nuclear weapons and materials. (NIS) • Provide technology development and on-call expertise in support of the Nuclear Emergency Search Team and ARG. (NIS)
Objective 5 Continue leadership in policy support and technology development for international arms control and nonproliferation efforts.	• Provide technical expertise ("backstopping") for negotiation of treaties (e.g., Comprehensive Test Ban Treaty [CTBT]) and other arms control agreements (e.g., START III). (NIS) • Develop technologies and supply satellite-based detection systems to verify compliance with the Nuclear Nonproliferation Treaty and CTBT. (NIS) • Develop remote sensing and other technologies for detecting and assessing clandestine programs for development of weapons of mass destruction (nuclear, biological, and chemical). (NIS) • Develop strategies and technologies to support a future START III agreement based on limitations of nuclear warheads. (NIS)
Objective 6 Meet national security requirements for naval nuclear propulsion and for other advanced nuclear power systems.	• None
Objective 7 Improve international nuclear safety.	• Provide technical expertise and review of ISTC proposals related to nuclear safety and participate in international nuclear safety conferences. • Provide technical expertise and technology (computer codes and analysis) as requested and approved by our sponsors (NRC and DOE) for international nuclear safety issues.

Table 2. Los Alamos Program Activities Are Addressing the DOE Objectives.[1] (Continued)

Environmental Quality Strategic Goal: Aggressively clean up the environmental legacy of nuclear weapons and civilian nuclear research and development programs, minimize future waste generation, safely manage nuclear materials, and permanently dispose of the Nation's radioactive wastes.

Objective 1 Reduce the most serious risks from the environmental legacy of the U.S. nuclear weapons complex first.	• Use Laboratory science and technology to work with sites such as Hanford and Rocky Flats to develop a safe, environmentally responsible path forward for dealing with their Cold War legacy. (EM)
Objective 2 Clean up as many as possible of the Department's 83 remaining contaminated geographic sites by 2006.	• Maintain active Environmental Restoration program which has developed plans and schedules to complete their mission by 2006. (EM)
Objective 3 Safely and expeditiously dispose of waste generated by nuclear weapons and civilian nuclear research and development programs and make defense high-level radioactive wastes disposal-ready.	• Maintain and continually upgrade hazardous and radioactive solid and radioactive liquid waste treatment and disposal facilities. (EM) • Established first facilities and operations certified by DOE to characterize and ship transuranic waste to WIPP. (EM)
Objective 4 Prevent future pollution.	• Work to exceed all the Secretary of Energy pollution prevention goals. Also, work with Laboratory operations and surrounding region to implement effective waste minimization programs. (EM)
Objective 5 Dispose of high-level radioactive waste and spent nuclear fuel in accordance with the Nuclear Waste Policy Act, as amended.	• Provide essential scientific support to the Yucca Mountain project that assures its success as a high-level waste repository. (EM)
Objective 6 Reduce the life-cycle costs of environmental cleanup.	• Continue to improve subcontracting efforts to assure lowest-cost cleanup of site occurs. (EM) • Deploy science and technology (such as real-time characterization, sorting and segregating contaminated soils from clean soils) that continue to drive the cost of this effort. (EM)
Objective 7 Maximize the beneficial reuse of land and effectively control risks from residual contamination.	• Work with the neighboring communities to identify and clean up sites. (EM) • Proposing increase in cleanup budget to make available highly valuable land in close proximity to Los Alamos town. (EM)

Table 2. Los Alamos Program Activities Are Addressing the DOE Objectives.[1] (Continued)

Science and Technology Strategic Goal: Deliver the scientific understanding and technological innovations that are critical to the success of DOE's mission and the Nation's science base.

Objective	Activities
Objective 1 Develop the science that underlies DOE's long-term mission.	• The Office of Energy Research funds research at Los Alamos that includes efforts with the following program offices: Basic Energy Sciences, Biological and Environmental Research, High-Energy and Nuclear Physics, Computational and Technology Research, and Fusion Energy Sciences. (ER) • Oversee the Laboratory Directed Research and Development Program (LDRD). LDRD is aimed at ensuring the vitality of the Laboratory in meeting the challenge of its DOE and national mission. (STB)
Objective 2 Deliver leading-edge technologies that are critical to the DOE mission and the Nation.	• The Laboratory's basic research efforts contribute to a wide spectrum of basic and applied research in areas such as materials science, chemical sciences, geosciences and engineering, neutron scattering, high-performance computing, and biosciences. (ER)
Objective 3 Improve the management of DOE's research enterprise to enhance the delivery of leading-edge science and technology at reduced costs.	• Support at Los Alamos, for use by the DOE complex and other users, several special multidisciplinary science facilities such as the Manuel Lujan Jr. Neutron Scattering Center, the National High Magnetic Field Laboratory, the Advanced Computing Laboratory, the Ion Beam Materials Laboratory, and the Electron Microscopy Laboratory. (ER) • Oversee the Los Alamos portion of the Joint Genome Institute in partnership with Lawrence Livermore and Lawrence Berkeley national laboratories. (ER)
Objective 4 Assist in the government-wide effort to advance the Nation's science education	• Lead a series of more than 20 special programs for all levels of education (K–12, undergraduate, and graduate). The programs provide participants with hands-on experiences in science, mathematics, engineering, and technology, allowing us to enrich and motivate today's science educators and tomorrow's science leaders. (STB) • Oversee the Laboratory's Postdoctoral, Graduate Research Assistant, and Undergraduate Student Programs. (STB)

[1]Abbreviations in parentheses refer to the Los Alamos program office through which funding is provided for that activity, as follows:

CIT - Civilian Industrial Technology Program
NWT - Nuclear Weapons Technology Program
NMSM - Nuclear Materials and Stockpile Management Program
NIS - Nonproliferation and International Security Program
STB - Science and Technology Base Program
ER - Energy Research programs—administered by the Los Alamos STB Program Office.
EM - Environmental Management Programs

Plans for these programs are described in Section II. Science and Technology. High-level funding tables are given at the end of each part of that section. For more detailed funding tables, see Appendix C. Resource Projections.

II. SCIENCE AND TECHNOLOGY

SECTION II. SCIENCE AND TECHNOLOGY

Section II depicts the scientific and technological activities through which the Laboratory addresses its mission. In the recent reorganization of Laboratory management, the Deputy Director for Science, Technology, and Programs administers programs and activities for all science and technology.

Science and technology activities have been divided into three groups, each of which is administered by an Associate Laboratory Director. In section II.A, we describe activities that fall under the responsibility of the Associate Laboratory Director for Nuclear Weapons. Accelerator Production of Tritium has also been included in this area because of its close relationship to this section. In section II.B, we summarize activities managed by the Associate Laboratory Director for Threat Reduction. Section II.C contains plans of those programs that the new Associate Laboratory Director for Strategic and Supporting Research is expected to administer. Work for agencies other than DOE is also described in this section.

Two important competency-related areas, (1) Science and Mathematics Education and (2) Laboratory-Directed Research and Development, are described in Section II.D. Lastly, Section II.E describes our major new initiative, Delphi. Other new initiatives are described under the programs in which they are being developed. For example, new initiatives in the area of Energy Research are presented at the end of Section II.C.2. Energy Research. Initiatives are provided for DOE's consideration. Inclusion in this plan does not imply Department approval of or intent to implement an initiative.

Data in funding tables represent the best budget projections at the time budget documents went to print. They may not represent DOE's current intentions, or the latest information.

A. NUCLEAR WEAPONS

1. Stockpile Stewardship

The Laboratory's stockpile stewardship activities serve one principal goal: to provide support for and ensure confidence in our nation's nuclear weapons stockpile. With the cessation of nuclear testing, our job took on two closely related responsibilities. The first is ensuring the safe and reliable condition of those weapons for which we have design responsibility. The second is our obligation to ensure that our government, our military services, any potential U.S. adversaries, and our own scientists and engineers have confidence in our ability to successfully carry out the national security mission of maintaining the nuclear deterrent.

Historically, confidence in the safety, security, and reliability of the weapons in the U.S. stockpile was maintained by developing, testing, and deploying new nuclear weapons—a combination that both ensured the quality of the stockpile and preserved the skill of U.S. weapons experts. The continuous development of new weapons designed to meet the military's evolving requirements and modern delivery systems mitigated problems associated with aging although we still had to evaluate and take action to resolve problems revealed during manufacture, surveillance, and deployment.

The stockpile is already older, on average, than was ever anticipated, and we can expect its future maintenance to require more effort, not less. Just as with an automobile or any other type of complex system, the older a weapon gets, the more attention it requires. Various aging phenomena occur at different rates and can affect safety or reliability differently. It is our responsibility to help identify and evaluate such issues and to be fully prepared to address and resolve them.

The stewardship of nuclear weapons involves a cycle of activities designed to ensure that the stockpile remains safe, secure, and reliable. During the dismantlement of weapons and routine surveillance operations, we examine a cross section of weapons to detect any abnormalities or potential problems, then we analyze the findings to determine whether they could represent a detriment to safety and performance. When necessary, we develop and implement solutions that maintain confidence in the safety and reliability of the weapons for which we have responsibility. Annually, we must certify this safety and reliability to the President of the United States.

In the absence of nuclear testing, stockpile stewardship is a demanding scientific and technical challenge. Success in meeting these challenges requires interdisciplinary approaches and the development of advanced computational modeling and simulation capabilities; enhanced techniques, tools, and instruments for experimental measurements, including hydrodynamic testing and high-energy-density physics experiments; innovative materials-science efforts; and establishment of new, efficient, economical, and environmentally compliant manufacturing methods.

Stockpile Stewardship at Los Alamos has been placed under a new office: the Associate Laboratory Director for Nuclear Weapons (ALDNW). This change in organizational structure was created to more tightly integrate the Stockpile Stewardship program. Included in the Associate Directorate are elements of two former program offices: Nuclear Materials and Stockpile Management (NMSM) and Nuclear Weapons Technology (NWT). As part of this consolidation, the following four Program Director positions have been established: Simulation and Modeling; Experimental Programs; Materials and Manufacturing; and Stockpile Systems. Also included in the Nuclear Weapons Associate Directorate are five divisions: Applied Theoretical and Computational Physics; Dynamic Experimentation; Engineering Science and Applications; Computing, Information, and Communications; and Nuclear Materials Technology.

The Nuclear Weapons Associate Directorship is responsible for almost all the nuclear weapons activities at the Laboratory, including the assessment and certification of the safety, reliability, and performance of the enduring U.S. nuclear weapons stockpile; surveillance, maintenance, and limited-scale fabrication of a variety of nuclear and nonnuclear components; and for nuclear materials for both defense and nondefense applications.

An essential responsibility of ALDNW is to communicate effectively with the weapons program's many customers: DOE, the Department of Defense (DoD), other elements of the executive branch, and Congress. In addition, the offices must communicate and coordinate with the other elements of the DOE complex, including the production plants. Monthly meetings are held with the Office of the Assistant Secretary for Defense Programs (DP) office DP-1 and the deputy assistant secretaries. Regular reviews include periodic customer-sponsored program assessments (for example, Enhanced Surveillance; Advanced Radiography; Accelerated Strategic Computing Initiative (ASCI), yearly with DOE and the three DOE weapons laboratories; and reviews with the principal investigators); many more topical reviews, including several with DoD; and continuing technical peer reviews at all levels.

As a matter of course, all segments of the weapons program—from the new ALDNW through the program directors, division directors, and project leaders—solicit customer feedback. Customers continually transmit requests and requirements for all needs.

DOE sponsors the programs in ALDNW. Table 3 at the end of this section provides funding details. Within DOE headquarters, ALDNW works closely with DP-1, DP-10, DP-20, DP-40, DP-50, and DP-60. For materials-related programs, the major DOE customers are DP-20, supported by the DOE Albuquerque Operations Office (DOE/AL) Weapons Programs and the DOE/AL Weapons Quality Divisions, along with the Office of Technology and Site Programs. In addition, some nuclear materials programs conducted by line organizations in ALDNW are sponsored by the Office of Nuclear Energy, the Office of Fissile Materials Disposition (FMD), and the Office of Environmental Management (EM).

The national security goals and objectives of the DOE Strategic Plan and the associated Government Performance and Results Act performance measures are strongly supported by the new ALDNW office. The stockpile stewardship activities described here address DOE's national security strategic goal.

a. Stockpile Surveillance and Surety

Maintaining confidence in the U.S. nuclear weapon stockpile requires the understanding and correlation of historical nuclear test data; aggressive research and development (R&D) programs in physics, materials science, and other scientific and engineering disciplines, including subcritical experiments and extensive hydrodynamic tests; and the development and use of leading-edge computational simulation capabilities.

Nuclear weapons assessment efforts are designed to address findings that arise from the surveillance program; to evaluate the significance of observed and predicted aging processes; and to consider the acceptability of options to repair, refurbish, or replace specific warhead components. Surety assessments address the safety, security, and control of nuclear warheads over the complete life cycle of a weapon—from design and manufacture through DoD custody to final dismantlement.

Stockpile Evaluation Program

The modern Stockpile Evaluation Program, through which we carry out our core surveillance activities, was established in 1958 to detect and evaluate stockpile issues affecting safety, use control, and reliability. The program addresses the entire warhead system (both nuclear and nonnuclear components) and allows for the sampling, measurement, and characterization of weapon components and subsystems. Whenever possible, it includes system or subsystem testing to thoroughly evaluate all aspects of weapon performance, reliability, and safety under all use conditions. This ongoing surveillance program includes assessments of newly produced components as well as of the various systems and components in the fielded stockpile. Los Alamos now has the surveillance responsibility for all plutonium pits, nonintegral valves from gas boosting systems, detonators from Los Alamos systems, and radioisotope thermoelectric generators (RTGs) that are part of some weapon systems.

Enhanced Surveillance Program

The Enhanced Surveillance Program was established in FY96 for developing tools, techniques, and models that will provide advanced capabilities to measure, analyze, calculate, and predict the effects of aging on weapons materials and components. The program's goals include estimating component and material failure mechanisms due to age, estimating service life, determining the feasibility of nondestructively monitoring critical components in place and in real time, and developing sensors for failure mechanisms whose failure time cannot be accurately predicted.

Stockpile Surety

We conduct an ongoing, aggressive surety assessment program geared toward analyzing the hazards to which weapons may be exposed, characterizing the resultant environments, and defining the warhead response. Surety assessments also provide analysis of component technologies and designs proposed for inclusion in the Stockpile Life-Extension program. Though our weapons are judged to be safe and secure, these assessments are aimed at demonstrating how we could further reduce surety risks by developing and implementing new technologies and component designs and incorporating them as replacements during the life-extension process. The assessments are also designed to reveal the cost of such efforts. As with all life-extension activities, such surety-enhancing modifications must also be assessed to ensure that they do not inadvertently alter the weapon's ability to support mission requirements, safety, and reliability.

Surety assessments provide 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, operational, and accident environments. Rigor and independence are critical aspects of risk analysis. This year, to provide peer review independent of Laboratory interests, we have begun to collaborate as part of the University of California (UC) Risk and Systems Safety Analysis. Specific activities will include independent peer review of Los Alamos studies, review of safety themes for component replacement technologies, and assistance in developing state-of-the-art assessment methodologies.

b. Stockpile Life-Extension Program

The Laboratory works to indefinitely maintain the safety, reliability, and performance of the U.S. nuclear deterrent by investigating, developing, and implementing life-extension options for the remaining stockpile systems. These may include new components, weapon modifications or refurbishments, or complete replacements, as required. In the context of stewardship, all weapon components must ultimately be considered "limited-life" components, and thus life-extension activities are essential. Through dialogue with the military, we revalidate requirements for the existing systems and explore options to ensure the systems' continued performance in meeting these requirements. Activities range from replacing traditional limited-life components to studying contingency options for replacement warheads, in the event refurbishments and component remanufacturing can no longer sustain high confidence in continued weapon certification without nuclear testing. Presently, no requirement exists to implement such contingency options for deployment in the stockpile. We will define refurbishments for the enduring systems and lay plans to execute them over time to ensure the systems' continued longevity.

c. Stockpile Certification and Revalidation

Certification is the culmination of our stewardship activities; it is the formal process by which the design laboratories confirm that each weapon system conforms to its required military characteristics. The Dual Revalidation program described below will, over time, provide a modern baseline for each weapon in the stockpile and produce two formal, independent assessments of each system's performance in terms of revalidated military requirements.

Annual Certification

Annual stockpile certification validates the safety and reliability of each type of weapon in the active stockpile. The process also identifies significant issues that may need to be addressed by a nuclear test if such tests become permissible. The technical certifications conducted by the nuclear weapons laboratories, along with the advice of the Nuclear Weapons Council are provided to the secretaries of defense and energy, who ultimately provide the certification and their recommendations to the President. The three nuclear weapons laboratory directors complete annual DOE technical certification reports and certification. These reports note specific problems and uncertainties and the need to continue stockpile stewardship efforts. They also describe plans to correct any problems. The annual cycle is a procedure instituted by presidential guidance that helps ensure close monitoring of and confidence in the stockpile now that testing has ceased.

Dual Revalidation

Dual revalidation, initiated in FY96, is designed to provide a new form of peer review of individual weapon types. DoD plays an integral role in the process. The program entails archiving nuclear, engineering, and measurement data; collecting and evaluating all surveillance data; recalculating the performance of past tests with current codes and comparing the results of each; and using experimental facilities to gain an improved understanding of weapon performance. We are developing a schedule for revalidation of the entire stockpile. The W76 warhead is the focus of the first revalidation study. The revalidation teams will complete component evaluations, system tests, and analysis of the W76 by FY00. The teams will revalidate the next weapon, which will be identified in FY98, and subsequent weapons at 2- to 3-year intervals.

d. Simulation and Modeling

Historically, physics and engineering simulation codes were used as tools to support the design, development, and testing of new weapons. With the cessation of nuclear testing and no requirements for new weapon development, the role of numerical simulation and modeling has taken on much greater significance. Our stockpile stewardship efforts rely heavily on our ability to perform reliable computer simulations, which allow us to assess and predict weapon behavior by integrating our knowledge of weapons science and engineering with information from past nuclear tests.

As the stockpile ages, changes detected during surveillance activities will most likely be three-dimensional in character. Currently, the numerical simulation and modeling capabilities for nuclear weapons are empirically based, and because of computer hardware and other related limitations, most weapon performance assessments have been restricted to two-dimensional models.

One of the biggest technical challenges facing the weapons program is the development of predictive three-dimensional simulation and modeling codes to evaluate the aging stockpile from a scientific and engineering perspective. The physical resolution needed for these simulations—roughly a billion zones—will require 30 terabytes of computer memory and a peak operational speed of about 100 TeraOps to perform calculations in a reasonable time for weapon assessments.

Through ASCI, DOE's DP Strategic Computing and Simulation program (DP-50) is enabling the Laboratory to pursue an aggressive code-development plan. We are implementing innovative hydrodynamic and transport methods and evaluating them for their suitability for weapons problems. Additionally, we are developing and validating new physics and theoretical models for phenomena that include high-explosives (HE) initiation and detonation, material spall and ejecta, and hydrodynamic turbulence and instabilities (see Figure 6). We are also developing codes to model materials simultaneously over many distance and time scales, along with manufacturing models and codes to assess the impacts of aging on materials. An engineering assessment application code project will allow us to model, in three dimensions, the structural and system response of a weapon under the normal conditions of the stockpile-to-target sequence as well as under abnormal or accident conditions.

The development of new applications codes is focused on four advanced nuclear performance and safety assessment code projects. These projects are devised to make efficient use of advanced high-performance computing technology and architecture to achieve the simulation capability needed for assessing primary safety and performance as well as secondary performance in three dimensions. New transport and hydrodynamic methods will enable these codes to represent detailed features (for example, aging-related defects) in weapons that our current codes cannot. Specifically tailored for the advanced performance and safety assessment codes, these new methods will be parallelized and scaled to exploit the many processors of ASCI computer platforms.

The initial installment of the Blue Mountain SGI/Cray machine occurred earlier this year. The capability of the SGI/Cray Blue Mountain computer was increased to 400 GigaOps in early FY98 and is expected to achieve 3 TeraOps in 1999. An ASCI code has already run a three-dimensional hydrodynamic simulation with 60 million cells in parallel across 16 boxes (more than 1,000 processors) of Blue Mountain. This is an important step toward a 30-TeraOp system and, ultimately, a 100-TeraOp system in 2004.

The Numeric Environment for Weapon Simulation project, starting in FY99, will provide the infrastructure, workstations, servers, and networks needed to give the weapons designers, engineers, and analysts access to high-end TeraOps platforms. A prototype high-performance visualization corridor will be established from the Blue Mountain computer to provide designers with a highly efficient end-to-end system for setting up, running, and analyzing weapons simulations.

The Code Verification and Validation project, starting in FY99, will build on existing efforts and will help increase our confidence that our new ASCI codes can address weapons issues. We are developing specific Code Verification and Validation project plans, and these plans

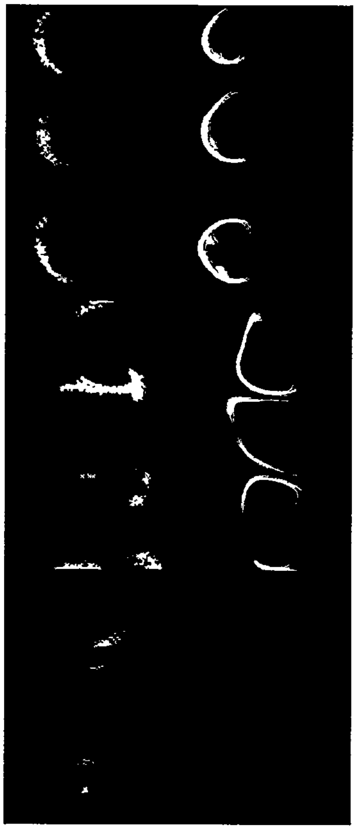


Figure 6. "Gas Curtain" experiments are laboratory-scale, high-explosive-driven measurements of fluid instability (i.e., Richtmyer-Meshkov Instability) of impulsive acceleration of a thin, high-density fluid layer embedded within a lower-density fluid. The observed laser-sheet illumination indicates intricate, vorticity-dominated flows that provide essential benchmark data for developing and validating three-dimensional computer simulations, including for the ASCI projects. Advanced gas curtain experiments investigate vital weapon science issues: mix models; convergence effects; three-dimensional flows; transition from fluid instability to turbulence. Shown here is a comparison of experimental measurements (left column) with computer simulations (right column) for three different initial conditions. The excellent agreement between observation and calculation leads to confidence in the simulation code.

include idealized test problems, data from past and future experiments, nuclear test anomalies and failures, and nuclear tests with unique diagnostic measurements that are sensitive to physics models.

At DOE's request, a conceptual design study is under way for a new Strategic Computing Complex to house the 30- and 100-TeraOp systems, as well as the design evaluation and code integration teams that will be their principal users. As conceived, this complex would be flexible enough to accommodate potential future expansion significantly beyond 100 TeraOps.

e. Theoretical Institute for Thermonuclear and Nuclear Studies (TITANS)

As long as the U.S. continues to maintain an enduring nuclear stockpile, it is vital that we preserve a strong skill base and the trained technical judgment to support effective stewardship. However, most of the people with practical nuclear weapons design experience will retire within the next 10 years or so; their knowledge and understanding must be passed on to the next generation of stockpile stewards. To help meet this need, the Laboratory established TITANS in FY96, with the objectives of educating the staff in nuclear weapons science and providing a mentoring process for new nuclear weapons designers. TITANS will help sustain a cadre of nuclear weapons designers and scientists well grounded in nuclear weapons science.

f. Hydrodynamic Testing

Hydrodynamic tests are high-explosives-driven experiments for studying mockups of nuclear weapon primaries during implosion. These experiments constitute our most important aboveground, nonnuclear testing capabilities because they allow us to examine the position, velocity, and condition of materials and material interfaces as well as the propagation and pattern of instabilities. These data, when coupled with three-dimensional modeling and simulation, will address the most essential issues in stockpile assessment: the functionality and safety of the primary stage.

PHERMEX and DARHT

The Pulsed High-Energy Radiographic Machine Emitting X-Rays (PHERMEX) facility is currently the principal flash x-ray diagnostic tool for studying hydrodynamic tests at Los Alamos. The Dual-Axis Radiographic Hydrotest (DARHT) facility is under construction. When complete, it will be one of the principal tools for evaluating and ensuring the safety and reliability of the enduring nuclear stockpile. DARHT will enable us to gather three-dimensional information and will give us much higher resolution for full-size hydrodynamic tests of nonnuclear primary mockups and for dynamic experiments designed for investigating shock physics, high-velocity impacts, materials science, high-explosives (HE) science, and industrial applications. To reduce environmental emissions, DARHT will include a phased implementation of containment for most experiments.

The DARHT structure was occupied for the first time in 1998, and components of the first-axis accelerator system are being installed for anticipated operation in FY99. DOE has decided that the second axis should take advantage of improved technology to produce and record multiple x-ray pulses, significantly increasing the information available for and confidence in future weapons safety and reliability assessments. Collaboration with the other UC national laboratories is helping us to develop this technology. We expect both axes to be operational in FY02.

Subcritical Experiments

Assessing the effects of component aging and new manufacturing techniques without underground nuclear testing requires us to measure the dynamic properties of nuclear materials by means of physical experiments. Although subcritical experiments at the U1a complex at the Nevada Test Site (NTS) involve HE and nuclear materials such as plutonium, they are designed to produce no self-sustaining nuclear reactions; therefore, they are consistent with the Comprehensive Test Ban Treaty. Subcritical experiments, which complement dynamic experiments conducted at other facilities, are important because they help us understand the properties of plutonium, reduce scientific uncertainties in weapon assessments, and improve our ability to predict aging weapon behavior. Los Alamos recently conducted the Rebound and Stagecoach experiments (see Figure 7). We plan to conduct two subcritical experiments per year.

Advanced Radiography

The laboratories funded primarily by DOE Defense Programs are also studying technologies that may enable an advanced radiographic capability beyond that of DARHT. Such a facility, referred to as the Advanced Hydrotest Facility (AHF), would provide high-resolution radiographs of dynamic experiments and hydrodynamic tests at multiple implosion times and view angles. Conceptually, such a facility would provide more precisely defined three-dimensional information, tracked in detail over time, than will be possible even with DARHT. The laboratories are studying, developing, and evaluating the feasibility of three technical approaches for such a facility: proton radiography and x-ray machines based on linear induction accelerators (like DARHT) and inductive voltage adders. Proton radiography, a newly emerging technology whose development is being led by Los Alamos, offers significant potential for a future AHF and is already providing data important for the Stockpile Stewardship program. Small dynamic experiments with the Los Alamos Neutron Science Center (LANSCE) proton beam have already provided multiple-snapshot data on HE behavior. These data have contributed to the basis for the assessment leading to the annual stockpile certification.

g. 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 explosion. In the past, most experimental data came 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. These experimental data are incorporated into sophisticated computer models that must, in turn, be validated against experimental data.

To perform weapons physics experiments and develop new experimental techniques, we use two different approaches to addressing high-energy-density problems: pulsed-electrical-power sources and high-energy lasers. The laser approaches are primarily pursued under the Inertial Confinement Fusion (ICF) program. Pulsed-power experimental capabilities include laboratory capacitor bank systems and HE-driven pulsed-power systems. Fixed capacitor banks and HE generators play complementary roles. Multi-mega-ampere electrical current pulses produce high magnetic fields which can precisely compress materials and produce high-pressure shocks. In addition, Los Alamos collaborates in designing and fielding experiments on the Sandia National Laboratories' "Z" pulsed-power facility, which is optimized differently to produce an intense x-ray source.

Pegasus

Pegasus is a high-energy pulsed-power facility in which we conduct a variety of weapons physics and basic science experiments, including precisely controlled, highly symmetric implosions. Experiments exploring advanced hydrodynamics in compressible and incompressible

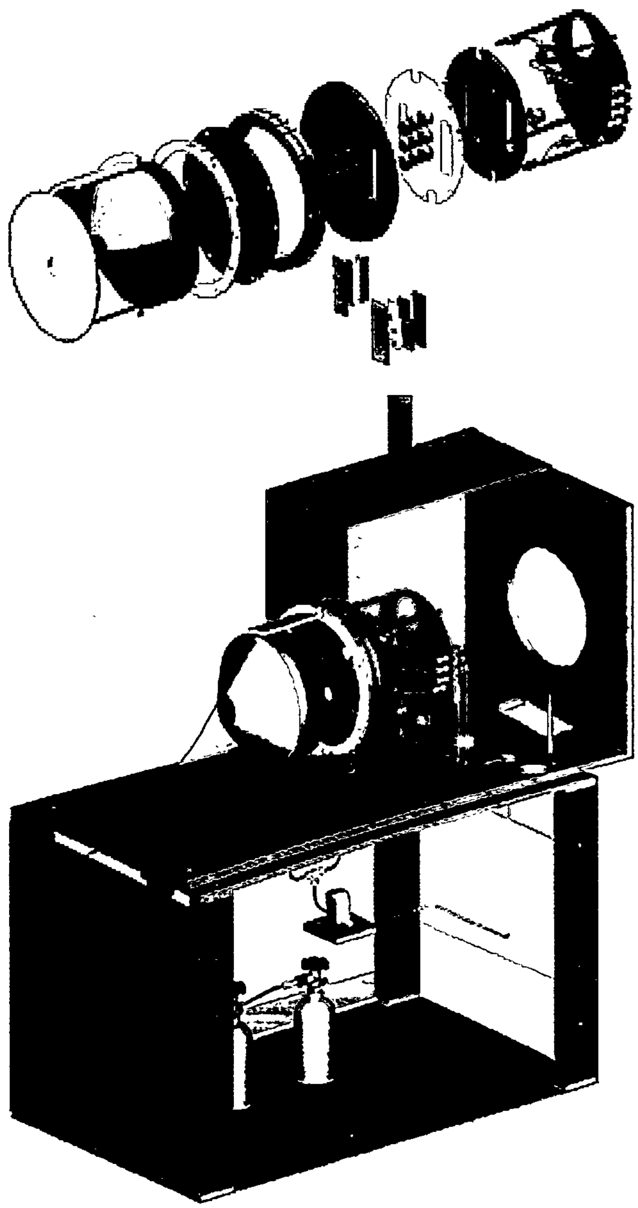


Figure 7. Rebound and Stagecoach are explosively driven, flyer-plate experiments dedicated to obtaining crucial equation-of-state and other material information about plutonium. Shown in the illustration is one of the three experimental assemblies of Rebound. This experiment (conducted on July 2, 1997) used a plane-wave high-explosive lens to propel a thin stainless-steel plate to velocities of several kilometers per second. The plate subsequently struck a number of plutonium samples of different thickness, sending shock impulses through them. In addition to equation-of-state data, Rebound also obtained data on sound velocities at high pressures and information about the conditions of plutonium after the shock wave had passed.

media provide detailed data to benchmark weapons design codes. Pegasus experiments conducted to explore the behavior of material under relevant shock conditions provide quantitative information about shocked surfaces, and that information is important to the Stockpile Stewardship program.

Atlas

When complete in FY00, Atlas, the world's largest pulsed-power facility, will provide the means for conducting important materials and hydrodynamic experiments 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 5 megabars in a volume of several cubic centimeters. The capacitor bank design consists of an array of 240-kilovolt Marx modules. The system is designed to deliver a peak current of 25 to 32 mega-amperes with 4- to 5-microsecond risetime. An experimental program for testing and certifying prototype components is under way.

Explosive-Pulsed-Power Systems

Two principal types of HE pulsed-power generators are currently in use: Caballero and Ranchero. Ranchero provides near-term access to Atlas-like drive conditions on a one-shot basis, allowing us to develop experimental techniques and produce weapons physics data. In the long term, systems like Caballero and Ranchero will explore even higher-energy-density regimes.

Inertial Confinement Fusion

Los Alamos plays a central role in the national ICF program, whose goals are to achieve an ignition demonstration at the National Ignition Facility (NIF) and to use ICF facilities to study weapons issues. The Los Alamos program emphasizes target-physics activities (including experiments, theory, and simulations), as well as target fabrication research and technology development, to investigate issues associated with both ignition and Los Alamos' stockpile responsibilities. Ongoing target-physics research includes areas of hydrodynamics and instabilities; radiation interactions; hohlraum plasma dynamics and laser-plasma instabilities; studies of alternate hohlraum geometries for both implosions and nonimplosion weapons physics experiments; and studies of dynamic material properties using time-resolved x-ray diffraction to study transient material response in small samples. These experiments complement those using other high-energy-density tools. Our experimental program includes research at three laser facilities: Lawrence Livermore's Nova (which will probably cease operations in FY99), the University of Rochester's Omega, and Los Alamos' Trident. In addition, we are actively planning experiments for NIF.

h. High Explosives

Los Alamos continues its role as one of the world's leading institutions in HE science and engineering. HE form one of the critical components of a nuclear weapon. From a fundamental science perspective, these materials are also among the most complex and least understood substances, particularly with respect to aging. The HE program's major activities and goals include baseline characterization of current stockpile HE, prediction of the useful lifetime of stockpile explosives to support Stockpile Life-Extension program schedules, development of more-accurate models of the performance and behavior of explosives (see Figure 8), accurate predictions of weapons behavior in both planned and unplanned scenarios, and continuous upgrades to the HE infrastructure to meet new operational requirements and experimental needs.

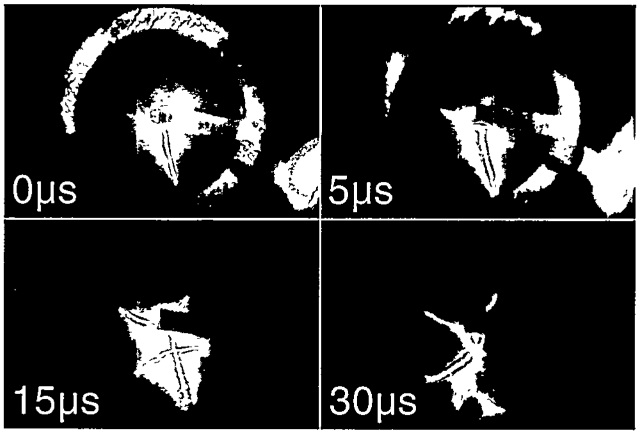


Figure 8. To understand explosive initiation under potential accidental environments, we use high-speed photography to study thermal ignition of high explosive PBX9501 at 190°C. The formation of cracks which cause the spread of reaction and transition to explosion is clearly visible in these time-sequenced photographs. This interaction between fracture mechanics and reactive flow is believed to be the driver in many accidental explosion scenarios, including both thermal ignition and low-velocity impact.

HERCULES

The High-Explosives Reaction Chemistry by Ultrafast Laser Spectroscopies, or HERCULES, is a new initiative in HE science. Femto-second lasers will measure reaction mechanisms and pathways with a time resolution of as little as 0.00001 percent of the total reaction time of the explosive. The application of spectroscopic techniques will provide knowledge of reaction mechanisms and reaction paths with sufficient time resolution to give us real kinetic values. This, in turn, will allow us to predict the bulk energy-release rates fundamental to the hydrodynamic material performance. If we are successful in determining product-species concentrations through the reaction zone and into the following flow, we will have obtained the definitive boundary conditions for any equation of state describing explosives products.

i. LANSCE Experiments

LANSCE is a multidisciplinary accelerator facility providing a source of intense pulsed neutron and proton beams for experiments supporting defense and civilian research. LANSCE contributes to the Los Alamos stockpile stewardship mission through the exploration, development, and application of accelerator-based particle science and technology to provide new tools that help ensure the safety and reliability of the nation's nuclear weapons stockpile. Stockpile stewardship research at LANSCE includes development and use of proton radiography as a new tool for studying weapons-related dynamic phenomena and for possible use in the future Advanced Hydrotest Facility; neutron tomography development for possible nondestructive surveillance techniques to assess subassemblies and components; internal strain-field measurements for understanding and predicting cracking and distortion in weapon components; characterization of damage and aging effects on HE; and measurement of shocked or detonated HE to develop advanced models of HE safety and performance characteristics.

j. Weapon Data Archiving and Assessment

Archiving previously recorded nuclear weapons data provides information needed by weapons designers and engineers for assessing and revalidating the safety and reliability of stockpiled weapon systems. In addition, archiving provides data needed in developing and validating improved models and simulation codes that will be used for future assessments. For the next few years, archiving activities will focus on supporting the W76 dual revalidation, the B61 bomb, and W88 pit rebuilding.

k. Future Contingencies and National Response

The Laboratory supports two major contingency readiness efforts: maintaining the ability to respond to a radiological emergency and maintaining the capability to conduct underground nuclear tests.

Emergency Response

The Accident Response Group (ARG) continues to evaluate and validate its capability to respond worldwide to U.S. nuclear weapons accidents, should any occur. A progressive series of training, exercises, and drills is used to provide diagnostics, safing, and packaging readiness. ARG is composed of an all-volunteer cadre of approximately 500 U.S. nuclear weapons design experts and support personnel from the DOE weapons laboratories and DOE support contractors.

The Nuclear Emergency Search Team (NEST) provides the deployment capabilities required to conduct search and recovery operations for nuclear materials, weapons, or devices and to locate, identify, diagnose, and disable improvised nuclear devices and radiological dispersal devices. NEST also trains scientific and technical specialists to provide technical advice (as directed by the President in PDD-39) that supports the U.S. government crisis response for operations involving nuclear materials and devices. This capability is also used on behalf of the U.S. to provide emergency response follow-on expertise in the event of a domestic or overseas radiological or nuclear emergency.

Test Readiness

A Presidential Directive requires DOE to maintain a capability to resume underground nuclear testing within 2–3 years, if requested. Test readiness is composed of four main elements: infrastructure, special equipment, procedures, and technically competent personnel. NTS personnel maintain their technical competency through active participation with Laboratory personnel in experiments supporting the Stockpile Stewardship program. We exercise all critical functions associated with NTS-based skills by conducting subcritical experiments and non-nuclear experiments at NTS and aboveground experiments at Los Alamos and by participating in NEST and ARG exercises.

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l. Materials and Advanced Manufacturing Technology

A close linkage of weapons design evaluation with manufacturing and processing capabilities, wherever they reside in the DOE complex, is critical in an era that allows neither nuclear testing nor new weapons production. Some engineering and manufacturing improvements to processes are critical to our collective ability to respond to future problems that may arise in the stockpile. We perform materials and manufacturing technology R&D with goals that include characterizing existing materials and processes to better specify remanufacturing requirements; developing replacement materials for materials that are no longer available; requalifying valuable existing parts and components for reuse; designing advanced tools and methods for agile manufacturing (for example, rapid prototyping, near-net-shape casting, and model-based product and process realization); developing environmentally benign material and production processes; and qualifying material and process changes.

m. Stockpile Management

Directed Fabrication—Nonnuclear Components

In the early 1990s, as part of the Nonnuclear Reconfiguration program, Los Alamos was assigned specific fabrication tasks. These included the manufacturing of detonators, detonator simulators, pit mockups, beryllium parts, and calorimeters, along with tritium loading of neutron tube targets. All these assignments were synergistic with existing Los Alamos R&D capabilities, for example, the fabrication of detonators for R&D purposes. The additional capabilities (including formal quality assurance tools to meet DOE and stockpile requirements) are now largely in place. The first War Reserve (WR) fabrication lot supplied directly for stockpile use was a small beryllium component furnished in September 1997. The second WR fabrication lot consisted of tritiated neutron-tube targets shipped to Sandia National Laboratories in the spring of 1998. Certain detonator components and diamond-stamped WR simulators for use in various system tests have already been furnished as well. The work of the Nonnuclear Reconfiguration program itself will be complete in FY99.

Pit Rebuild

In its long-term strategy to establish and preserve the capability to manufacture pits, DOE's initial focus has been on capturing and exercising all the technologies, capabilities, and systems on a laboratory scale through the Pit Rebuild program. This program predates the assignment of a pit manufacturing mission by DOE in 1996. The program's short-term goal to build a W88 technology development unit pit in FY98 was achieved.

Pit Fabrication at Limited Capacity

Fundamental to current and future nuclear programs is the maintenance and augmentation of the capabilities and facility infrastructures required to support the complete range of Los Alamos' existing nuclear materials responsibilities, which include samples and components fabrication for R&D, pit surveillance, materials science and technology development, materials stabilization, pit rebuild and fabrication, neutron source recovery, and other missions and activities.

In December 1996, through its Record of Decision on the Stockpile Stewardship and Management Programmatic Environmental Impact Statement, DOE assigned to Los Alamos the mission of reestablishing pit fabrication capability and capacity, with the limited capacity of 50 pits per year. While Los Alamos has some existing capacity for pit fabrication, fully implementing this mission to these capacities will require decisions on alternatives that are included in a Los Alamos Site-Wide Environmental Impact Statement released by DOE for public comment. However, from a strategy and timing perspective and under current planning, the next steps would be the development of the infrastructure required for an enduring pit fabrication capability with an inherent capacity of about 20 pits per year, which is comparable to the historic Los Alamos fabrication capacity.

A W88 pit-production activity to build a preproduction lot of modest quantity will be simultaneous with the infrastructure and equipment upgrades activities. Here the goal is to establish this enduring fabrication capability as a springboard to eventual larger capacity pit production at some other location. A companion goal is the fabrication of development unit pits for the B61-7 (FY00) and W87 (FY01). Maintenance and facility modifications for safety and life extensions of the nuclear materials facilities and implementation of limited-scale fabrication capacity will have to be pursued in parallel with pit surveillance and R&D activities.

Surveillance Testing and Dismantlement

Inherited from closed plants in the Nuclear Weapons Complex are tasks of performing the actual tests that support surveillance of weapons components. Los

Alamos has responsibility for all pits, detonators from Los Alamos systems, nonintegral values from gas systems, and RTGs that are part of some weapon systems. Dismantlement at Pantex, which obtains the components to be tested, involves Los Alamos representation in the Tri-Lab office, regular assistance with weapons assembly/disassembly and safety issues at Pantex, and numerous visits to Pantex by Los Alamos weapons staff.

ADAPT

The set of products that drive the Advanced Design and Production Technologies (ADAPT) initiative includes primaries, secondaries, and nonnuclear components. The concerted effort to reestablish a modest level of pit fabrication capabilities in the U.S. is linked to the process development portion of the ADAPT initiative. For pits, ADAPT will provide processes that are agile and safe. It will also provide processes that minimize hazardous waste and help demonstrate capability for low-cost flexible response to stockpile needs, as well as scalable-capacity technology for nuclear components. A recent success is development of the capability to recycle contaminated nitric acid. Soon, part-cleaning with pressurized (supercritical) carbon dioxide will replace the use of solvents that become contaminated. In addition, ADAPT plays a coordinating role in the weapons qualification aspects of improved processes.

Developing partnerships with private industry will be an important strategy, and a major emphasis will be on coordinating activities across the DOE complex. Continuing integration of that complex has expanded Los Alamos involvement with the plants as well as with the other laboratories. The complex-wide ADAPT goal is to conserve and leverage resources for the stewardship enterprise, increase efficiency and productive intrasite links, improve communications and responsiveness, and achieve real economies.

A key feature of our working relationship with Savannah River Site, supporting the joint Los Alamos-Sandia-Savannah River Tritium Engineering Master Plan, is a very beneficial personnel exchange program, with extended visits of both tritium management and technical staff. Our cooperative ADAPT ventures with Savannah River include gas reservoir materials studies, tritium purification and recovery, facility modeling, boost system function testing, and reservoir metallography evaluations.

Several ADAPT projects are being developed jointly with Y-12. Among these are support for the resumption of enriched uranium capability, a common approach to the issue of carbon reduction in recycled uranium, the qualification of uranium processing changes, and assistance with component machining issues. New joint activities in FY98 included preparation of technical proposals for future cooperation in the area of uranium chemistry.

Our ADAPT interactions with Pantex are extensive. We have numerous visits and regular bi-site reviews, an established process development team, a variety of joint planning meetings, and an active personnel exchange. The latter includes assignment of a Pantex project manager to Los Alamos. Among the joint projects are pit storage and monitoring; component requalification for refurbishment; conventional HE production; HE disposal through base hydrolysis; and transfers of engineering models, such as a rapid prototyping model, for tooling purposes.

The basis of our work with Allied Signal-Kansas City is a shared manufacturing assignment in detonator components and common interests in a wide range of production-related issues. To supplement numerous visits on both sides, we are preparing space at our detonator facility so that resident Allied Signal-Kansas City employees can perform a slotting operation on detonator heads. By doing this work at Los Alamos, Allied Signal eliminates a shipping step and the risk of damage to the fragile parts. Los Alamos and Allied Signal have held a joint planning session on manufacturing procedures and have launched numerous cooperative ventures, including technical dialogue on the manufacturing infrastructure for WR

pits and parts supply for a gas system that is under production.

Materials Stabilization

Los Alamos remains committed to the goal of reducing its own vault backlog of legacy nuclear materials by the year 2002, a target based on Defense Nuclear Facility Safety Board Recommendation 94-1 concerning the stabilization of nuclear materials. Los Alamos is the only site to have stabilized and packaged any plutonium for long-term storage, meeting the comparatively recent DOE Standard 3013.

Nuclear Materials Facilities

We are planning or currently pursuing upgrades to several of the following nuclear materials facilities, a number of which are decades old. These upgrades will allow the facilities to continue effectively supporting R&D capabilities needed for ongoing missions and to continue providing the full range of plutonium technologies and capabilities essential to the management and refurbishment of the stockpile. (These maintenance and upgrade activities are independent of the pit manufacturing assignment, full implementation of which would call for some additional facility modifications or enhancements.)

Chemistry and Metallurgy Research Building

This 45-year-old building was one of the first actinide chemistry and materials research facilities in the world. It now houses the analytical chemistry capabilities central to all Los Alamos plutonium operations, including plutonium science, pit surveillance and rebuild, preparation and certification of national plutonium standards, stabilization and characterization of nuclear materials, development of analytical techniques for nuclear materials, and the materials accountability and waste management infrastructure. The center also houses some other materials-related functions, including some uranium and other actinide research, fabrication, and metallography activities, and destructive and nondestructive analysis.

Nuclear Materials Storage Facility (NMSF)

Slated for renovation to correct design deficiencies that have so far prevented its use, this facility is needed if Los Alamos is to continue its existing nuclear materials mission. Most of the current inventory of plutonium is housed in a former day-storage vault at the TA-55 Plutonium Facility. The present storage vault was not designed for the extended storage of material, so the NMSF's additional storage capacity (up to 6.6 metric tons of special nuclear materials) is important for current and future operations.

TA-55 Plutonium Facility

This facility contains a complete plutonium handling, processing, and R&D capability, with approximately 80,000 square feet of secure space that provides the safety and security envelope for all types of plutonium operations. Activities performed at the facility include advanced R&D on plutonium behavior, chemistry, and handling; handling and processing of plutonium; and fabrication of plutonium components.

Although it is the newest of the nation's weapons plutonium facilities, TA-55 is now 20 years old. Several of the building's systems need upgrading, and components approaching the end of their useful life need to be replaced. Planning has begun on a Capability Maintenance and Improvement Project (CMIP) to refurbish safety systems, to make the modifications required to support limited-scale pit manufacturing, and to maintain our ability to continue with present assignments. The near-term part of the CMIP is called Transition Manufacturing and Safety Equipment. A major emphasis is on the safety infrastructure and the replacement of safety items such as the air-supply ductwork, the uninterruptable power supply, the backup electrical generator, and the continuous air monitors. In the short term, our small-scale pit manufacturing efforts will also benefit from upgrades and improvements to the trolley system and to equipment or facility provisions for operations such as radiography, foundry, metal preparation, machining, assembly, waste management, analytical chemistry, and material control and accountability. Design work is also under way on the Nuclear Materials Security and Safeguards Upgrades Project, which will provide an updated and fully integrated security control system, associated alarm systems, and other items for TA-55 as well as other nuclear materials facilities at Los Alamos. A third project, the TA-55 Fire Loop, involves the replacement of the Plutonium Facility's external water piping that supplies the fire suppression systems inside the buildings. As the initial part of the project, work is under way to anchor tanks and install seismic upgrades to aboveground lines in the water pump houses.

Weapons Engineering Tritium Facility

Originally designed as a state-of-the-art tritium facility with weapons gas-boost systems R&D as the primary mission product, this facility incorporates boost system design capability with operating tritium research and testing facilities (see Figure 9). Following upgrades scheduled for completion in FY98, the facility will be in a position to receive the second of two neutron tube target loaders from TA-21 and to begin lending support to TA-55's special recovery line, which processes tritium-contaminated objects.

Sigma Complex

Noted for its extensive capabilities for the synthesis, processing, characterization, and fabrication of an unusually wide range of materials, this large facility has a wealth of specialized laboratories, a rolling mill, and a 5,000-ton press. Completion of the nearby Beryllium Technology facility in FY98 will expand Sigma's science and technology base capabilities.

TA-18

The TA-18 complex provides the Laboratory's and DOE's nuclear facilities and nuclear materials programs with criticality safety support for specific facility process operations and for facility safety analysis. Critical assembly experiments are performed at the facility to assess

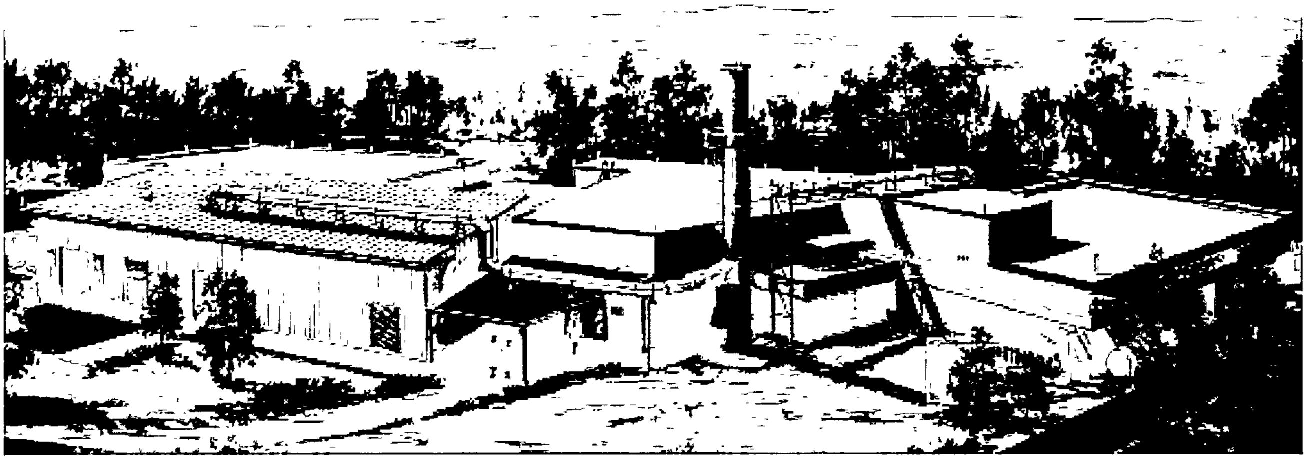


Figure 9. The Weapons Engineering Tritium Facility, shown in this artist's conception, is scheduled to be completed in FY98.

the safety and performance of individual production operations and devices and to validate the results of calculational methods. Operations, support, and supervisory personnel throughout DOE receive criticality safety training at the facility.

Nuclear Materials Management

The NMSM program office supports nuclear materials management with materials surveillance, materials accountability, U.S.-Russian excess fissile materials work, heat source development, and R&D associated with environmental management technologies. The R&D takes place at both Los Alamos and Rocky Flats. NMSM's Stabilization and Disposition program provides oversight. Sponsorship for materials surveillance will shift from DP to EM in FY99.

Materials Surveillance

The materials surveillance program currently funds two materials management efforts. First, the neutron source recovery program, which is sponsored by DOE DP-31, provides a mechanism for retrieving unwanted plutonium-239/beryllium neutron sources from public institutions and companies as well as government agencies. During FY97, more than 100 sources were processed. Second, the materials surveillance program funds a technical advisory, change-of-station position at DP-22 in addition to providing local software and analysis support for materials management forecasting and other studies. Special studies at DP-22 are generally in the systems analysis realm or involve specific issues in the overall nuclear materials management arena. Sponsorship for materials surveillance will change from DP to EM in FY99.

Materials Accountability

The Laboratory's efforts in managing nuclear materials are designed to comply with DOE Order 5660.1A, Management of Nuclear Materials, and to assure that

- the Laboratory's nuclear materials inventories are adequately assessed;
- the future nuclear materials needs of organizations with identified core competencies in nuclear materials are given due consideration 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.

Fissile Materials Disposition

To continue the reduction of nuclear risk, proper disposition of nuclear materials must follow warhead dismantlement in both the U.S. and Russia. Initial implementation activities must focus on securing, stabilizing, and storing surplus plutonium from the U.S. and the former Soviet Union. Plutonium must be recovered from weapon components and converted into unclassified forms appropriate for disposition options. More important, the transparency provided by these unclassified forms enables the immediate placement of this plutonium under broader inspection and safeguards regimes—bilateral, multilateral, or international. Such placement promotes irreversibility by making it 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. DOE is in the process of selecting a site for the proposed Pit Disassembly and Conversion facility. The four contender sites are Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and Pantex.

Today's disposition work by Los Alamos, the lead laboratory for weapon component disassembly and conversion and for nuclear fuel technology, capitalizes on preliminary first 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 planning for a safe, modern storage facility is in process.

Weapon Component Disassembly and Conversion. The Los Alamos Advanced Recovery and Integrated Extraction System (ARIES), a key element of the national disposition program, converts classified weapons fissile material into a stable, unclassified plutonium product assayed and packaged for long-term storage. The ARIES pilot demonstration project is in its third year and will begin operations in the second quarter of FY98. A design-only conceptual design report for the full-scale ARIES production facility is complete. Following discussions with numerous Russian scientific institutes and facilities staff, Los Alamos initiated collaborative work with the Russians to support the construction of a Russian conversion system and, ultimately, a Russian plant producing a steady stream of excess weapons fissile material stabilized and packaged into safeguarded and verifiable storage before final disposition steps.

Nuclear Fuels Technology. In a decision announced during the second quarter of FY97, DOE recommended a dual-path approach for fissile materials disposition. Some of the excess and verifiable weapons material will be made into a reactor fuel of mixed oxides (MOX) of plutonium and uranium. The remainder of the excess material can be mixed with radioactive fission products and vitrified, that is, immobilized in a glass or ceramic matrix.

Los Alamos has the only U.S. capability for producing MOX fuel, which can be burned in commercial nuclear reactors to meet the spent fuel standard—a major U.S. option and the option favored by Russia. Although the plutonium would not be completely consumed during reactor use for producing energy, it would be difficult and very expensive to recover it from spent fuel, rendering it safe from diversion or misuse.

Fabrication of MOX pellets from weapons material has been demonstrated at Los Alamos and is proceeding. Russia is developing MOX technologies as well. Los Alamos is using MOX fabrication technology for weapons-grade plutonium in the joint U.S.-Russian parallel experiment (Parallex) in which MOX fuel pellets made from weapons plutonium in both countries will be tested in a Canadian heavy-water reactor. Also, Los Alamos has fabricated MOX fuel pellets for testing in Idaho's Advanced Test Reactor, which is a light-water reactor. The MOX studies and collaboration, along with the disassembly and conversion efforts, are of mutual benefit to the two countries and have favorable implications for future nuclear arms reduction and materials disposition initiatives.

Radioisotope 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 new radioisotope heat sources;
- developing plutonium-238 fuel fabrication processes;
- 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 along with service evaluations for various applications.

Among the uses of RTGs and radioisotope heat units (RHUs) are space exploration missions. In July 1997, during the Pathfinder mission, the world shared the televised images of the barren Mars landscape and explorations of the Sojourner rover vehicle, which relied on three, small, lightweight RHUs in the suspension axle to warm electronics and batteries. The Cassini mission to Saturn was launched in October 1997. Cassini uses 157 RHUs made at the Los Alamos Plutonium Facility. After a flyby of Jupiter in December 2000, another 4 years will be required before the flight reaches Saturn.

Environmental Management R&D

The Laboratory is providing support to DOE for stabilizing nuclear materials to address the Defense Nuclear Facilities Safety Board Recommendation 94-1 (Los Alamos is the lead laboratory for 94-1 R&D). The Laboratory is providing other sites with stabilization guidance for which the technical basis is 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 to improve our understanding of underlying material interactions and to ensure that technical capabilities are available in the future to deal with any unforeseen problems with stored materials. Because of Los Alamos' diverse capabilities 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 stabilization work on unusual material forms.

The Laboratory is supplying technical and programmatic assistance for the development of materials management and disposition strategies at the Rocky Flats Environmental Technology Site (RFETS) as progress is made towards the challenging goal of site closure in 2006. Los Alamos previously established a memorandum of understanding with the primary RFETS contractor, Kaiser-Hill, that provides a framework for our involvement. A Los Alamos team is stationed at RFETS to provide support to Kaiser-Hill and other RFETS subcontractors. For example, in 1997 Los Alamos personnel assisted Kaiser-Hill in achieving several of its key performance measures, including the stabilization of more than 8,000 liters of plutonium solutions, stabilization of 50 kilograms of plutonium residues, and characterization of 450 transuranic waste drums for Waste Isolation Pilot Plant certification. In 1998, Los Alamos staff will assist Kaiser-Hill in several areas of the critical path activities in plutonium residue processing by providing support to facilitate the off-site transport of special nuclear materials; to ship low-level, mixed, and transuranic wastes off-site; to drain and stabilize more plutonium solutions; to process various categories of plutonium residues; and to remove plutonium and uranium holdup in RFETS buildings.

Nuclear Vision

To better understand how the technology context may evolve, or indeed how technology might aid or hinder the possibilities for reducing nuclear dangers in a world that increasingly uses nuclear technologies for energy and other benefits, Los Alamos has been examining possible futures related to worldwide nuclear activities over the course of the next 50 years. Elements of this study have included the future of nuclear energy and other civilian applications; nuclear weapons and proliferation; environmental matters; and other related issues. This small project has been organized around three main activities: internal and external workshops, research and analyses on nuclear topics, and development of linkages with other synergistic world efforts studying similar questions in the U.S. and elsewhere.

Rather than predict the future, the project attempts to look at alternatives in terms of realities with direct implications for the future, such as the increasing demand for nuclear energy in east Asia; the growing global inventories of nuclear materials; the demand for energy, which is outpacing the supplies of nonrenewable fuel sources; the reduction of superpower stockpiles; the rapid diffusion of nuclear technical knowledge and capabilities across the globe; and the proliferation risks of nuclear, chemical, and biological weapons of mass destruction. These many factors can affect each other in complex ways. Identification of potential science and technology needs is an important element of the project, along with an assessment of specific actions in technology, policy, and institutional areas that would help establish a roadmap for a nuclear future. Noteworthy accomplishments to date include nonfertile-fuel technology development work and a briefing to the Nuclear Energy R&D Task Force of the President's Committee of Advisors on Science and Technology.

Table 3. Projected Funding for Stockpile Stewardship and Management ($M).[1]

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Program and Initiatives (DP0101)	64.2	70.6	105.4	86.6	105.8	125.1	128.4	125.9
Accelerated Strategic Computing Initiative (DP0101)	32.5	52.9	91.9	97.4	101.2	102.0	102.0	102.0
Core Research and Advanced Technologies (DP0102)	105.2	122.8	123.3	115.2	113.9	124.9	128.0	132.7
Los Alamos Neutron Science Center (DP0102013)	33.1	34.3	42.1	38.7	38.7	42.5	43.7	45.3
Stockpile Computing (DP010205)	36.0	32.8	43.6	33.9	44.5	44.5	44.5	44.5
Defense-Related Waste Management (DP010104)[2]	0.0	0.0	42.0	42.0	43.7	45.4	47.2	49.1
Subtotal (DP01)	271.0	313.4	448.3	413.8	447.8	484.4	493.8	499.5
Inertial Confinement Fusion (DP02)	21.6	21.7	22.0	22.6	28.3	29.0	29.8	30.1
Technology Transfer (DP0301)	13.4	13.0	20.0	10.0	10.0	10.0	10.0	10.0
Education Initiatives (DP0302)	3.9	3.8	3.6	3.6	3.6	3.6	3.6	3.6
Subtotal (DP03)	17.3	16.8	23.6	13.6	13.6	13.6	13.6	13.6
Stockpile Management (DP0401)[3]	139.0	169.1[4]	223.7	231.6	250.6	256.8	263.4	278.0
Enhanced Surveillance (DP0401017)	10.7	10.4	17.0	18.1	18.8	19.6	20.4	21.3
Advanced Design and Production (DP0401290)	4.8	8.3	8.7	10.2	17.9	18.6	19.4	13.0
Nuclear Emergency Search Team (DP0402)	7.3	10.1	9.3	9.1	9.4	9.4	9.4	9.4
Nonnuclear Reconfiguration (DP040303)[5]	14.5	8.2	0.0	0.0	0.0	0.0	0.0	0.0
Materials Surveillance (DP0405)[6]	2.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal (DP04)	178.4	208.1	258.7	269.0	296.7	304.4	312.6	321.7
Program Direction (DP05)	3.1	8.0	2.0	2.0	2.0	2.0	2.0	2.0
DP Total	491.4	568.0	754.6	721.0	788.4	833.4	851.8	866.9
Other Funding								
Fissile Materials Disposition (GA010)	20.8	28.4	36.5	36.5	36.5	36.5	36.5	36.5
Heat Sources (Nuclear Energy/AF70)	10.9	8.6	10.4	10.4	10.4	10.4	10.4	10.4
Environmental Management R&D (EW7040)[7]	14.8	14.7	13.0	15.2	14.2	17.0	15.0	15.0
Total	46.5	51.7	59.9	62.1	61.1	63.9	61.9	61.9

[1]Budget figures do not include general plant projects, capital equipment, or capital construction in FY97 and FY98. Capital Equipment and General Plant Projects are part of the total operating budget in FY99–FY04.
[2]Transfer from Environmental Management starting in FY99.
[3]Enhanced Surveillance funding is not included here.
[4]FY98 increase is for zero-sum transfer of facilities from Stockpile Stewardship and Nuclear Energy to Stockpile Management.
[5]The present Nonnuclear Reconfiguration Program will conclude in FY98, leaving in place the capability for refurbishment of nonnuclear components in Stockpile Management.
[6]Transfer to Environmental Management starting in FY99.
[7]Included in Environmental Restoration and Waste Management data.

2. Accelerator Production of Tritium

Tritium is necessary for maintaining the nuclear portion of the U.S. defense structure. Because half of the tritium supply decays every 12 years, it must be continuously replenished. Since the 1988 shutdown of the last dedicated nuclear production reactor, we have recycled tritium from dismantled nuclear weapons. Recycling tritium, however, will not work indefinitely, necessitating a new source of tritium within the next decade.

Since 1995, DOE has followed a "dual-track" program to develop a new tritium supply using either a commercial nuclear reactor or an accelerator system. The program is managed within the Office of Defense Program's Tritium Project Office (DP-60). In the first track, only existing or nearly complete commercial light-water-reactor (CLWR) systems are being considered because of the cost and environmental impact of constructing a new reactor. DOE expects that using commercial reactors may result in lower costs for tritium production. The Accelerator Production of Tritium (APT) track is also being followed because, though it will possibly cost more than the CLWR, it will be a clean, environmentally sound system with few public policy or proliferation issues.

The 1997 Defense Authorization Act, as well as DOE's programmatic planning, calls for a decision between the two tracks by about December 1998. Once one of the technologies has been selected as the preferred option, the other track will continue to be pursued to the point that an adequate backup capability has been demonstrated. In support of that decision, the CLWR project has been working to resolve policy and institutional issues and to negotiate a contractual arrangement with a power utility. The APT project has worked to resolve technology issues and to develop a solid design and cost estimate.

Over the past 3 years, the APT project has completed a plant design that several expert panels have reviewed and judged to be technically sound. The costs to design and build the APT have been independently verified, and these costs have followed a downward trend with design maturity. A new modular approach to the plant design will allow further cost reductions as our arms-reduction policy changes. The environmental and safety features have stood the test of strict examination. APT has developed an exceptional management approach that has received praise from within DOE and elsewhere. In addition, APT is an investment in technology that will enable other important applications through its construction and operation. Among those applications are new options to effectively deal with our nuclear power waste and excess weapons plutonium legacies.

The APT project is a national effort, with Los Alamos National Laboratory providing the overall project direction. In addition, Los Alamos is responsible for developing and transferring the technology to the prime contractor, Burns and Roe teamed with General Atomics (BREI/GA). Over the past year, the BREI/GA team has relocated substantial resources to Los Alamos as part of the engineering design. Because the plant will be built at Savannah River Site, Westinghouse Savannah River Company is involved to ensure a smooth transition to plant operations. Brookhaven, Lawrence Livermore, and Sandia national laboratories, as well as the Thomas Jefferson National Accelerator Facility, have supporting roles.

One of the major goals of the DOE Strategic Plan is National Security, which includes supporting national security, promoting international nuclear safety, and reducing the global danger from weapons of mass destruction. Objective 1 of the National Security goal entails maintaining confidence in the safety, reliability, and performance of the nuclear weapons stockpile without nuclear testing. Since all nuclear weapons currently require tritium to perform properly, DOE's Strategy 4 is to "provide a reliable source of tritium as required for the nuclear weapons stockpile by FY05 or FY07, depending on the production option selected." The APT project is on schedule to have a reliable source of tritium in place by FY07, provided the DOE supplies the necessary funds.

In 1997, the APT Project achieved all 15 major milestones, with excellent cost and schedule performance indices. Significant accomplishments include completion of the plant conceptual design, an independent review of the estimated plant cost with agreement to better than 1%, and further confirmation of the technology through aggressive engineering development and demonstration activities. In September 1997, the Secretary of Energy reviewed the project and approved Critical Decision 2, allowing start of plant engineering design in FY98.

Recognizing the need to avoid building an excess-capacity, higher-cost plant, the project is developing a modular design. When completed in spring of 1998, that design will permit deferral of a commitment to Strategic Arms Reduction Treaty (START) I capacity until 2002, providing time for changes in tritium requirements to be realized and thereby saving DOE nearly $1 billion. Further, it will provide an option to return to START I production capability if ever needed, without interrupting tritium production at the lower level.

Several plant configurations were studied in order to maximize the flexibility and minimize the costs. The configuration that is considered to most effectively accomplish these objectives is illustrated in Figure 10.

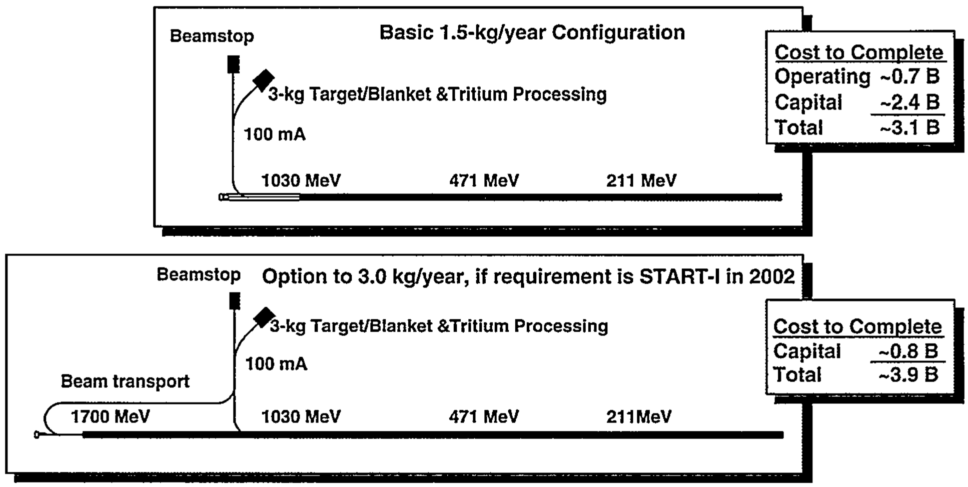


Figure 10. Proposed APT plant configuration.

For a reduced capacity of 1.5 kilograms of tritium per year, the accelerator will be about 800 meters long and will accelerate the protons to about 1,030 mega-electron-volts. The beam will then be bent 90° and will be directed into the target/blanket building. Should it be determined by 2002 that START I levels of tritium production (about 3 kilograms of tritium per year, including a significant "surge" production capacity) are required, the accelerator will be extended about 250 meters, boosting the proton energy to about 1,700 mega-electron-volts. The beam will then be transported to the original target. If the decision is made in 2002 to add this production capacity, the machine will be ready in 2007 to produce at START I levels. Alternately, the extra capacity could be added any time during the life of the facility, and most of the necessary construction could be performed without impacting ongoing production.

The current baseline cost to complete the APT facility, including engineering development, contingencies, and cost escalation, has been estimated and independently confirmed at about $3.9 billion. The cost of building a START I machine in the modular configuration and schedule (deferring decision on START I until 2002) is not significantly different. However, the modular design approach provides a potential cost savings of nearly $1 billion should reduced production levels be sufficient.

The cost profiles for the START I and reduced-capacity versions of APT are assumed to be identical until 2002, consistent with a deferred decision. Thereafter, the cost profile for the START I machine is higher, consistent with the higher construction cost. Should a decision to upgrade to a START I machine be made earlier, the budget impact comes sooner but with lower spend rates in the later years.

The budget profile for the Los Alamos portion of the APT project is shown in Table 4. Most of the Laboratory's contribution is in the engineering development and demonstration effort, which will be largely completed by 2002. The Laboratory's work in support of preliminary and final design is much smaller, and the Laboratory will have only minor roles in plant construction and operations. As a result, the impact of a decision on START I versus the reduced-capacity version not coming until 2002 is not expected to have a large impact on the Laboratory's budget, so only the START I baseline is included in Table 4.

Table 4. Projected Funding for Accelerator Production of Tritium ($M).

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Operating (DP0404012)	72.2	85.0	69.0	49.0	21.0	14.0	16.0	13.0
Design (Capital) (39DP04040)	0.0	7.0	23.0	24.0	16.0	5.0	0.0	0.0
Total	72.2	92.0	92.0	73.0	37.0	19.0	16.0	13.0

3. Theory, Modeling, and High-Performance Computing

Theory, Modeling, and High-Performance Computing is one of the Laboratory core competencies. Because high-performance computing and modeling play key roles in addressing problems across the Laboratory, modeling and computational efforts are found across numerous divisions and program offices. These activities support both the core mission of the Laboratory and the civilian national missions.

Funding is received from both DOE Defense Programs and the Office of Energy Research (OER). Because the funds are administered by the Laboratory program offices, additional descriptions and funding tables applicable to these defense and energy research activities have been provided in Sections II.A.1. Stockpile Stewardship and II.C.2. Energy Research.

A major component of our vision is the development of a simulation capability in the 100-TeraOp regime by the year 2004. To achieve this objective, we will

- develop applications as a driver for and a partner in the development of high-performance computing and communications environments;
- focus hardware and software architects to work closely with applications scientists in developing next-generation capabilities, including hardware and systems design;
- develop scalable algorithms, libraries, and run-time systems for current and future computer systems and also develop new ways to use these systems; and
- design, develop, and implement the integrated environments that make these systems useful. Examples include (1) the High-Performance Storage System (HPSS) for managing previously unimaginable amounts of data at very high speeds and (2) network interfaces such as the now-standard high-performance parallel interface (HIPPI) communications capability.

a. 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 computer science research, 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 Strategic Simulation Program. An effort is under way at DOE to create a new multi-institutional Accelerated Climate Prediction Initiative (ACPI) as a partner with ASCI. Los Alamos will have a prominent role in ACPI.

A key aspect of our strategy for the future, already being implemented today, is to leverage the hardware and software infrastructure investments as well as the research activities required by these three programs. The objective of this strategy is not only to accelerate progress in meeting the goals of the programs themselves but also to develop an agile simulation environment capable of addressing emerging problems important to the nation that the private sector alone will not or can not address.

b. Accelerated Strategic Computing Initiative

Because the ASCI program has been described earlier in the Stockpile Stewardship section, this section will focus mainly on the high-performance computing infrastructure component of the program. In 1996, the three participating laboratories—Los Alamos, Lawrence Livermore, and Sandia—received and installed their initial ASCI computer systems. At Los Alamos, the ASCI Initial Delivery (ID) system, an SGI/Cray Origin 2000 Supercomputer capable of performing over 100 billion calculations per second, has undergone a technology refresh (TR). This supercomputer, the TR system, marks the second phase of the ASCI Program. This TR system can perform approximately 400 billion calculations per second and can store the equivalent of 35 billion words (256 gigabytes) in memory. A second system, Nirvana Blue, has also undergone a technology refresh in our Advanced Computing Laboratory (ACL). The Nirvana Blue Refresh System (RS) supercomputer can perform 300 billion calculations per second and can store the equivalent of about 25 billion words (192 gigabytes). These two technology refreshed systems have a total of 1,792 processors—1,024 in the ASCI system and 768 in Nirvana Blue. Figure 11 shows our progression toward this supercomputer.

Beginning in June 1998, Los Alamos received the first in a series of shipments that, when complete in October of 1998, will constitute the ASCI Blue Mountain Sustained Stewardship TeraOps computer. This machine will be capable of a peak of 3.072 trillion floating point operations per second and will consist of 6,144 Silicon Graphics R10000 processors, each capable of more than 500 billion floating point operations per second. The machine will immediately be used to solve problems of

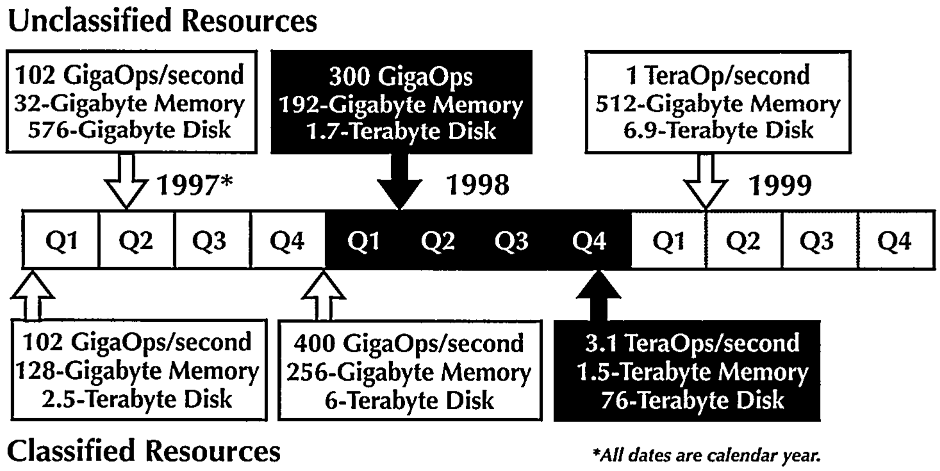


Figure 11. The implementation schedule for Nirvana Blue and Blue Mountain supercomputers.

national interest relating to the safety, reliability, and performance of the nuclear stockpile. In addition, beginning in November of 1998, the first shipment of the Nirvana Blue Final System will be installed. This system, when complete in March of 1999, will consist of 2,048 SGI R10000 processors and will be capable of over 1 trillion floating point operations per second. This machine will be used to simulate unclassified problems of national interest, such as climate modeling and wildfire simulation, among others.

Although the two supercomputers may be linked for unprecedented power, the computer at the ACL is being 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 already performing stockpile stewardship calculations. In 1997, calculations were performed that were influential in bringing about design changes in the construction of the Dual-Axis Radiographic Hydrotest facility.

Hardware Architecture

Movement toward a distributed computing environment utilizing multiple TeraOp computer platforms, tens of terabytes of disk storage, petabytes of archival storage, and copious ancillary equipment (e.g., remote rendering servers and smaller symmetric multiprocessor-based [SMP] computer platforms) leads to an architecture that is very different from the traditional designs. Our challenge is to optimize the balance between these resources in support of the ASCI applications.

Software Architecture

The software environment to which the Center is moving is in partnership with Sandia and Lawrence Livermore national laboratories through the ASCI program's Problem Solving Environment (PSE) research and development.

The plan is for a layered software environment. It leverages applications from commercial, public domain, and Tri-Lab developers to support secure, distributed high-performance computing in the areas of parallel I/O, mass storage systems, scientific data and information management, visualization, and resource allocation and management. In such an environment, for instance, it is essential that the secondary and tertiary storage devices be accessible in parallel at very high aggregate bandwidths.

To aid in the analysis and dissemination of ASCI simulation results, researchers in the Computing, Information, and Communications (CIC) Division are currently prototyping a scalable, high-performance data corridor to condition, analyze, and visualize multiterabyte data sets. This data analysis and visualization capability will be deployed to a focused set of designers and code developers this coming year to provide a novel, high-bandwidth data interaction capability for use in the verification and validation of ASCI simulations.

c. High-Performance Computing and Communications

As discussed in Section II.C.2. Energy Research, the OER-sponsored HPCC 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.

Strategic Simulation Program

The Strategic Simulation Program 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. This program is described in more detail in Section II.C.2. Energy Research.

Parallel Object-Oriented Methods and Applications (POOMA)

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 an infrastructure of layered C++ class libraries designed to simplify the development of scientific applications code 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 objects which reflect simple mathematical notation; thus, developers do not need to be familiar with the details of C++ object-oriented programming to make immediate use of the framework.

Efforts this past year have utilized expression template methods to enable kernel speeds equivalent to hand-coded C-kernels for large simulations. Thus, users of the framework are able to have the complexities of data communication, domain decomposition, and load balancing handled automatically by the framework while retaining near-optimal kernel speeds.

As the complexity of multiphysics simulation increases, the necessity of a software framework to encapsulate parallelism and enable portability becomes essential to achieving high-performance computing objectives. The interspersion of message-passing and physics kernels in typical high-performance computing simulations makes both the parallelism and physics impenetrable and the resultant code unmaintainable. The absence of this interleaving of parallelism and physics with explicit encapsulation by the POOMA framework allows the physicist to concentrate on physics and the computer scientist to concentrate on computer science—the result being a faster turn around in the problem-solving cycle.

The POOMA framework is not only easy to use but is extremely agile and portable across rapidly evolving, high-performance parallel computing architectures. The first ASCI code to run all three ASCI platforms at Los Alamos, Lawrence Livermore, and Sandia was a POOMA-based neutronics simulation, MC++. This code was prototyped on a serial workstation and recompiled on the three ASCI platforms with no changes to the code developer's source.

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; advanced accelerator modeling and design; and Monte Carlo neutronics.

Scalable Run-Time Systems

As we scale towards a multi-TeraOp clustered SMP system, applied research is required to provide run-time system features that scale efficiently for the class of applications relevant to ASCI and other high-performance computing programs. These efforts include lightweight thread libraries, operating system (OS) bypass methods, and parallel application coupling.

Lightweight Threads

Currently, most Unix platforms have agreed to support POSIX threads—an industry-standard thread interface. At issue is the scalability of POSIX threads. As the sizes of SMPs grow larger, applications will suffer from the large overhead of POSIX threads and will have limited scalability on account of the POSIX standard providing no mechanism for process and memory locality. The lightweight-thread libraries and schedules under development in CIC Division will not impose the "heavy" kernel-level processes associated with POSIX threads and will be optimized for process/memory locality. Several high-performance applications supported by CIC Division require a multithreaded approach—CIC Division's investment in lightweight user-level threads will satisfy this need and provide a scalable path toward multithreaded high-performance computing applications on multi-TeraOp platforms.

OS Bypass

In moving data between SMP boxes on a clustered SMP system, it is often the case that the data paths in a given application are well understood, yet no mechanism is provided in standard message-passing libraries for taking advantage of this knowledge. OS-bypass methods provide an approach whereby data is transferred directly between pages of memory on separate SMP boxes without requiring attention from the CPU. In this manner, latency is reduced and the CPU can continue with calculations as data is transferred. Currently, CIC is leading an OS-bypass standards effort called Scheduled Transfer and will develop a reference implementation this coming fiscal year. Recent research with prototype OS-bypass methods on a MyraNet Pentium Pro cluster have shown significant improvement in latency reduction.

Parallel Application WorkSpace (PAWS)

Many clustered SMP simulations require separate applications to interact concurrently. This capability enables clustered parallel applications, such as coupled ocean-atmospheric simulations, and distributed parallel computing, such as concurrent parallel multiresolution and parallel visualization of a target simulation. The research challenges here are the management of separate parallel applications with varying data distributions, a common control for both data pull and push between parallel applications, computational steering of analysis components, and dynamic parallel attachment. The PAWS team has developed an initial capability in each of the above areas and is now in the process of applying PAWS technology to ASCI and Energy Research Grand Challenge applications.

The High-Performance Storage System

HPSS, winner of a 1997 R&D 100 award, is a collaboration to provide a highly scalable, highly parallel hierarchical storage system with improvements in performance and capacity by at least two orders of magnitude. The collaboration involves the development partners—Los Alamos, Lawrence Livermore, Sandia, Oak Ridge, and Lawrence Berkeley national laboratories, and IBM Global Government Industries—and the deployment partners, which are spread across the continental United States, Hawaii, and Western Europe.

HPSS provides a scalable parallel storage system for highly parallel computers as well as traditional supercomputers and workstation clusters. HPSS requirements are driven by high-performance computing environments, in which large amounts of data are generated by massively parallel processors. Scalability is in several dimensions: data transfer rate, storage size, number of name-space objects, sizes of objects, and geographical distribution. Although developed to scale for order of magnitude improvements, HPSS is a general-purpose storage system.

In meeting the high end of storage system and data management requirements, HPSS is designed to use network-connected (as well as directly connected) storage devices to achieve high transfer rates. The design is based on IEEE Mass Storage System Reference Model, Version 5. The resulting product is being developed to be portable to many vendors' platforms. Other key objectives are modularity with open interfaces and reliability/recovery.

HPSS is currently deployed in the Los Alamos Central Computing Facility to serve users whose requirements for storing massive amounts of data are not being met by existing storage systems. Typical applications include three-dimensional hydrodynamic and radiation transport codes that generate many files in the 20- to 50-gigabyte range and hundreds of files as large as several gigabytes.

The addition of Kerberos authentication early in 1998 will expand HPSS availability to users' desktop workstations. This enhancement will allow each user to use a single storage repository for all of one's work.

Development has finished on HPSS Version 4.1, and integration testing has begun. Version 4.1, which will be deployed in the summer of 1998, provides enhanced support for the Distributed File System, better scalability, and even higher performance. Version 4.2, which is currently in the requirements definition stage, will provide for file aggregation, further enhanced scalability, and additional client interfaces and authentication mechanisms. This version will be released early in 1999.

Continued enhancements to HPSS performance will require our involvement with industry partners in developing new data storage technologies, such as optical tape and holographic storage; new storage paradigms, such as hierarchical and massively parallel disk and tape arrays; and new device connection technologies. This involvement will range from funding potential partners to conducting applied research in our own testbeds.

The application of data management technologies to storage systems such as HPSS will lead to systems that are easier for users to access. This virtual storage environment with a data management layer built upon conventional data storage software will provide users with access to information using languages that are natural to each user's field of study.

Falcon: Advanced Software for Simulating Oil Reservoirs

Many weapons simulations depend upon efficient, scalable linear solver techniques. Other problem domains, such as oil reservoir simulations, have similar needs and can be more demanding of the underlying algorithms in terms of matrix quality and stiffness. Researchers in Los Alamos have developed robust linear system solvers under the auspices of a multi-institutional collaboration on oil reservoir simulation.

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 package. Falcon was developed to run on massively parallel processors such as the CRI T3D, but it is portable enough to run on traditional vector supercomputers as well as 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.

An important benefit of this work with the oil and gas industry has been the development of highly scalable linear methods to solve the equations of interest for the reservoir simulation. These same solvers, with very little changes, are the same techniques required to solve the radiation transport equations critical to several ASCI applications. We have the oil and gas industry to thank for refining techniques essential to the ASCI program.

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.

Disaster Modeling and Forecasting

We are approaching a watershed in our ability to simulate complex natural and man-made systems with the use of rapidly increase hardware capabilities and the infrastructure which supports them. The driver for this enormously increased capability is the Science-Based Stockpile Stewardship program, but other challenges of comparable complexity will be able to take advantage of these advances. Since the nation spends, on average, a trillion dollars per year dealing with and mitigating disasters, not only could we reduce human suffering—perhaps even saving lives—but we would also have the opportunity to have an impact on this enormous expenditure by applying new techniques in modeling and simulation to disaster forecasting and response.

With respect to forecasting disasters, there are at least two kinds of challenges. The first and more difficult challenge is the predictive component to provide a lead time in preparing a response. Examples include the spawning of acute weather phenomena like tornadoes, the outbreak of disease, and the timing of an earthquake. The second challenge is in forecasting the precise movement or spread of outbreaks. There are other opportunities for applying the capabilities we are developing in both training and preparation through the use of simulations to the running of what-if scenarios.

To demonstrate the potential of applying computational science to such a class of problems, we have begun by selecting two particular areas for a focused effort. We see these areas as spanning the spectrum of modeling techniques—from the deductive (our wildfire modeling) to the data-driven (the mutation of the influenza and the epidemiology of the disease). Both of these areas are being initiated in concert with concerned government agencies, who have responsibilities in these areas.

In the case of wildfires, we have adapted a U.S. Forest Service empirical fire behavior model, known as BEHAVE, and coupled it in a fully interactive way to an atmospheric dynamics code (HIGRAD) to simulate the behavior of both real and idealized fires. This coupled model has been used to simulate the South Canyon and the Calabasas wildfire incidents as well as a prescribed burn at the Kennedy Space Center. Our calculated results compare very favorably with the gross features as well as some of the details of the real events we are modeling.

Our major research effort has been to develop a theoretically based model to supplant the heuristic approaches currently in use. The FIRETEC fire behavior model is designed to predict fire spread and is based upon fundamental transport equations and a parameterization of the combustion process. It includes diffusion-based radiation transport, a stochastic treatment of the down-wind transport of burning embers, moisture effects, and emission and transport of water vapor, volatiles, carbon dioxide, ash, and soot. We will also include characterization of the fuel bed at high resolution and are presently collaborating with the Forest Service, the University of California–Santa Barbara, and Dynamac Corporation to use remotely sensed data at 2- to 30-meter resolution to specify the horizontal variability of fuel type in chaparral and Florida scrub ecosystems. The FIRETEC code has recently been extended to three spatial dimensions and is being coupled to the HIGRAD atmospheric dynamics code that predicts local to fire-scale weather conditions. In turn, HIGRAD receives its boundary conditions from the RAMS mesoscale atmospheric model, which predicts weather conditions from relatively large scales down to local scales of ~100 meters. This new capability will provide us with a significant tool for fire marshals to assess fire spread in real time and to respond with informed deployment of their fire-fighting resources.

Complementing our effort in the wildfire modeling, we have embarked on an active program to address the ever-present threat of a serious worldwide outbreak of influenza. The recent emergence of a brand new strain of virus, the H5N1 virus in Hong Kong, has only heightened our awareness of how suddenly a new and virulent strain can emerge both in avian and human populations. Fortunately, we have considerable experience in the technologies that must be employed. For the influenza program, we are building on the success of our previous efforts in developing an HIV sequence database and associated analytical and modeling tools, which has provided an international resource in the fight against AIDS. The Los Alamos analysis of HIV sequence data led to the discovery of major categories of the viral sequence, which has been a key factor in decisions concerning vaccine design and deployment.

Our attack on the influenza problem has three core activities: (1) creating, organizing, and maintaining an international database of sequence data, including both avian and human data; (2) Analyzing the sequence space, serological space, and shape space of the rapid evolution of the influenza virus in order to develop predictive methodologies; and (3) modeling classical epidemiological aspects of influenza, including age factors, immunization status, and use of antiviral drugs. We are employing an arsenal of existing techniques, including phylogenetic analysis, structural modeling, and sequence analysis, and we are developing new techniques such as extensions of multidimensional scaling algorithms applied to serological data. In addition, we are developing epidemic models that will enable planning for, and control of, epidemic and pandemic outbreaks. These investigations, developed in collaboration with colleagues at the University of California–Irvine, University of California–Los Angeles, and the Centers for Disease Control in Atlanta, Georgia, are geared towards making optimal choices for the components of the annual influenza vaccine, as well as towards developing a sufficient understanding of the evolution of this highly contagious pathogen so that worldwide pandemics can be ameliorated and eventually prevented. Concepts developed as part of this project are now being incorporated into experiments in mice by researchers at the Centers for Disease Control, and we expect a close coupling between computational and experimental programs to continue.

B. THREAT REDUCTION

1. Nonproliferation and International Security

On November 14, 1994, President Clinton, while issuing Executive Order 12938, declared the following:

> I...find that the proliferation of nuclear, biological, and chemical weapons ("weapons of mass destruction") and of the means of delivering such weapons, constitutes an unusual and extraordinary threat to the national security, foreign policy, and economy of the United States, and hereby declare a national emergency to deal with that threat.

Two years later, President Clinton assured Congress that the United States has the capability to prevent the illegal importation of nuclear, biological, and chemical (NBC) weapons into the country when he said the following:

> The [U.S.] has developed and maintains myriad international and domestic programs to prevent the illegal importation of weapons of mass destruction into the United States...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.

Nonproliferation of weapons of mass destruction is clearly fundamental to U.S. national security policy, and DOE has major responsibility for combating proliferation of weapons of mass destruction and its many related threats. In his first address to DOE employees in 1997, Secretary of Energy Peña stated 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 national security programs are key to ensuring national and international security. The DOE Office of Nonproliferation and National Security (DOE-NN) focuses on reducing the danger posed by weapons of mass destruction. Specific DOE-NN program areas are

- assuring the security of nuclear material (domestic and international);
- preventing the spread of weapons of mass destruction expertise in the former Soviet Union;
- developing technology for treaty monitoring and proliferation detection;
- assuring the nonproliferation of chemical and biological weapons;
- preventing nuclear smuggling and terrorism;
- planning for emergency management and response; and
- providing intelligence analysis and reporting.

The DOE Defense Programs multiprogram laboratories (Los Alamos, Lawrence Livermore, and Sandia) provide the primary resources and capabilities that enable DOE to meet its nonproliferation responsibilities. DOE-NN 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.

Responsibility for nonproliferation programs at Los Alamos is assigned to the Nonproliferation and International Security (NIS) Program and Division. 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.

DOE-NN provides approximately 75% of NIS Program funding. The remainder comes to NIS through the Laboratory work-for-others program from many other government agencies, including the Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), and the several and separate elements of the U.S. Intelligence Community.

The three principal NIS program elements and their major DOE customer interfaces are the following:

- Nonproliferation and Arms Control (NIS/NAC)—Office of Arms Control and Nonproliferation (NN-40), Office of Security Affairs (NN-50), and Office of Emergency Management (NN-60).
- Research and Development (NIS/RD)—Office of Research and Development (NN-20).
- International Technology (NIS/IT)—Office of Energy Intelligence (NN-30).

These NIS program components, addressed in detail in the next three sections, are supported by the Center for International Security Affairs (CISA), by the nine groups and two facility management units that form NIS Division, and by the other Laboratory technical divisions. Tables 5 through 8 at the end of the section provide the funding information for activities related to Nonproliferation and International Security Programs.

a. Nonproliferation and Arms Control

Los Alamos NAC programs are focused on reducing the threat to U.S. national security posed by weapons of mass destruction. NBC weapons constitute a threat to the U.S. military, to our allies, and to our populace. We are concerned with proliferation by nations and with the potential spread of these lethal technologies to subnational terrorist groups. We also want to ensure that the superpower nuclear arms reductions are irreversible and that we will never see a resumption of the nuclear arms race. The central elements of our approach are preventing the spread of weapons of mass destruction materials, technology, and expertise; detecting proliferation worldwide; and reversing proliferation.

The NAC programs provide key technologies and technical expertise to enable this essential national security mission. Activities carried out in support of U.S. policies include

- assisting in the negotiation of treaties for arms control, nuclear testing restrictions, and fissile-material production limitations;
- evaluating export-control requirements;
- developing instruments and systems to improve control of nuclear materials in the U.S., in the former Soviet Union, and under international safeguards through the International Atomic Energy Agency (IAEA);
- implementing nuclear material protection, control, and accounting (MPC&A) programs in the former Soviet Union;
- addressing the issue of nuclear smuggling; and
- providing training for inspectors involved in the implementation of various nuclear material control agreements.

The technical core of the NAC programs is the development of means to control nuclear materials and the spread of nuclear technologies. These technical systems (domestic and international nuclear materials safeguards, MPC&A for Russia and the other new independent states of the former Soviet Union, and nuclear export controls) are among the few remaining barriers to nuclear proliferation. With this technology base and the broad technical expertise of the whole Laboratory, we also provide technical support to the nation's nonproliferation and arms-control policy development and implementation.

In addition to its long-standing involvement in and support of the Nonproliferation Treaty and the IAEA, NIS/NAC is currently involved in preparations for implementation of the Comprehensive Test Ban Treaty (CTBT), preparation for discussions on transparent nuclear warhead reductions, a Fissile Material Cutoff agreement, the Bilateral Agreement with the Russian Federation concerning the cessation of the production of plutonium for weapons, Nunn-Lugar agreements to provide safe storage of Russian fissile materials, the U.S./Russia/IAEA Trilateral Initiative for verification of fissile material, and numerous Lab-to-Lab arrangements to improve Russian and Chinese nuclear material security.

The key thrusts for NAC programs are

- Russian fissile materials,
- U.S. fissile materials,
- nuclear safeguards in Japan/Korea/China-Asia,
- export controls,
- CTBT implementation,
- strengthened IAEA safeguards ("Programme 93+2"),
- Strategic Arms Control/Dismantlement—irreversible arms reductions, and
- countersmuggling.

b. Research and Development

NIS Program and Division support U.S. nonproliferation and national security policies by developing sensors as well as analytical and modeling capabilities for detecting and characterizing proliferation. Proliferation in this context includes testing of weapons of mass destruction and the related production of materials and equipment. The Laboratory is carrying out research and development for remote-sensing monitoring and assessment technologies for detecting and identifying emanations, effluents, and other distinctive signatures of potential nuclear weapons research and development 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.

Los Alamos is a leader in providing research and development support to the nation's nonproliferation program. Research and development to support proliferation detection is an NIS strategic initiative. This research and development includes identification and cataloging of signatures for proliferation activities and development of sensors capable of detecting and characterizing these signatures. Instrumentation will be deployed on space-, air-, sea-, and land-based platforms. Current research and development projects, such as chemical analysis by laser interrogation of proliferant effluents, multispectral thermal imaging, and remote ultralow-light-level imaging, are investigating a broad spectrum of potentially useful techniques.

NIS performs nonproliferation and treaty verification research and development for DOE's Office of Research and Development, which currently sponsors the largest U.S. research and development program supporting U.S. national nonproliferation and arms control policy objectives. Principal task areas include

- on-site systems primarily for monitoring nuclear materials and facilities;
- emergency response to the transnational use of chemical and biological weapons;
- nuclear test detection for verifying compliance with nuclear testing treaties; and
- advanced systems and technologies for detecting the proliferation of weapons of mass destruction.

Verifying compliance to a comprehensive ban on nuclear testing requires significant improvements to existing verification systems; such research and development is another NIS strategic initiative. The CTBT is directed not only toward acknowledged nuclear weapons states but also toward those other nations and organizations with interests in developing a nuclear weapons capability. The Laboratory program is attempting to develop monitoring systems capable of detecting all potentially significant nuclear tests, even at very low yields. Satellite-based systems will continue to be the backbone of the monitoring system for tests in the atmosphere and in space (see Figure 12). Follow-on monitoring systems to the existing ones deployed on the Global Positioning System and Defense Support Program satellite systems are being developed to take advantage of modern sensor technology to achieve improved sensitivity at lower weight and power levels. Through such programs as Fast on-Orbit Recording of Transient Events (FORTÉ), our recently launched satellite-based experimental testbed for electromagnetic pulse detection, emphasis is being placed on the use of small, more efficient, and less expensive satellite systems (see Figure 13). In the area of underground testing, the emphasis for monitoring will be on the detection of small, evasively tested devices. These types of tests must be detected by worldwide seismic and hydroacoustic systems, which are undergoing significant capability upgrades in preparation for monitoring the CTBT. NIS will continue to play a major role in the required ongoing evolution of all of these systems as they

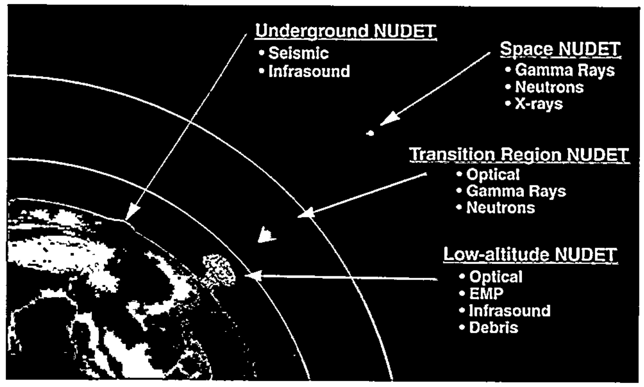


Figure 12. NIS is developing technologies to verify the Comprehensive Test Ban Treaty.

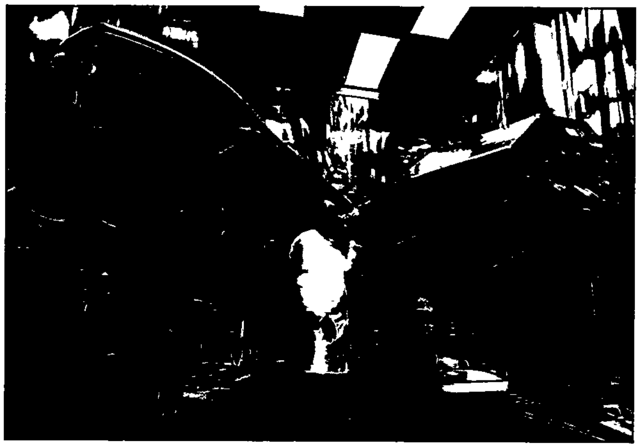


Figure 13. Final inspection of the FORTÉ satellite before its successful launch from an Air Force Pegasus-XL rocket. FORTÉ is a lightweight satellite designed to test technology to monitor compliance with arms control treaties. FORTÉ's instruments will detect, record, and analyze bursts of radio and optical energy arising from near the Earth's surface.

are brought up to the required capabilities to satisfy this new monitoring regime.

In addition to supporting DOE-NN, NIS is a major participant in NASA's space research program. This support is derivative from and synergistic with the research and development performed to support the DOE nonproliferation mission. 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 onboard the Ulysses spacecraft. Los Alamos instruments onboard the Lunar Prospector spacecraft collected the data that provided the definitive answer regarding the presence of water on the moon's surface.

c. International Technology (IT)

The growing worldwide inventories of special nuclear materials, the technical simplicity involved in producing biological and chemical agents, the increased access to missile technology for delivery systems, and increases in regional strife have all contributed to the problem of proliferation of weapons of mass destruction. The problem is further complicated by the specter of subnational terrorists employing these weapons or of organized international criminals trafficking in nuclear materials and nuclear weapons components. Information-based attacks on critical national infrastructures are also of increasing concern. Moreover, rapid advances on all technology fronts have increased the likelihood of a "technological surprise." To guard against such happenings, Los Alamos National Laboratory, under the auspices of DOE, continues to vigorously pursue a program that provides technical assessments of these critical issues in support of national policy-makers.

NIS/IT programs draw upon all-source data, the Laboratory's nuclear weapons expertise, and the multidisciplinary capabilities of the Laboratory, which, all combined, provide intelligence analysis under the auspices of DOE-NN. For NN-30, these projects provide technical estimates of foreign nuclear weapons, the related infrastructure, and the underlying science and technology base and capabilities. Laboratory scientists provide assessments of nuclear weapons technology, materials production, nuclear proliferation potential, and dual-use technologies (that is, technologies that are important to national defense but are beneficial in peaceful pursuits). In order to enhance the effectiveness of our analysts, NIS/IT has developed new methodologies for acquiring, cataloging, and analyzing the large volumes of all-source data that are an essential part of a first-rate assessment.

For other federal agencies, projects in NIS/IT tap into the interdisciplinary competencies resident at the Laboratory to develop specialized hardware and tailored application of extant capabilities.

From explosives to pulsed power to information security to materials science, new technologies and new capabilities are being developed through NIS/IT to help deter, detect, and respond to the threat of proliferation of weapons of mass destruction and other threats to our national security. Through NN-30, the mission to deter, detect, and respond includes the following:

- technical support in developing innovative options for mitigating new security threats, including those associated with the worldwide proliferation of advanced conventional weapons;
- assessments of the relative impact of arms control treaties on foreign nuclear weapons programs;
- advanced computational and analysis capabilities that provide 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 these weapons;
- technologies that provide enhanced capabilities to commanders, special mission units, or law enforcement agencies;
- creative technical solutions to otherwise "intractable" national security problems;
- U.S. law enforcement community access to appropriate Laboratory technical capabilities to counter criminal activities and terrorism with real-time access to Laboratory resources to support on-site reaction teams; and
- intelligence-based evaluations of nuclear smuggling and illicit trafficking in nuclear technologies and materials.

d. Center for International Security Affairs (CISA)

The mission of CISA, which reports to the NIS Director, is to develop, coordinate, and implement international programs aimed at reducing threats to the U.S. from weapons of mass destruction. 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 Lab-to-Lab 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 Lab-to-Lab 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 research and development.

Figure 14. Nonproliferation and Arms Control programs help to implement control and accounting systems in the former Soviet Union that are designed to secure nuclear material from theft or diversion.

e. New Initiatives for NIS

The effectiveness of the NIS Program and Division is handicapped by being located in 50 mostly substandard facilities scattered across the 43-square-mile Los Alamos site. Los Alamos proposes to consolidate this unique national resource physically as well as organizationally near the core of Laboratory activities by co-locating almost all NIS activities in new and existing facilities within convenient walking distance in TA-3, the Laboratory's main technical area. Accomplishing this consolidation will require the construction of a major new facility—the Nonproliferation and International Security Center (NISC). This consolidation will enhance program synergy and effectiveness by co-location of the NIS nonproliferation, arms control, treaty verification, and intelligence functions near the scientific, technological, and information sources that support these programs. Over 88% of the NIS staff will be consolidated in the TA-3 area—only those NIS activities in TA-18/36 and TA-66 will not be relocated. TA-18 is a Category 1 nuclear facility that would be impractical to move to TA-3. CISA is located in a relatively new and well-situated facility in TA-66.

The new NISC facility will be approximately 163,375 square feet (gross) and will be built on what is now a parking lot located near a low-traffic street across from the Physics Building, SM-40, and the Space Sciences Laboratory in which NIS-1, -2, -3, and -4 activities currently are conducted. NISC will be the home for NIS-2, -5, -7, -8, and -9 groups; the three NIS Program Offices (NIS/NAC, NIS/RD, and NIS/IT); Facility Management Unit 75; and the NIS Program/Division Office. The new facility will house much of the arms control, treaty verification, nuclear safeguards, nonproliferation, and weapons assessment functions of NIS Division. The staff and facilities provide the expertise and infrastructure to support the programs related to this mission. The proposed location for the facility is ideal because it is only a short walk to reach those NIS space sciences activities not located in NISC. (These activities will be consolidated in the space vacated by NIS-2 and NIS/RD.)

The facility will be multistory (a full basement plus four stories aboveground) and will house 435 people in spaces designed for technical and administrative offices, light laboratories, light manufacturing, special security, and support activities. The laboratories will be for physics, electronics, optics, instrumentation development, computer, intelligence, and other uses.

The total estimated cost and the total project cost for the project are $59.7 million and $62.9 million, respectively, assuming that Title I and II design will begin in FY00 and that occupancy will occur in the third quarter of FY03.

Table 5. Projected Funding for Nonproliferation and Verification R&D ($M).

Program Activity	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Detection and Deterrence Technologies (GC0401)	7.8	7.4	8.0	8.4	8.8	9.3	9.7	10.2
Treaty Monitoring (GC0402)	7.0	29.2	28.0	29.4	30.9	32.4	34.0	35.7
Proliferation Detection (GC0403)	27.1	17.8	19.0	20.0	20.9	22.0	23.2	24.3
Crosscutting R&D Activities (GC0404)	16.5	5.6	5.7	6.0	6.3	6.6	6.9	7.3
Total	58.4	60.0	60.7	63.8	66.9	70.3	73.8	77.5

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

Program Activity	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Nuclear Safeguards and Security R&D (GD, GH)	7.5	6.0	8.0	10.3	8.7	9.0	9.4	9.7
International Policy and Analysis (GJ11, GJ12, GJ0902)	2.8	3.8	5.5	5.8	6.1	6.4	6.7	7.0
Nuclear Transfer and Supplier Policy (GJ01)	5.5	5.4	5.0	5.3	5.5	5.8	6.1	6.4
International Safeguards (GJ02, GJ04)	4.4	4.6	4.0	4.2	4.4	4.6	4.9	5.1
FSU Material Accountability and Control (GJ08)	17.1	23.6	24.0	20.0	16.0	12.0	12.0	12.0
Industrial Partnering Program (GJ0902)	0.0	1.0	1.3	2.3	2.3	2.3	2.3	2.3
Industrial Partnering Program (SC62)	2.0	1.8	1.0	0.0	0.0	0.0	0.0	0.0
Total	39.3	46.2	48.8	47.9	43.0	40.1	41.4	42.5

Table 7. Projected Funding for International Technology ($M).

Program Activity	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
DOE Energy Intelligence	5.6	6.5	6.0	6.1	6.6	6.9	7.3	7.7

Table 8. Summary of Projected Funding for Nonproliferation and International Security Programs ($M).

Program Activity	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Nonproliferation and Verification R&D (GC)	58.4	60.0	60.7	63.8	66.9	70.3	73.8	77.5
Nonproliferation and Arms Control (GJ, GD, GH, SC)	39.3	46.2	48.8	47.9	43.0	40.1	41.4	42.5
International Technology (NT)	5.6	6.2	6.0	6.1	6.6	6.9	7.3	7.7
Total	103.3	112.4	115.5	117.8	116.5	117.3	122.5	127.7

2. Department of Defense Programs

The 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 enhance technical core competencies. Currently, DoD programs account for approximately 4% of the Laboratory's annual funding and are major contributors to our science and technology (S&T) base and internal discretionary funds. A budget summary of overall DoD funding is provided in Table 9 at the end of this section.

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 S&T to a broad spectrum of DoD 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 (DARPA) 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 en route, 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 operations, electronic warfare, information warfare, biological- and chemical-warfare (BCW) agent detection, real-time logistics control, and counterproliferation. Plans to achieve these capabilities through S&T 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 (DP) nuclear weapons laboratories—Los Alamos, Livermore, and Sandia National Laboratories—also present significant opportunities for DoD programs. These investments are intended to stabilize the core nuclear weapons programs necessary to ensure a safe and reliable U.S. nuclear deterrent 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 DoD in the twenty-first century.

Los Alamos supports DoD armed service interests when the Laboratory's unique capabilities and nonaligned status apply to technological needs in conventional defense. 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 DoD's preferred resource for both innovative solutions to national security requirements and a strong, enduring S&T base for future needs. In the near term, however, there is an immediate need for Los Alamos (and the other two DP labs) to support DoD as expressed to DOE by the JCS vice chairman. DoD believes that the DP Laboratories can play a significant role in addressing current deficiencies in three priority areas: detecting and defeating hard and deeply buried targets; applying modeling and simulation to force structure and acquisition decisions; and examining potential alternatives to antipersonnel land mines. The three DP labs have already prepared a report on hard and deeply buried targets defeat in response to language in the 1998 National Defense Authorization Act. Active discussions on collaboration between DoD and DOE in these three areas are currently ongoing.

a. Defense Technology Portfolio

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

Conventional Weapons Technology

The Conventional Weapons Technology platform employs 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.

In addition to 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 improve significantly the predictive capabilities of our codes; 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 DoD and its contractors. Finally, we are exploring antimine and hard-target kill technologies of importance to emerging DoD missions.

Modeling and Simulation

Simulation, defined in this context, is the modeling of macroscopic systems for requirements, prototyping, acquisition, test and evaluation, operational 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 and with the continued development of scientific theories of systems behavior, simulations are increasingly important tools for defense scientists and analysts. They also enable us to demonstrate how our proposed technologies can affect the battlefield—a powerful means of supporting program development and acquisition decisions.

JointSim is a continuing initiative to develop higher-level-architecture, object-oriented, composable, distributed simulations for defense planning, doctrine, tactics, acquisition, and virtual testing. SAMSON (simulation and modeling supporting operational needs) 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 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 for studying deployment and logistics issues of major force deployments, is a systems analysis product that addresses real problems for DoD. 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 foundation for addressing other national security issues.

As simulation becomes increasingly important to our understanding and decision-making concerning technology acquisition and research, so does developing a comprehensive body of science that will ensure appropriate development and use of that technology. Currently, such a body of science does not exist. Our intent is to work with key sponsors in DoD who share our interests and will benefit from the results.

Defense Beams and Sensors

The Defense Beams and Sensors platform encompasses beams (particle and laser) and sensor technologies (active and passive) for DoD applications. Specific technology initiatives include biological and chemical warfare-agent sensors; command and control, communications, computers, and intelligence (C4I) 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 countermeasure systems. The Los Alamos beams and sensors programs support the fielding of these DoD systems from the development of the required science base, through the field-testing and demonstration of advanced-technology prototypes, to the subsequent technology transfer to industry for mass production.

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

In addition, the Los Alamos DoD beams and sensors programs support the Army's effort in biological-weapons defense. For near-term applications, the Laboratory is developing helicopter-based 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 these long-range standoff LIDAR systems, 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 of the aerosol cloud. For longer-term applications, Los Alamos is participating in the DoD Joint Biological Remote Early Warning System (JBREWS) advanced-concept-technology demonstration (ACTD). Using robust and inexpensive hardware based on existing technology, JBREWS will provide wide-area, large-volume coverage for detection and identification of biological agents. Los Alamos is teamed with Lawrence Livermore National Laboratory on the JBREWS ACTD. The team focuses on C4I and emphasizes communication networks, network detection algorithms, and the JBREWS ACTD command-post running of the JBREWS C4I application. The JBREWS ACTD software application tool is to be used in command post operations, mission planning, and system modeling.

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. Many of these technologies are applicable to advanced development programs such as that for the Joint Advanced Strike Technology 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, as well as antipersonnel land mine replacements. 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 systems are under development at Los Alamos for these applications. These weapons are based on compact, explosive-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 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 has 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 DoD in high-performance computing.

Environmental Technologies

For several years, Los Alamos has performed research and development activities for DoD under the authority of the Economy Act of 1932 and the Atomic Energy Act of 1954. These activities are diverse and are based on the capabilities established to support the primary defense mission of the Laboratory. The Laboratory is involved in the joint DoD, DOE, and Environmental Protection Agency Strategic Environmental Research and Development Program and with individual DoD sites. Projects include nonthermal plasmas for removal of contaminants in jet engine exhaust, such as in cruise missile testing; supercritical carbon dioxide for cleaning and hardening of concrete; use of autonomous robots for detection of unexploded ordnance; and the reclamation of depleted uranium from test devices. Some of those projects under investigation for desert applications are being considered for use at sites in cold and tropical regions. In support of the DoD Environmental Security focus, Los Alamos is involved in the Base Realignment and Closure program. For example, the Laboratory is teamed with the University of California–Santa Cruz and Lawrence Livermore National Laboratory to develop instruments and methodologies for monitoring waste streams at the DoD Fort Ord site.

Biotechnology

Los Alamos research efforts in basic bioscience and biotechnology, physics, chemistry, and high-performance computing provide multiple opportunities from which DoD can support their needs in combat casualty care, soldier protection, and health-care technologies. Laboratory scientists are currently funded by DoD sponsors to advance TeleMed, the electronic virtual medical record, which is receiving wide acclaim as an example of an application that provides multimedia data on demand over the Internet through distributed database technology. Based on optical-physics principles, a noninvasive optical-biopsy technology developed at Los Alamos is currently undergoing clinical trials by the Food and Drug Administration for detecting bladder and colon cancer. The same principles are being applied to the assessing of breast tissue at the time of needle biopsy for determining breast cancer. Acoustic interferometry provides the means for assessing intracranial pressure changes with a small transducer. Coupling this technology with human-tissue-modeling capabilities, scientists have proposed a tool that can detect trauma and pressure changes in the brain in a noninvasive and rapid diagnostic. They have developed a biomagnetic sensor from magnetoencephalography research, which earlier resulted in a noninvasive tool for assessing brain function. The hand-held sensor is another potential tool for rapidly detecting brain trauma in combat casualties.

Structural biology core competencies at the Laboratory have provided the means for designing molecular mimics that defeat certain classes of biotoxins by preventing their binding to the vulnerable cell in the human body. DARPA is funding these pathogen countermeasures. New proposals are coupling molecular and cellular biology to sophisticated sensor technology, a combination that would ultimately provide a sensitive detector of illness. These efforts expand upon DoD's defenses against covert, potentially instantaneous lethal attacks with a biological agent. Other applications of sensor technology proposed to DoD would capture the signature of a chemical agent and record it for later readout. Thus, victims of Gulf War Syndrome would have a record of the types and quantities of agents to which they had been exposed.

Table 9. Projected Funding for Department of Defense ($M).

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Department of Defense	54.3	45.4	37.8	40.0	40.0	40.0	40.0	40.0

C. STRATEGIC AND SUPPORTING RESEARCH

1. Environmental Management

Environmental Management (EM) Programs at Los Alamos are committed to the execution of the Laboratory's mission while contributing to the preservation of regional and world sustainability. Regional sustainability is significantly affected by how the Laboratory addresses legacy contamination. It is also affected by how the Laboratory conducts its operations. It is a principal objective of EM to preserve both the environment and future choices of the people of this region on how this environment may be used. This objective is met by remediating contaminated sites, managing Laboratory-generated waste in a responsible manner, and streamlining ongoing operations. These activities are accomplished through the Environmental Restoration (ER), Waste Management (WM), and Environmental Stewardship programs, respectively.

EM also contributes to solving complex environmental problems through its initiatives in the area of Sustainability Science. Global environmental issues are addressed by linking environmental measurements, world-class high-performance computing modeling, simulation, and assessment capabilities to provide prediction tools for decision-makers. These tools are used to evaluate the environmental consequences of major decisions such as damming a river or the effects of urban sprawl in arid regions. Other environmental science activities are described in the following text.

EM receives support from several DOE/EM program offices, including Environmental Restoration (EM-40), Waste Management (EM-30), Science and Technology (EM-50), and Transition and Management (EM-60). The major DOE customer interfaces for the Laboratory's EM programs are the DOE Albuquerque Operations Office (DOE/AL) Assistant Manager for the Office of the 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. Beginning in 1999, EM will receive its funding for WM activities related to newly generated waste from DOE Defense Programs (DP). DOE/EM will continue to provide funding to address "legacy" waste that was placed into storage before 1999 [mixed low-level waste (MLLW) and transuranic (TRU) waste]. EM also receives support from the Laboratory's indirect budget for special projects such as remediating orphan waste found in Laboratory facilities and actively managing unused, contaminated facilities.

In September 1997, DOE identified seven key objectives relating to its environmental programs. These objectives are the following:

- Objective 1—Reduce the most serious risks from the environmental legacy of the U.S. nuclear weapons complex first.
- Objective 2—Clean up as many as possible of DOE's 83 remaining contaminated geographic sites by 2006.
- Objective 3—Safely and expeditiously dispose of waste generated by nuclear weapons and civilian nuclear research and development programs, and make ready the disposal of defense-related high-level radioactive wastes.
- Objective 4—Prevent future pollution.
- Objective 5—Dispose of high-level radioactive waste and spent nuclear fuel in accordance with the Nuclear Waste Policy Act as amended.
- Objective 6—Reduce the life-cycle costs of environmental cleanup.
- Objective 7—Maximize the beneficial reuse of land and effectively control risks from residual contamination.

The Laboratory's activities in full support of these objectives is described in the following sections. The Laboratory also actively supports the DOE/AL Accelerated Clean-up Paths to Closure Plan. In this plan, significant cost savings are anticipated by expediting the restoration at sites like Los Alamos that are managed by DOE/AL.

Table 11 at the end of this section shows the total DOE funding for environmental programs.

a. Waste Management and Environmental Restoration

In partnership with DOE, the University of California (UC) developed performance goals for the WM Program and the ER project; these goals emphasize results most important to DOE. One result of this partnership has been the streamlining of project controls activities for these programs. EM has placed greater emphasis on stakeholder interactions. In addition to working closely with the newly reconstituted Citizen's Advisory Board, EM is cosponsoring with others a series of free public meetings to discuss such topics as sustainable water use and "green" construction techniques. EM is also providing small-scale technical assistance to neighboring communities in such areas as asbestos abatement and landfill design.

Table 10. Waste Management Facilities and Operations.

Waste Type	Facility	Operations Conducted
Chemical	TA-54, Area L	Accumulation, repackaging, and shipment
Low-Level Waste	TA-54, Area G	Compaction and disposal
Mixed Low-Level Waste	TA-54, Areas L and G	Storage, preparation, and shipment off-site
Radioactive Liquid	TA-50, Building 1	Treatment and solidification
TRU and Mixed-TRU	TA-54, Area G and West	Storage, retrieval, characterization/certification and shipment off-site
	TA-50, Building 69	Characterization, size reduction, and certification
	TA-50, Building 37	Repackaging, characterization, and certification

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 10 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 wastes and other nonradioactive wastes. The Laboratory's hazardous, chemical, and mixed WM activities are regulated by NMED and EPA. WM manages hazardous and toxic chemical wastes and radioactive wastes (low-level waste [LLW], MLLW, radioactive liquid waste, and TRU and mixed-TRU wastes).

In FY97, WM conducted work in accordance with the DOE-approved WM baseline and the WM FY96 and FY97 tactical plan. To measure its progress as a best-of-class operation, WM benchmarks its activities and operations against other exemplary programs and refines its processes. DOE and WM have developed several performance objectives to achieve this best-of-class ranking. WM will eliminate the MLLW legacy (as measured in the current Site Treatment Plan) by September 2004 and manage any MLLW generated after FY98 on an annual throughput basis. WM plans to begin shipment of TRU waste to the Waste Isolation Pilot Plant (WIPP) in June 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 WM work. In FY97, WM reduced work-related costs by 6% by improving processes, aggressively managing and reducing legacy waste, and preventing or reducing generation of future mission wastes through the Environmental Stewardship Initiative.

The WM Program initiated the Transuranic Waste Inspectable Storage Project during FY97 to retrieve TRU waste that had been placed into storage under earthen cover in the 1970s. Much of this waste is considered to be mixed-TRU waste, and it did not meet current requirements for storage that allows inspection of the waste. Retrieval operations have proceeded ahead of schedule, and waste containers have also been found to be in better condition than had been expected. The project is projected to continue through FY03, but it may be completed ahead of schedule if the operations continue without major problems.

Los Alamos also became the first DOE site granted authority to certify TRU waste for shipment to WIPP during 1997. Certification authority is granted only after extremely rigorous audits of capabilities and procedures, and this is judged to be a major success for the Laboratory's TRU-characterization program. The WM Program will begin to actually certify TRU waste for shipment to the WIPP site during FY98 and will have some waste ready for shipment when WIPP opens.

New process equipment for enhanced removal of radionuclides from radioactive liquid waste will also be installed at the Radioactive Liquid Waste Treatment Facility during FY98. This equipment, called ultrafiltration and reverse osmosis, will replace chemical precipitation processing that was installed at the facility some 35 years ago. Equipment for reduction of nitrate in the wastewater from the facility will also be installed in FY98.

Environmental Restoration

In the ER project, our mission is to clean up the Laboratory and Los Alamos town site as fast as possible in the most cost-effective manner so that land and facilities become available for more beneficial use. More than 2,000 sites that may have been contaminated over the past 50 years have been entered into a corrective action process to determine what actions, if any, need to be taken for them 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. ER 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 operated 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. FY98 continues the theme of working toward mutually agreed-upon, outcome-oriented performance objectives. ER has developed a plan to complete the remediation by 2008, having thus far identified over 950 sites as requiring no further action. As ER continues to emphasize remediation activities, highly contaminated or complex sites will receive greater attention. These sites include material disposal areas and lightly contaminated, rugged canyon areas. The ER project restructured in FY98 to enhance the focus on these two 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:

- decommissioning of the Omega West reactor;
- decommissioning several older, surplus facilities at TA-21; and
- removing high-pressure tritium-handling equipment from a building at TA-21.

Waste Minimization/Pollution Prevention

In a specific thrust area called the Environmental Stewardship Initiative, EM leads the work of minimizing waste and preventing 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 minimize the Laboratory's impact on the environment and surrounding communities. By conducting Laboratory operations for future environmental sustainability, the Laboratory reduces the potential for shutdowns and fines and improves Laboratory productivity by minimizing wastes that are expensive to dispose of. This work builds the trust of surrounding communities by demonstrating the Laboratory's commitment to the best environmental practices.

The initiative's long-term goal for the Laboratory is to produce zero 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 Laboratory operations and support throughout the Laboratory for process and system improvements.

The Environmental Stewardship Initiative has four major elements: waste minimization, air and water emissions minimization, environmentally preferable procurement, and conservation. Individually and collectively, these elements of environmental stewardship build on the success of the Laboratory's Pollution Prevention

Program to integrate and systematize the Laboratory's long-standing efforts to protect the environment. The four major elements are described in greater detail below.

- 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 with alternatives, 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 to maximize energy conservation, manage land effectively, and use 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. One such project is the installation of a closed-loop wastewater recycling system in the plating operation at the Sigma facility. Installed during the start-up phase of this project, the $1 million investment has successfully avoided several millions of dollars in waste storage and treatment costs. 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 is being done in preparation for 1999, when all programs will be charged for the waste they generate. The Environmental Stewardship Office and the WM Office are developing pilot projects for full recovery of waste treatment, storage, and disposal costs. Third, the Environmental Stewardship office is the Laboratory's lead organization assigned to develop and implement programs to achieve the 1999 DOE 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.

Sustainability Science

The Sustainability Science thrust at Los Alamos 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 Sustainability Science team works with many segments of the environmental community, including U.S. government agencies (DOE, EPA, Department of Defense, Department of Commerce, and Department of the Interior), international agencies and organizations, private industry, and universities. A significant portion of this work is done in partnership with our primary sponsor, DOE-Environmental Management's Office of Science and Technology. We apply our strong scientific and engineering capabilities to facilitating the solution of WM, ER, nuclear materials, and facility stabilization problems. We are working with other national laboratories to produce science and technology development roadmaps that assure needed technology is available in a timely manner to accelerate the cleanup and waste management efforts of the DOE complex. Our goal is the deployment of technologies that address environmental needs within Los Alamos and elsewhere within the DOE as well as the United States and the world. Many of these technologies are described on a Web site at http://www-emtd.lanl.gov. The major sustainability science initiatives are described in the remainder of this section.

The Environmental Management Science Program, jointly managed by DOE/ER and DOE/EM, currently supports 12 projects at Los Alamos. The objective of this program is to provide the scientific basis for environmental problem-solving. The projects selected for support in this very competitive process include Atmospheric Pressure Plasma Cleaning of Contamination Surfaces; Enhanced Sludge Processing of HLW: Hydrothermal Oxidation of Chromium, Technetium, and Complexants by Nitrate; and High Fluence Neutron Source for Nondestructive Characterization of Nuclear Materials. To execute these and other projects, the Environmental Management Program has formed partnerships with several universities and other national laboratories. These partnerships allow each organization to apply their unique expertise and build a complementary, integrated solution to tough environmental problems. An example of such a partnership addresses groundwater contamination in Bernalillo County. Working with Sandia National Laboratories, the University of New Mexico, and the Bernalillo County Health and Environment Department, Los Alamos is developing tools that can be used by the county to evaluate the risk of pollution by businesses and recommend alternatives. Partnerships with industry provide the basis from which many of the research efforts of Laboratory are developed into commercial applications.

Recently, our efforts with the Office of Science and Technology of DOE/EM have resulted in several new major initiatives at the Laboratory while we continued our general program. These include deployment of a decontamination and volume-reduction system for the Accelerated Site Technology Deployment (ASTD) Program, whereby commercially available technologies for glovebox cleanup will be deployed. In a similar vein, we will conduct a large-scale demonstration project for comparing innovative technologies for commercially available glovebox cleanup technologies with those of the ASTD Program. It appears that Los Alamos will be the lead laboratory in a multifacility effort to ensure that the technologies dealing with TRU waste are available.

Our efforts supported by the Los Alamos Laboratory-Directed Research and Development Program continue to demonstrate a proof-of-concept for remediating difficult-to-treat contaminants. Of particular importance are (1) development of an acoustic-based method for significantly enhancing the removal of dense nonaqueous phase liquids from groundwater, and (2) development of a chemical-exchange method for removing dilute concentrations of tritium concentrations from groundwater. Since no cost-effective technologies exist for either of these major needs, their program development potential is high.

The Integrated Environmental Science Tactical Goal focuses on competency development for High-Resolution Environmental Studies to allow regional assessments of the impacts of global climate systems. Increased spatial, temporal, and spectral resolution are enabled by Los Alamos capabilities, such as remote sensing, earth sciences, and the Accelerated Strategic Computing Initiative multi-TeraOp computers, and are required for the following:

- integrated assessments of global change through coupled atmospheric, ocean, ecosystem, and infrastructure models;
- microsimulations of eco-regions, their problems, and possible solutions;
- regional-scale estimates of the timing and magnitude of global change;
- international negotiations and planning for the effects of climate change;
- environmental security (transborder pollution, environmental treaty verification); and
- planning equitable utilization of resources (energy, water, forests, fisheries, minerals).

Los Alamos is a leader within the DOE laboratory system in developing an Environmental Security Program in collaboration with DOE, EPA, the Department of Defense (DoD), and other government agencies. Projects are under development in regions where environmental events hold the potential to cause local, regional, and/or transnational instability: Russia/former Soviet Union, Middle East/North Africa, China/East Asia, and Latin America. In specific projects related to water resources, Los Alamos is a participant in a multinational program in the Middle East designed to build trust between belligerent parties and has been named as lead laboratory for a White House–directed program on U.S./China Water Resource Management.

Los Alamos serves as the lead Laboratory for the EPA's Green Chemistry Program. The EPA promotes fundamental breakthroughs in chemistry that are useful to industry and accomplish pollution prevention through source reduction. DOE promotes similar objectives to achieve energy conservation. Green chemistry is defined as the use of chemical principles and methodologies for source reduction. It encompasses all aspects and types of chemical processes—including synthesis, catalysis, analysis, monitoring, separations, and reaction conditions—that reduce impacts on human health, energy consumption, and the environment relative to the current state-of-the-art. Program activities include research and development, coordination with private sector participants, and educational activities related to the Green Chemistry Program.

Los Alamos actively supports the development of technical competency in bioremediation, with a specific focus on actinides and heavy metals resulting from DP activities. The Laboratory is proposing that a site in Mortendad Canyon be approved by DOE/ER as a field research site in the Natural and Accelerated Bioremediation Research Program.

Los Alamos continues to provide strong technical support for the Yucca Mountain High-Level Waste Repository Project, which is located approximately 100 miles north of Las Vegas, Nevada. This support generally falls into the areas of site characterization and field testing. In the site characterization area, the work is centered on the modeling and transport of radionuclides through the mountain, mineralogy and petrology, geochemistry, and volcanism. Much of this work will support the performance assessment area as the project heads toward the submittal of a licensing application to the Nuclear Regulatory Commission. For the field testing, Los Alamos scientists and engineers are responsible for coordination and support of the numerous testing activities in the mountain. These include the Drift Scale Heating Test, which simulates the heating from nuclear waste in the same geometrical configuration, and the Busted Butte Transport Test, which will simulate the flow of radionuclides through the unsaturated zone of the mountain.

Los Alamos has made significant technical contributions to understanding the formation and movement of flammable gases that are contained in the high-level waste solids in the tanks at the Hanford Site. These efforts have contributed to defining the safety basis and controls that must be implemented to ensure safe storage of the wastes in their present configuration. In the technology development area, we continue to support pretreatment efforts in sludge washing and technetium removal. Finally, in support of the initiative to privatize the remediation of the high-level waste tanks, Los Alamos continues to lead the independent safety program that will set the safety standards and requirements that the private contractors will have to meet for the remediation efforts.

The Laboratory is providing complexwide 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 stationed at Rocky Flats Environmental Technology Site provides direct technical support in nuclear materials management, waste management, and environmental restoration as site-closure strategies are developed.

For several years, Los Alamos has performed research and development activities for DoD under the authority of the Economy Act of 1932 and the Atomic Energy Act of 1954. This work is very diverse and is based on the capabilities established to support the primary defense mission of the Laboratory. The Laboratory continues involvement in the joint DoD, DOE, and EPA Strategic Environmental Research and Development Program. One project is to develop a primer for munitions that currently have significant environmental attributes by using a newly developed material. Nonthermal plasmas are another medium having wide-ranging applications, including the removal of contaminants in jet engine exhaust such as in cruise missile testing. As an adjunct to our earlier work on supercritical water oxidation, the Laboratory has coalesced a broad range of capabilities into a cohesive team that now includes the use of supercritical carbon dioxide in cleaning. The technology has also been extended to the development of significantly stronger concrete. The application of those technologies will enhance environmental management as well as national security. Both involve alliances with other agencies and the private sector.

Finally, the Laboratory is involved in deactivating neutron sources that are abandoned or are 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 sources and americium/beryllium sources. The Laboratory is further developing its capabilities to deactivate neutron sources over the next 5 to 10 years.

Table 11. Projected Funding for Environmental Management Programs ($M).

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
EW – Environmental Management Program (Defense)								
Operating	132.1	149.6	94.7	113.7	115.4	136.9	143.7	149.8
Capital	4.5	5.8	0.4	0.4	1.0	0.4	0.4	0.4
Construction	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	139.6	156.5	95.1	114.1	116.4	137.3	144.1	150.2
EX – Environmental Management Program (Nondefense)								
Operating	2.2	1.0	3.4	9.4	9.9	10.3	7.9	8.1
Capital	0.1	0.1	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	2.3	1.1	3.4	9.4	9.9	10.3	7.9	8.1
Total Funding – Environmental Management Program								
Operating	134.3	150.6	98.1	123.1	125.3	147.2	151.6	157.9
Capital	4.6	5.9	0.4	0.4	1.0	0.4	0.4	0.4
Construction	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	141.9	157.6	98.5	123.5	126.3	147.6	152.0	158.3

2. Energy Research

The programs funded by the DOE 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/ Energy Research 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. Figure 15 shows how Los Alamos ER activities are connected to the four DOE/OER scientific themes. Projected funding for Energy Research programs is provided in Table 12 at the end of this section.

a. Basic Energy Sciences

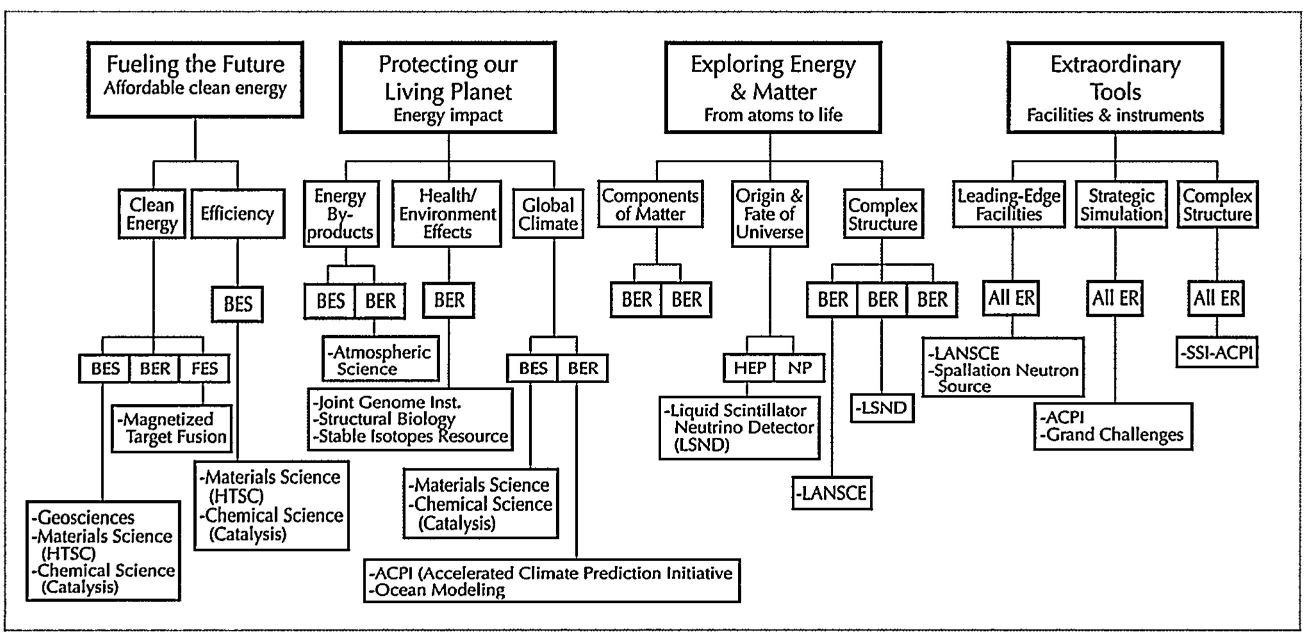
The DOE Office of Basic Energy Sciences (OBES) supports research that will advance the scientific and technical knowledge and skills needed to develop and use new and existing energy resources in an economically viable and environmentally sound manner. OBES focuses on research in materials sciences, 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).

Materials Sciences

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 the multidisciplinary science facilities at Los Alamos, such as the Manuel Lujan Jr. Neutron Scattering Center (hereafter referred to as 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.

The project involving high-temperature superconductors and correlated electron materials addresses the cutting-edge scientific issue of the interplay among structural, electronic, and magnetic properties that determine their unique properties and function. The advancement of our understanding of high-temperature

Figure 15. Los Alamos Energy Research activities are connected to the four DOE/OER scientific themes.



superconductors achieved in this program has direct impact on the closely related DOE Energy Efficiency applied high-temperature superconductivity programs at Los Alamos and other DOE laboratories. The highly correlated f- and d-electron materials research underpins our knowledge of f-electron materials central to DOE actinide programs and of the technologically important d-metal materials.

The photoelectron spectroscopy of transuranic materials program has achieved the first measurements of the f-electron character of delta stabilized plutonium. This capability provides the foundation for addressing the electronic structure of plutonium critical to DOE Defense Programs and for studying the surface chemistry of the transuranics for DOE environmental programs.

An interdisciplinary effort in understanding these and other complex electronic materials properties involves a theory and modeling project to extrapolate from microscopic to mesoscopic properties of materials.

To exploit the new neutron spectrometers at the Lujan Center, a new project called Complexity in Electronic Materials Probed by Neutron Techniques was proposed. This project builds on the Laboratory's considerable experimental and theoretical expertise in strongly correlated electronic 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 DOE laboratories, industry, and universities. The magnet, when completed in 2000, 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.

Chemical Sciences

The Division of Chemical Sciences of the Office of Basic Energy Sciences supports a range of programs in molecular sciences at Los Alamos National Laboratory. Several projects are funded by the Heavy-Element Chemistry Program in this Division, including efforts in both aqueous and nonaqueous coordination chemistry. Efforts aimed at identifying aqueous speciation of the early actinides in near-neutral and basic media employ a range of spectroscopic methods to identify structure and elucidate ligand dynamics in complexes under conditions relevant to those observed in the environment or in waste processing. A program in organometallic actinide chemistry examines the nature of metal-ligand bonding in the early actinide elements and provides important information on trends in electronic structure and reactivity along this series of elements. These efforts generate important information about the chemical behavior of plutonium and other actinide elements, and strong synergy exists with other Laboratory programs in environmental management science, waste repository performance assessment, and residue stabilization.

An important program supported by the Chemical Energy Program looks at the activity of unsaturated transition metal complexes in solution for binding and activating small molecules such as sulfur and nitrogen oxides, dihydrogen, carbon dioxide, and alkanes. This effort has been important in understanding the nature of activation involving "sigma-bound" small molecules as intermediates in stoichiometric or catalytic reactions. This program is part of a larger portfolio of research in homogeneous and heterogeneous metal-mediated activation of small molecules. These efforts build on Laboratory capabilities in surface science; reaction engineering and in-situ diagnostics; materials synthesis and characterization (including neutron scattering); theory and modeling;

and supercritical fluid systems. Applications of these efforts include the detection, separation, catalytic conversion, and destruction of molecular species in solution or at metal or metal oxide surfaces (programs funded by the DOE Offices of Defense Programs, Nonproliferation and National Security, and Energy Efficiency).

The newest effort at Los Alamos is a program funded by the Advanced Battery Program. In this effort, researchers are examining fundamental aspects of the physical chemistry and electrochemistry at the surface of electroactive materials (such as those used in composite electrodes). By investigating the electrochemical behavior of particulate materials in a variety of local environments (matrices), it will be possible to generate important information correlating electrode behavior with processing conditions. This effort builds on expertise arising from long-standing Los Alamos programs in fuel cell development and is part of a very strong capability in the development and characterization of electronic materials.

Finally, a theoretical effort supported by the Chemical Engineering Sciences Program 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.

All efforts benefit from association with Los Alamos facilities and expertise supported by core missions. Examples of such facilities and expertise include transuranic laboratories, neutron scattering/diffraction capabilities at the Los Alamos Neutron Science Center, and high-performance computing facilities.

Geosciences and Engineering

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

Geophysics projects involve both experimental and modeling components. Electrical properties of rocks and minerals allow determination of the thermal state of Earth's upper mantle and crust. Seismic properties and enhanced three-dimensional modeling of heterogeneous systems provide a better understanding of reservoir exploration and natural data sets, including application to weapons test monitoring. Elastic-wave phenomena in rock samples under nonlinear regimes provide new approaches to evaluating reservoirs, seismic response, and failure of rocks and comparable engineered aggregates such as concrete. New methods for modeling and evaluating subsurface multiphase fluid processes are proposed for integration in this program, with particular applications to reservoir characterization and dynamics.

Geochemical projects involve detailed characterization of geologic systems and basic interaction processes. Techniques have been developed for analyzing natural radioactive materials at ultratrace concentrations and for characterizing young geologic processes. Laboratory researchers are using uranium decay-series disequilibrium measurements to define the scale and timing of transport and mixing processes. The researchers are using cosmogenic helium and neon in surface soils and sediments to quantify processes involved in soils development and interaction with the hydrosphere. The researchers are also investigating model characterization for cosmogenic isotope production in terrestrial materials to provide better quantification of geologic systems and interaction processes. Microorganism interaction mechanisms with soil materials are increasingly recognized as a critical component of terrestrial geochemical system. Investigations of iron utilization processes by microbes in geochemical systems are providing basic understanding of coupled redox reactions. Integrated investigation of interaction processes in fractures on macroscopic to regional scales is proposed for extension of these projects.

Solar-wind research integrates theoretical and experimental research of the physics of solar wind and Earth's magnetotail and magnetosphere. The projects include components of plasma theory, computer simulations of energy transport and particle acceleration, and spacecraft data analysis in the study of solar wind-magnetospheric coupling, as well as aspects of magnetospheric dynamics.

Engineering research focuses on rheological and transport properties of particle suspensions in Newtonian and non-Newtonian liquids. This work integrates experimental and numerical simulation approaches to quantify basic processes understanding. Industrial and geologic systems in which the complex rheological response of suspensions limits process efficiency are important applications of this research.

b. LANSCE: National Neutron Science User Program

In addition to serving in a national security role, LANSCE serves as a national neutron science user facility, funded by 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 or organometallic compounds, the information obtained is critical to next-generation technologies. Much of the basic research 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 and nuclear physics experiments. There are currently 10 state-of-the-art instruments, including a powder diffractometer with a resolution higher than that of any other instrument of its type in the United States and a unique chopper spectrometer. As a 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 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 has participated 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 kilowatts. 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.

A large part of the scientific program to be carried out on the new spectrometers at the Lujan Center will be planned and executed by the same team that built each instrument. However, these spectrometers, along with the currently available spectrometers, will also be available to the general user community, with access, as is the present practice, to be recommended by the LANSCE Program Advisory Committee. The Laboratory is also creating several programs that will combine LANSCE with other Laboratory strengths (such as transport measurements and theory) to address such areas as correlated electrons and complex fluids.

Another unique development at LANSCE is being pursued in collaboration with scientists from NHMFL. The resulting pulsed 30-tesla magnet will allow scientists to make neutron diffraction measurements at a higher field than is currently available for this purpose anywhere in the world. The scientific program carried out at this facility will involve Lujan Center personnel, scientists from NHMFL, and other interested members of the national scientific community, particularly those with interests in magnetic phase transitions.

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 scheduled for completion in 1998. This project will provide more reliable and convenient operations and will extend the annual run cycle to 8 months.

To maintain close ties to the user community, LANSCE uses 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 to give individuals a means for participating in LANSCE; and a full-time user-coordinator to give users a single point of contact for the facility.

c. 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) has been used to search for neutrino oscillations. LSND has published evidence for the existence of neutrino oscillations in two, independent channels. The existence of neutrino oscillations has profound implications for nuclear and particle physics, as well as astrophysics and cosmology. LSND is expected to run for one more year at LANSCE. The LSND experiment also measures low-energy, neutrino-proton elastic scattering. The Booster Neutrino Experiment, a new experiment to run at the Fermilab Booster, has been proposed to confirm the LSND result.

Laboratory scientists are leading several efforts at LANSCE using low-energy neutrons to study fundamental interactions. The first source of ultracold neutrons in this country has been developed at LANSCE. Planned experiments include new measurements of the decay-particle asymmetries in 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. A related experiment is planned for Brookhaven's Relativistic Heavy Ion Collider (RHIC). The Heavy-Ion Team is constructing several major parts of the Pioneering High-Energy Nuclear Ion Experiment detector being built at 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, a large heavy-water detector being constructed in Canada. They are also studying time-reversal-invariance in neutron decay, and beta decay with trapped radioactive ions.

The Los Alamos Nuclear and Particle Astrophysics Team 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 giga-electron volts to 10 tera-electron volts. Milagro will be located in the Jemez Mountains, west of Los Alamos.

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) and 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 vigorously pursued.

d. 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 and as concerns about global warming demand development of new energy sources. Despite the potential for fusion to address these widely recognized issues, fusion funding was reduced as Congress balanced the budget. In response to reduced funding, the fusion research community, guided by the Fusion Energy Sciences Advisory Committee, is working to restructure the U.S. program. Greater emphasis is now placed on plasma science as a knowledge base, and large facilities, such as those needed for a tokamak-based technology-development program, are postponed, at least for the time being.

Los Alamos fully supports this new emphasis. Important ideas can be studied on a modest scale for evidence of whether 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 should be addressed through international collaboration. The International Thermonuclear Experimental Reactor (ITER) is a successful example of an international approach, and the United States is participating to the maximum extent possible.

Los Alamos 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 tritium processing using the world-class Tritium Systems Test Assembly, plasma-sprayed beryllium coatings for plasma-facing components, and design of accelerator-based neutron sources for fusion materials testing.

In keeping with the new restructured program and the imperative to find lower-cost development paths for fusion energy, Los Alamos has undertaken two new fusion initiatives. The first, called the Penning Fusion Experiment, is a new series of experiments to study ion physics in nonneutral particle traps. Funded as one of the exploratory concepts in the Office of Fusion Energy Sciences (OFES), the new experiment builds on success of the past few years in creating a spherical potential well with electrons in a Penning-like discharge. If successful, the Penning approach would lead to unusually small unit-size reactor systems, which would be much more attractive for development than conventional fusion systems.

A second major Los Alamos fusion initiative in the past few years is called Magnetized Target Fusion (MTF). Like the Penning Fusion Experiment, MTF represents a radically different approach to fusion with the potential for lower-cost development. By working in a regime intermediate in fuel density between conventional fusion and inertial fusion, MTF has the advantage of requiring much less costly systems for development, even in the ITER-like regime of burning plasma performance. Fortunately, pulsed-power facilities—such as Atlas, under construction by DP—allow significant tests of the MTF idea to be carried out with no other need to construct expensive facilities. The basic idea of MTF is to heat fusion fuel (plasma) to thermonuclear temperatures by placing the plasma inside an imploding metal liner. Magnetic fields provide thermal insulation between the fuel and the imploding liner. While the idea is not new, major advances have been made since MTF (called liner fusion at the time) was last considered in the 1970s. ER researchers have advanced the needed plasma science and technology, especially with the invention and study of compact toroids, and DP researchers have advanced the science and technology of liner implosions for other purposes. Thus we have arrived at a propitious time to test the principles of MTF, and Los Alamos is preparing a proof-of-principle proposal for consideration by OFES.

e. 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

Since its establishment in 1988, the Center for Human Genome Studies (CHGS) has provided technical direction and coordination for the human genome program at Los Alamos. Center efforts are currently distributed among five Los Alamos divisions (Life Sciences; Theoretical; Computing, Information, and Communications; Chemical Science and Technology; and Engineering Sciences and Applications), and extensive interdisciplinary actions are encouraged. Support to the project from these divisions consists of expertise in the areas of cell biology, cytogenetics, flow sorting, molecular biology, informatics, and robotics. The CHGS also oversees operation of the Center for Genetics in Medicine at the University of New Mexico School of Medicine. This DNA-sequencing facility was established in 1997 to process sequencing gels and then return the data for analysis and archiving at Los Alamos.

Programmatic emphasis at CHGS has reflected the interests of DOE's Office of Biological and Environmental Research (OBER). Initially, the emphasis was on producing chromosome-specific DNA libraries and the development and application of physical mapping techniques. Successful construction of high-quality chromosome 16–specific gene libraries in combination with established in-house projects researching genes residing on chromosome 16 led to a long-term project at Los Alamos to generate a high-resolution integrated physical/genetic/cytogenetic map of chromosome 16.

The ultimate goals of the International Human Genome Project, scheduled for completion in 2005, are to sequence the entire human genome and to identify every gene within it. To date, only about 1% of the 3 billion base pairs in the human genome have been sequenced. Until recently, the U.S. Human Genome Project has focused on creating resources such as physical and genetic maps, software, and automated technologies that would ultimately enable cost-effective, large-scale sequencing. Much of this effort is now redirected into large-scale genomic sequencing projects. Accordingly, OBER has decided to shift the emphasis of its research support from physical map construction to high-throughput DNA sequencing. The primary goal is to contribute a share of the reference sequence of the human genome that is commensurate with DOE's genome budget. The scale of production required for efficient DNA sequencing has resulted in the DOE efforts becoming more centralized. DOE created the Joint Genome Institute (JGI) to integrate work previously pursued in parallel fashion by its three human genome centers (at Lawrence Livermore, Lawrence Berkeley, and Los Alamos national laboratories). Research collaborations between the three centers have increased for more effective use of the unique expertise and resources at the individual institutions. While the JGI is developing a central production sequencing facility in California (scheduled to come on-line during FY99), the constituent laboratories are engaged in complementary high-throughput sequencing operations targeted at regions of human chromosomes 5, 16, and 9 that were previously mapped with DOE support. Future efforts will be directed at characterization of the genes revealed in these sequenced regions in order to gain insight into biological function.

Current research activities in the Los Alamos center are supportive of the JGI goals. In 1998, Los Alamos researchers will sequence approximately 3 megabases of DNA on human chromosome 16. They will also prepare total genomic bacterial-artificial-chromosome libraries for screening in order to supply clones to the new JGI sequencing facility. Informatics personnel will provide support to the sequencing and clone selection activities in the center, and they will provide annotation for the DNA sequenced at Lawrence Berkeley National Laboratory. In order to achieve these goals, the center has been reorganized into sequencing, clone selection, and informatics units. In order to have a viable program in the future, we have also organized a functional genomics unit. This unit is preparing for cDNA sequencing responsibilities in FY99 and for expression studies of the genes sequenced by the JGI in FY99 and beyond.

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. Construction of the new dedicated protein crystallography instrument at the Lujan Center will greatly expand our neutron scattering user facilities.

This spallation source offers a much safer neutron source than conventional reactors and should not be the subject of the same level of scrutiny. Currently, operational macromolecular-neutron stations (currently only in Europe and Japan) are typically 2 to 4 times oversubscribed, leading to long waiting times. Such experiments are critical to the future of structural biology in the U.S. and internationally. The Lujan Center (protein neutron) instrument provides an ideal testbed, with a proven pulsed neutron source, for protein neutron crystallography. This is being done in consultation with the user community. This work will directly benefit the planned Spallation Neutron Scattering Source at Oak Ridge National Laboratory. The collection of single-crystal data that took several months to collect will take two weeks at the Lujan Center and will be further reduced at the Spallation Neutron Scattering Source.

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 underway to identify and clone the genes that are involved in the repair of damage induced by very low doses of ionizing radiation. Initiatives have been proposed that will identify other mammalian genes involved in DNA damage recognition and repair resulting from low-dose exposure.

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 focuses on the structural and functional features of chromatin organization and the way in which modulation of that organization is related to low-dose effects. 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, macromolecular structure and dynamics, biomedical technology, and cellular structure and dynamics.

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 develops and makes available advanced flow-cytometric instrumentation for 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/autoimmune deficiency syndrome (HIV/AIDS) database collects and distributes DNA sequences and determines phylogenetic relationships.

Biomedical Applications

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

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 affected 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 OBER. Specific DOE support comes from three activities: Atmospheric Radiation Measurements (ARM); the Strategic Simulation Program; and Quantitative Links. The ARM project seeks to make key atmospheric observations for use in global climate models. The Strategic Simulation Program 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 National Laboratory 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.

f. 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 affect 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 is providing 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.A.3. 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 principles—transport phenomena in concentrated, multiphase, dispersive systems.

Computer Hardware, Advanced Mathematics, and Model Physics Program

The major goal of the DOE Accelerated Climate Prediction Initiative (ACPI) 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. ACPI 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. ACPI, in collaboration with the HPCC Program, supports the work of Los Alamos researchers on the Grand Challenge problem of global ocean and climate modeling. In addition, ACPI 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.A.3. Theory, Modeling, and High-Performance Computing.

g. New Initiatives

Spallation Neutron Source

Los Alamos is a major partner in and provides the accelerator expertise for the Spallation Neutron Source Project at Oak Ridge National Laboratory. This project, like many others, keeps us in a web of partnerships across the DOE complex, with industrial partners, and with the international scientific community. Los Alamos works with four other national laboratories (Oak Ridge, Lawrence Berkeley, Brookhaven, and Argonne) to carry out this initiative that OBES has designated as its top priority.

We have worked on the design and integration of the linear accelerator during the past 2 years. We believe this has led to an innovative and cost-effective conceptual design that will provide the project with the high-intensity proton beam needed to create the neutron flux for researchers in a wide area of applications. The design features a means for sequentially upgrading from the initial 1 megawatt of beam power to more than 4 megawatts. This will provide a neutron flux more than 20 times greater than any existing spallation source. The project underwent an extensive conceptual design review by DOE last June that approved our technical and financial plans. This fiscal year emphasizes the R&D and organizational efforts needed for a construction start in 1999.

Catalysis

Los Alamos, in partnership with Lawrence Berkeley and Pacific Northwest national laboratories, has proposed the Joint Catalysis Institute (JCI) as a vehicle to focus multidisciplinary, integrated catalysis research on areas relevant to carbon management. The objectives of the JCI are to coordinate the catalysis efforts of the three DOE multiprogram national laboratories and to provide the extensive resources (facilities and staff) needed to develop the technologies that will lower CO_2 emissions, convert them to valuable products, or divert them to long-term storage. A successful multidisciplinary approach must also link the best minds from academia, industry, and the national laboratories to state-of-the-art facilities (for example, high-performance computers, novel reactors, and advanced analytical instrumentation). The JCI will facilitate this linkage through the establishment of a virtual laboratory.

The initial partners, combining their resources through the virtual laboratory, are ideally positioned to significantly impact the world's carbon management efforts. Developing the technologies needed to improve carbon management is also key to dealing with other emerging twenty-first century energy issues, including waste minimization and green chemistry, innovative chemicals and materials processing, and ensuring an inexpensive stable energy supply through alternative fuels (for example, converting natural gas to liquid fuels).

Magnetized Target Fusion: A Low-Cost Approach to Fusion Energy

Los Alamos is leading a multi-institutional team that proposes to develop a completely new direction for fusion energy called magnetized target fusion. The essential idea is to preheat a compact-toroid plasma using techniques developed in the past 20 years by OFES, and then compress it to thermonuclear conditions with an imploding liner using techniques developed by DP. This fundamentally different approach combines the advantages of magnetic fields for plasma energy confinement, as used in conventional magnetic fusion energy (MFE) research, with pulsed energy for heating to thermonuclear temperature, as used with inertial confinement fusion (ICF). The lower costs of magnetized target fusion compared with conventional MFE or ICF addresses the critical problem of affordable development confronting fusion energy worldwide. Accordingly, the idea can be tested inexpensively using existing pulsed-plasma formation hardware and defense-program facilities for the liner implosion.

A proposal to do a proof-of-principle experiment in a 3-year time frame is being submitted to the Office of Fusion Energy in June 1998, with research to begin in FY99. The goal of this national effort, which has been documented in an OFES-sponsored community-based R&D roadmap, is to "breakeven in 5 years," where breakeven is defined as fusion energy produced per pulse relative to liner kinetic energy (see http://fusionenergy.lanl.gov/). For the first 3 years, the estimated total budget is $6.4 million and involves researchers at Los Alamos, the Air Force Research Lab (previously Phillips Lab in Albuquerque), Lawrence Livermore, the University of Washington, General Atomics, and Westinghouse. About 10% of the budget will be used for exploratory concept development, primarily at universities, with projects selected by a Program Advisory Committee. No major facilities are expected to be required in this initial 5-year time frame despite the fact that this approach to burning-plasma performance compares favorably to ITER and the National Ignition Facility.

The literature of fusion has many references to this general approach to fusion (see the bibliography on the above-mentioned web page), but the past work has been mostly theoretical in nature and has never been seriously tested experimentally. Obviously there are critical issues to confront, and the community-based R&D roadmap identifies three major ones:

- Plasma formation in the high-density regime of interest to MTF;
- Stability of target plasma and influence of magnetohydrodynamic modes on global energy confinement; and
- Plasma-wall interactions and the mixing of high-Z radiating impurities into central plasma.

In the proposed research plan these issues are examined with state-of-the-art computational tools and experimental tests. Regarding economical energy application, a number of promising ideas have been identified, but the path to practical fusion energy with this intrinsically pulsed approach has received much less thought than with conventional MFE or ICF. However, if MTF is scientifically feasible, the low cost for exploring options would be a tremendous advantage. Given the current emphasis on plasma science in the restructured national fusion program and the need to identify cost-effective development paths for fusion energy, research on MTF seems compelling.

Strategic Simulation Initiative

The Strategic Simulation Initiative (SSI) proposes to expand the application of predictive modeling and simulation as well as multi-TeraOp-scale computing to a small number of critical problems in DOE's unclassified mission portfolio. The present focus is on accelerated climate prediction and combustion simulation and modeling.

The tools being developed have the potential to revolutionize the way science is performed and provide broad benefits to society. This initiative complements DP's Accelerated Strategic Computing Initiative in a number of ways:

- reduction of risk by expanding the set of science areas that are exploring this class of simulation approaches;
- potential for shared development of critical software and mathematical infrastructure to support this class of simulation;

- potential expansion in the number of computer architectures that can be explored as candidates for providing this class of resource; and
- potential for sharing large-scale computational resources, data resources, and intermediate-scale supporting hardware such as visualization servers.

In addition to these goals, SSI will be implemented in such a way that SSI technologies and software tools have broad application across DOE's missions in order to enable applications other than ones chosen initially to move to this new way of doing science. These applications might include subsurface transport, materials, fusion energy, high-energy physics, and structural genomics.

Table 12. Projected Funding for Energy Research ($M).

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Fusion Energy (AT)	3.4	3.7	3.1	3.0	3.0	3.0	3.0	3.0
High-Energy Physics (KA)	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0
Nuclear Physics (KB)	10.6	10.1	11.0	12.1	12.1	12.1	12.1	12.1
Basic Energy Sciences (KC)	19.6	18.5	19.6	21.5	21.5	21.5	21.5	21.5
Computational and Technology Research (KJ)	15.4	13.6	14.2	14.2	14.2	14.2	14.2	14.2
Biological and Environmental Research (KP)	21.0	18.0	19.1	20.5	20.5	20.5	20.5	20.5
University and Science Education (KT)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	71.0	64.7	67.9	72.3	72.3	72.3	72.3	72.3

3. Civilian and Industrial Technology Programs

Program Offices at Los Alamos National Laboratory have the responsibility for leading the effort to develop and manage the integration of projects into programs that maintain and build Laboratory technical capabilities to meet the needs of a specific customer set. The Civilian and Industrial Technology Program Office (CIT-PO) customer set includes several Department of Energy Offices (the Office of Energy Efficiency and Renewable Energy, the Office of Fossil Energy, and the Office of Policy); selected programs within the Office of Defense Programs and the Office of Nuclear Energy, Science, and Technology; the Department of Transportation; the Department of Commerce; the Department of the Treasury; the Department of Justice; the Department of Agriculture; the Department of Labor; the Nuclear Regulatory Commission; and the Department of Health and Human Services (the National Institute for Occupational Safety and Health). Also part of CIT-PO's charter are the Laboratory's Intellectual Property and Contract Management functions and the Technology Commercialization (Regional Economic Development) effort. It is the vision of the CIT-PO, working in cooperation with the Laboratory's technical divisions, that the Laboratory be recognized for its excellence in all the areas of its stewardship. In FY97, CIT-PO managed a portfolio of $48 million federal dollars and $31 million in industry research.

The CIT-PO is currently organized into eight functional areas. Program managers lead the six civilian/industrial business units or programmatic sectors (Transportation, Process Industries, Extractive Industries, Biotechnology/Pharmaceutical, Telecommunications/Information Technologies, and Advanced Manufacturing), which have both federal and industrial components (see Figure 16). The other two areas—the Partnerships and Agreements Team and the Technology Commercialization Office (Regional Economic Development)—are each led by an office leader.

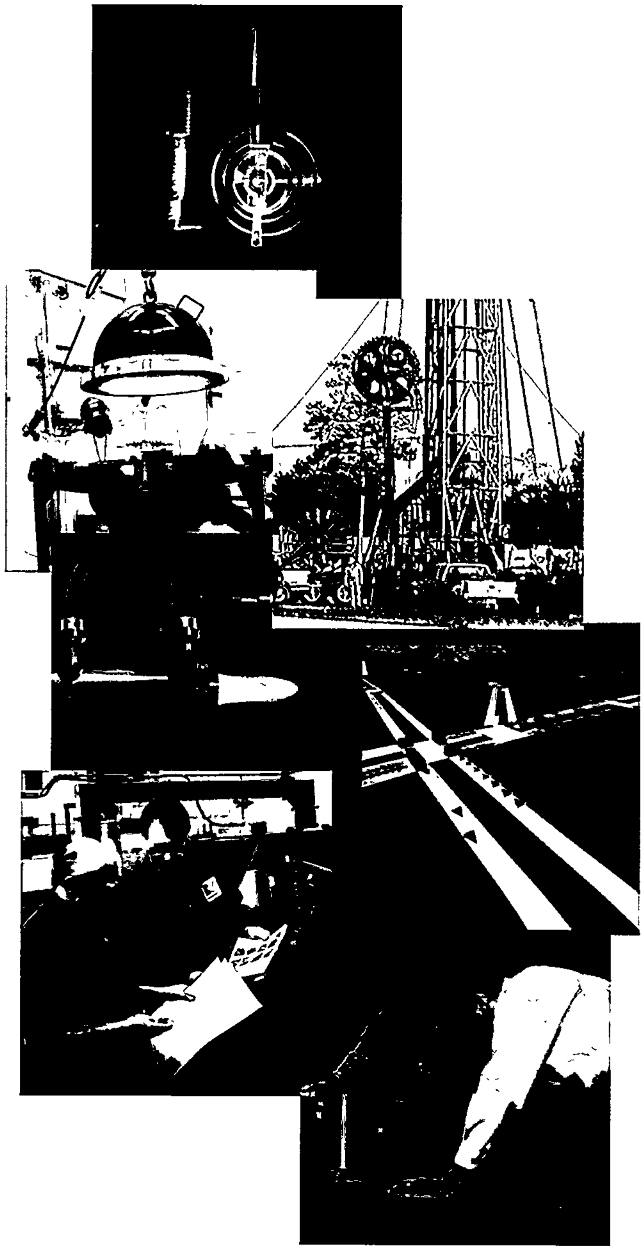


Figure 16. The Civilian and Industrial Technology Program Office manages funds from federal and industrial customers to nurture Laboratory programs in (from top) biotechnology, the process industries, the extractive industries, the microelectronics/telecom/information management industries, transportation, and advanced manufacturing for defense applications. CIT-PO also includes the Technology Commercialization Office which encourages regional small business growth and entrepreneurial ventures based on Laboratory technologies.

a. Applied Energy Programs

Projects in the Applied Energy Programs portfolio support the nation's strategic energy needs in energy supply, energy use (including energy efficiency and energy conversion), 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 projected funding is provided in Table 13 at the end of this section. The CIT-PO portfolio supports the DOE Energy Resources Strategic Goal. Our programs assist DOE and its partners in promoting secure, competitive, and environmentally responsible energy systems that serve the needs of the public.

Energy Efficiency and Renewable Energy

The Office of Energy Efficiency and Renewable Energy (EE/RE) supports a number of programs at Los Alamos in energy efficiency and renewable energy, ranging from electrical energy systems to transportation. These programs make use of the Laboratory's competencies in computing, chemistry, materials, theory, systems engineering, and geosciences.

Office of Utility Technologies

Electrical Energy Systems. The Laboratory's Superconductivity Technology Center (STC) is one of three U.S. centers established by DOE with the goal to develop power applications for high-temperature superconductors (HTS). Such applications include motors, transmission lines, generators, transformers, current limiters, and magnets for energy storage. The specific mission of the STC is to expedite development of this exciting HTS technology by demonstrating the feasibility of these HTS applications through partnerships with American industry. During FY96 and FY97, a number of significant milestones in this program were reached, such as the development of HTS tape that produced world-record current levels in 1-meter lengths. In addition, the Laboratory provided crucial input to industrial partners in the design and demonstration of a practical HTS current limiter and power transmission cable. Industry interest continues to flourish, leading to collaborations with organizations such as American Superconductor, 3M, EPRI, Lockheed Martin, Pirelli Cable, and Reliance Electric, as well as many others.

Geothermal Systems. Geothermal companies are working with Los Alamos to develop a test of the applicability of seismic methods to geothermal fracture mapping. This work builds on methodology developed for the Hot Dry Rock Program and modified for use in oil and gas exploration. We are applying that methodology 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. Knowledge of fracture location and areal extent in geothermal reservoirs would greatly reduce the cost of exploration and development. Our specialized fluid chemistry team laboratory participates in research and development activities at a number of U.S. geothermal sites.

Hydrogen. Los Alamos supports EE/RE's objectives in understanding the combustion characteristics of hydrogen by providing combustion modeling expertise using the KIVA computer code. Our work in the development of fuel cells with hydrogen as the base fuel is discussed in the section on advanced automotive technologies.

Office of Building Technology, State, and Community Programs

In FY96, Los Alamos began a new project to develop a high-efficiency, "green" light bulb for the Building Technology Office of EE/RE. This project 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.

Office of Industrial Technologies

Los Alamos participates in a number of EE/RE's industrial technology initiatives. The Industries of the Future Program is an initiative whose goal is to provide precompetitive, enabling research for a number of energy-intensive U.S. industries. A consortium 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. Currently, we have projects in place with the petroleum and chemical industries.

The Laboratory has applied research on multidimensional computer programs for the analysis of practical combustion systems to the in-cylinder dynamics of internal combustion engines and to continuous-spray combustors, with the aim of designing cleaner, more efficient combustion systems. Research in support of the Advanced Industrial Materials Program began as a theoretical effort and has evolved into several projects. 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 also played a strong role in EE/RE's Catalysis Program. The goal of our activities is to provide design and selection tools for chemical process catalysts.

Office of Transportation Technologies

EE/RE's Office of Transportation Technologies funds the Fuel Cells for Transportation Program to study fuel cells as power supplies for automobiles. The program also focuses on development of impurity-tolerant electrodes, improvement of fuel cell performance, and fuel reforming. The program's applied research uses the Laboratory's systems integration, modeling, technology, and economic assessment capabilities. The objective of the core fuel cell program at Los Alamos is to develop proton-exchange-membrane fuel cells for alternative transportation with ultralow emissions.

In addition, EE/RE's Office of Transportation Technologies funds Laboratory participation in the Partnership for the New-Generation Vehicle projects, which include innovative exhaust sensors, advanced powder metallurgy manufacturing, engine management using adaptive controls, and high-performance computing for automobile design. Additional automotive technology projects focus on lithium battery research and low-cost aluminum alloys, polymer active materials for ultracapacitors, and catalysts for nitrous oxide reduction.

Office of Nuclear Energy, Science, and Technology

Isotope Production and Distribution

The Isotope Production and Distribution Program at Los Alamos is one of seven production sites for the Office of Isotope Production and Distribution, part of DOE's Office of Nuclear Energy, Science, and Technology (NE). A variety of isotopes for commercial purposes are produced. 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 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.

Office of Fossil Energy

Coal Programs

We continue to work directly with the Office of Coal and Power Systems to support the Office of Fossil Energy's (FE's) efforts to chart the future direction and evaluate future needs of coal research and development in the United States. As part of the Clean Coal Technology Program, we are exploring international applications and innovative partnership ideas for products developed under the program, and we are examining innovative partnership concepts to transfer clean coal technology into private-sector applications.

Gas Programs

A significant effort has been focused on developing a natural-gas–powered natural-gas liquefier with no moving parts and requiring no electrical power. The thermoacoustic natural-gas liquefier is expected to enhance efficiency and reliability while lowering costs for the liquefaction process, and it has spawned a cooperative research and development agreement (CRADA) with a liquefaction company.

Petroleum Programs

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 a number of specialized industry groups.

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 that 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.

b. Work for Others

Non-DOE Federal Sponsors

Transportation

The CIT-PO portfolio in Applied Energy includes a number of projects funded by non-DOE sponsors. The Department of Transportation supports the Transportation Analysis Simulation System (TRANSIMS), a new, simulation-based analysis system intended to model architectures of advanced transportation systems. TRANSIMS is based on bottom-up generation of system activity and behavior, and it uses detailed simulations of interacting subsystems and traveler intelligence. In this approach, regional microsimulation and representation of traveler-by-traveler plans and travel execution yield emergent behavior patterns to predict transportation issues ranging from land use to air quality. 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. Los Alamos is also 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.

Nuclear Safety

We maintain 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. Los Alamos provides assistance with operating reactor licensing, including analysis and code support, and with nuclear materials 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.

Industrial Partnerships

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. 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 research and development community. Table 13 at the end of this section provides projected funding for industrial partnership.

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, CIT-PO is the designated ORTA. The CIT-PO director and staff represent Los Alamos technology transfer activities to DOE, the University of California (UC) Regents, all federal and state agencies, and industry. 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 team has executed over 270 CRADAs, which represent nearly $750 million of company and Laboratory collaborative research efforts over the lives of the projects. The team negotiates approximately 70 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' Technology Partnerships Program

It is appropriate 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 because the weapons fabrication 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 fabrication 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.

Table 13 indicates that the funding for DP Technical Partnerships is $13.4 million for FY97, $13.0 million for FY98, and $10.0 million each year for FY99 to FY04.

User Facilities

From FY96 to FY98 (to date), the Laboratory has executed 70 user facility agreements. As of April 1998, Los Alamos has 64 staffed user facilities—equipment and laboratories available to users from outside the Laboratory. User facilities are powerful and efficient vehicles for gaining access to the scientific and technical resources found in DOE's national laboratories. Users includes scientists and engineers from universities, other governmental agencies, and the business community. Some facilities are "megafacilities" that comprise several smaller facilities with a common purpose, for example, evaluating superconducting materials. Others are specifically focused on a particular process or technology.

CIT-PO can help users gain access to these experimental facilities at the Laboratory for the purposes of fabrication, calibration, testing, and evaluation of products and processes. The partner directs the activity that occurs within the framework of the agreement. The partner must pay for the cost of using the facility, but a waiver of DOE-added factor cost and depreciation cost is readily available for nonprofit organizations and for small and minority- or woman-owned businesses.

Table 14 at the end of this section lists the existing user facilities at Los Alamos.

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 6 years, DOE's Office of Defense Programs (DP) has funded the Small Business Initiative, a special program for interactions with small businesses. With these funds, the Laboratory has undertaken more than 55 CRADAs with small businesses in the U.S.

In addition, Los Alamos has designed unique programs to provide Laboratory access to small businesses. When approached by a small business for short-term technical assistance, we can help without 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 send Laboratory personnel to a company to work on problems of mutual interest. Through the Small Business Initiative, the Laboratory seeks to enter into 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 or 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, led by the Technology Commercialization Office, 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 grew 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.

c. New Initiatives

Civilian and Industrial Technology Programs

Los Alamos CO_2 Sequestration Process Program

Los Alamos has provided two important, innovative technical thrusts for CO_2 management. One is a process for carbonate mineralization of CO_2, and the other is an artificial photosynthetic method for recycling the carbon back to fuels. The thrusts, funded by Laboratory-Directed Research and Development (LDRD), FE, and ER, have led to a proposal to FE for a CO_2 sequestration center (program). It will involve concept development, process development, and review and analysis of processes to sequester CO_2 from the atmosphere or recycle it to fuels and products. The anticipated budget is approximately $10 million per year.

Research Consortium for Multiphase Fluid Dynamics

A research consortium has been assembled consisting of three national laboratories, seven industrial partners, and four university faculty members. The ultimate goal of this research consortium is to develop and disseminate a general, experimentally validated model for turbulent multiphase fluid dynamics suitable for engineering design purposes in industrial-scale applications. The work proposed here focuses on the particular case of a turbulent flow of a particle-laden gas at industrial conditions. A well-benchmarked model for this case can be incorporated into commercially available software packages that will be produced by the year 2003. The Office of Industrial Technology within DOE/EE will be funding this project at approximately $1 million per year for 5 years, with the Los Alamos share to be approximately $350 thousand per year.

Alkane Functionalization Catalysis

At a recent Catalysis Roadmapping Workshop, representatives from the U.S. chemical industry identified selective oxidation and alkane activation as two of the most important research areas that could change the way they do business. Catalysis research is driving the replacement of 1950s chemical manufacturing technology with modern chemical plants that are generally modular, less capital intensive, and much more efficient in terms of energy usage and waste generation. Los Alamos, in cooperation with an industrial partner, is developing a novel, low-temperature alkane functionalization catalyst that will truly represent a step change in technology beyond "brute force" processes. This is projected to be a $1.2 million project over 3 years.

Mining Communications

We are developing a joint program with the national Mining Association, FE's Federal Energy Technology Center, 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 per year for 3 to 5 years. Activities funded by LDRD have led to the development of a prototype instrument that has been used to demonstrate sensitivity and applicability in an underground mine. FE is expected to fund instrument development and demonstration in several different mining applications.

Oil and Gas Industry

We are pursuing a plan to significantly increase industry- and DOE-sponsored research and development activities at the Laboratory in oil and gas. The goal is to increase funding to $20 million per year from the current $5 million. Contacts with companies interested in sponsoring research are being increased, and particular interest has developed in computational applications, sensor development, and advanced drilling technology.

Summer Entrepreneurial Internship

The Technology Commercialization Office is initiating an entrepreneurial internship as a unique way for students interested in entrepreneurship and technology commercialization to gain hands-on experience by nurturing the development of high-tech start-up businesses. We recognize the need for a new mechanism to commercialize new technologies while stimulating economic development in the northern New Mexico region. Traditionally, commercialization of new technology has occurred using one of two general methods: (1) licensing the technology to an existing entity or (2) forming a new company. The latter involves the nurturing of a new invention and the creation of a business structure to support. We are currently engaging in a concentrated effort to promote this method, with special emphasis on northern New Mexico.

Biotechnology

Biological science has been an integral part of research activities at Los Alamos since the Manhattan Project. Initially, the goal was to understand the health effects of radioactive materials. Today, our multidisciplinary environment enables molecular and structural biologists, biochemists, geneticists, computer scientists, engineers, mathematicians, materials scientists, and physicists to work together to solve multifaceted problems of national priority and interest. The bioscience community is funded from a number of federal agencies (for example, the Department of Energy, the National Institutes of Health, the Department of Defense, and national security agencies) and through partnerships with private industry. By building on the core competencies in genomic, cellular, and molecular biology; physics; and computational biology and theoretical modeling, the Laboratory has a strong base on which to build a coherent and interdisciplinary foundation to meet the challenges of the biological sciences in the next century.

Our role in CIT-PO is to develop programs that enhance the Laboratory's core competencies and to build bridges to the civilian sector. For example, an industry analysis of the biopharmaceutical drug industry shows a lucrative partnership opportunity for the Laboratory. Large biopharmaceutical and pharmaceutical companies spend the majority of their research dollars on developing new drugs. These companies increasingly are turning to small biotechnology companies and academia for the basic research that leads to discovery of new drug candidates. The Laboratory has the necessary capabilities to meet the research demands of the biopharmaceutical industry. In addition, the multidisciplinary environment and national user facilities that make up the infrastructure of the national laboratories are very uncommon in the private sector.

The Laboratory's Advanced Computing Laboratory is helping to drive national standards in healthcare technology and has produced a "virtual" electronic medical record that is being used to link rural clinics in northern New Mexico. Biomedical applications of laser and optical physics have yielded noninvasive and minimally invasive diagnostics for the detection of cancer. Research in magnetoencephalography has produced a portable biomagnetic sensor capable of detecting minute changes in the brain and heart from the minute magnetic fields that are generated. Exquisitely sensitive detectors with high specificity are being applied to identify biological molecules and olfactory signatures. New medical isotopes are being developed that will benefit clinical diagnostic imaging and cancer therapy applications. Biomaterials technology promises new hope for prosthetic limbs. Bioremediation of the environment will play an important role in cleaning up the nuclear legacy. These are but a few examples of Laboratory biotechnology that are playing an important role in the biotechnology and biomedical needs of the public while also enhancing the core competencies of the Laboratory.

Research and Development Park

The Laboratory is pursuing the development of a research and development park. For more information, see Section III.A.3. Site and Facilities.

Table 13. Projected Funding for Civilian Industrial Technology ($M).

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Energy Efficiency and Renewable Energy	13.4	13.5	14.0	15.6	15.6	15.6	15.6	15.6
Nuclear Energy	6.5	5.5	4.5	5.2	5.2	5.2	5.2	5.2
Fossil Energy	4.0	4.7	6.0	6.0	6.0	6.0	6.0	6.0
Defense Programs Technology Partnership	13.4	13.0	20.0	10.0	10.0	10.0	10.0	10.0
Subtotal DOE Funding	37.3	36.7	44.5	36.8	36.8	36.8	36.8	36.8
Industry-Sponsored Programs and Partnership	15.7	16.0	12.0	18.0	23.0	28.0	35.0	35.0
Reimbursables	8.2	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Subtotal Work for Others Funding	23.9	23.5	19.5	25.5	30.5	35.5	42.5	42.5
Total	61.2	60.2	64.0	62.3	67.3	72.3	79.3	79.3

Table 14. The Existing User Facilities at Los Alamos.

Los Alamos Designated User Facilities (ER)

1. National Flow Cytometry and Sorting Research
2. National Stable Isotopes Resource
3. Weapons Neutron Research Facility
4. Clinton P. Anderson Meson Physics Facility
5. Los Alamos National Environmental Research Park
6. Manual Lujan Jr., Neutron Scattering Center (LANSCE)
7. National High Magnetic Field Lab

Los Alamos Approved Technology Deployment Centers/User Facilities (DP)

1. Radiochemistry User Facility (9/30/94)
2. Integrated Safeguards and Non-Proliferation Facility (9/30/94)
3. Beryllium Atomization and Thermal Spray Facility (9/30/94)
4. Plasma Processing Research Facility (11/1/94)
5. Acoustic Characterization Facility (11/18/94)
6. Advanced X-Ray Diffraction Laboratory (2/27/95)
7. Extreme Pressure and Temperature Diamond-Anvil Cell Laboratory (2/27/95)
8. Ion Beam User Facility (2/27/95)
9. Accelerator Code Center (3/1/95)
10. Detonation Systems Facilities (3/2/95)
11. Plastics Engineering Facility (3/2/95)
12. Advanced Materials Laboratory (3/13/95)
13. Evaluation of Non-Destructive Assay Instrumentation Facility (5/2/95)
14. Explosive Pulse Power Facility (5/2/95)
15. Large-Scale Explosives Formulation and Fabrication Facility (5/2/95)
16. Supercritical Fluids Experimental Facility (5/2/95)
17. Separation Science and Technology Technical Deployment Center (5/2/95)
18. Explosives Chemistry Research Development and Testing Facility (5/5/95)
19. Virtual Laboratory Testbed (3/7/96)
20. Resonant Ultrasound Spectroscopy Material Properties and Inspection Facility (6/15/95)
21. Hazardous Materials Preparation Laboratory (6/27/95)
22. Elastic Lidar Facility (6/27/95)
23. Center for Advanced Engineering Technology (6/27/95)
24. Powder Synthesis Laboratories (6/27/95)
25. Antenna and Pulse Power Outdoor Range (6/27/95)
26. X-Ray Characterization Laboratory (7/6/95)
27. High Temperature Superconductors/Electrical Characterization Laboratory (7/6/95)
28. Advanced Testing Line for Actinide Separation Facility (7/6/95)
29. Pulsed-Laser Deposition Laboratory (7/6/95)
30. Electronic Technologies User Facility (7/6/95)
31. Laser Induced Breakdown Spectroscopy Research Facility (7/27/95)
32. Directed Light Fabrication Facility (8/9/95)
33. Accelerator Radio-Frequency Structures/Superconducting Test and Fabrication Laboratory (8/21/95)
34. Molecular Species Specific Lidar Facility (10/20/95)
35. Thick-Film Processing and Deposition Laboratory (10/20/95)
36. High Speed Electron Laboratory (10/20/95)
37. Los Alamos Radioisotopes and Analytical Resource (11/1/95)
38. Tritium Science and Fabrication Facility (11/1/95)
39. Materials Science Laboratory (11/1/95)
40. Ion Beam Materials Laboratory (12/4/95)
41. Subpicosecond High Brightness Accelerator Facility (12/4/95)
42. Advanced Free Electron Laser Facility (12/4/95)
43. Fenton Hill Hot Dry Rock Test Facility (12/5/95)
44. Advanced Oxidation Laboratory (12/5/95)
45. Combustion-Driven Supersonic Flow Facility (12/5/95)
46. Trident Laser Laboratory (1/30/96)
47. Geostationary-Orbit Trapped Radiation Environment Facility (2/2/96)
48. Amorphous Alloys Laboratory (2/14/96)
49. Nondestructive Testing and Evaluation User Facility (4/18/96)
50. Fuel Cell Facility (6/14/96)
51. Clean Laboratory and Mass Spectrometry Facility (7/2/96)
52. Library Without Walls/Research Library (11/22/96)
53. Polymers and Coatings User Facility (2/6/97)

4. Work For Others—Other Federal Agencies

This section provides a summary of Work for Others (WFO) activities for other federal agencies other than DOE. The activities are arranged by the sponsoring organization. A budget summary (including Department of Defense [DoD] funding) is provided in Table 15 at the end of this section. Work for Others that does not involve other federal agencies is discussed in Section II.C.3. Civilian and Industrial Technology Programs.

a. Department of Defense

Department of Defense plans and activities are administered under the Associate Laboratory Director for Threat Reduction and are discussed in Section II.B. Threat Reduction.

b. Department of Commerce

National Oceanic and Atmospheric Administration

Los Alamos space plasma instruments on the NASA Advanced Composition Explorer spacecraft provide real-time solar wind data to the National Oceanic and Atmospheric Administration (NOAA) Space Environment Center. This data is used by NOAA to warn public and private organizations of impending geomagnetic storms that may threaten electric power grids and satellite communications systems.

c. Department of Transportation

New legislation directs the Department of Transportation (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 Federal Highway Administration and on the development for DOT of a prototype simulation testbed used to evaluate alternative state measurement and state estimation schemes for traffic incident detection.

d. 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 (for example, palladium-catalyzed Heck coupling) and on polymer supports designed to enhance ligand and catalyst solubility in dense-phase carbon dioxide.

e. 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's programmatic missions in arms control, nonproliferation, and intelligence.

f. National Science Foundation

The National Science Foundation space research programs at Los Alamos include both observational and modeling studies of magnetospheric physics in support of the National Space Weather Program. An additional project provides assistance for a meeting of the American Physical Society Division of Atomic, Molecular and Optical Physics to be hosted by Los Alamos National Laboratory.

g. Department of Health and Human Services

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 the National

Institutes of Health (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.

h. Other Federal Agencies—Defense Related

This category defines defense-related work for federal agencies other than NASA and DoD. At present, all work in this category is related to the Intelligence Community.

Intelligence Community

The Laboratory applies its full range of scientific and technical expertise to the solution of nationally important problems relating to technical intelligence and emerging foreign technologies. We strive to do the following:

- apply information science techniques to Intelligence Community problems;
- understand changes in scientific and engineering research and defense infrastructures in the former Soviet Union 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.

i. Department of State

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

j. Other Federal Agencies

In addition to the work itemized previously in this section, 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 developing enhanced methods for maximizing public access to electronic, integrated government services and automated electronic fraud detection of financial transactions.

k. Nuclear Regulatory Commission

Los Alamos provides the Nuclear Regulatory Commission (NRC) with assistance in nuclear material safeguards. We also 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 15. Summary of Funding for Work for Others—Other Federal Agencies ($M).

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Department of Commerce	1.58	1.52	0.00	0.00	0.00	0.00	0.00	0.00
Department of Defense	54.34	45.41	37.78	40.02	40.02	40.02	40.02	40.02
Department of Transportation	4.59	4.56	5.00	0.00	0.00	0.00	0.00	0.00
Department of Interior	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Environmental Protection Agency	0.46	1.13	0.50	0.75	0.75	0.75	0.75	0.75
National Aeronautics and Space Administration	5.87	6.45	9.46	4.73	4.73	4.73	4.73	4.73
National Science Foundation	0.60	0.39	0.86	0.89	0.89	0.89	0.89	0.89
Department of Health and Human Services	10.37	10.50	10.49	9.77	9.77	9.77	9.77	9.77
Department of State	1.59	1.63	1.15	1.15	1.15	1.15	1.15	1.15
Other Federal Agencies—Defense Related	11.61	16.25	15.00	16.50	16.50	16.50	16.50	16.50
Other Federal Agencies—Energy	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other Federal Agencies	2.83	2.89	3.16	2.78	2.78	2.78	2.78	2.78
Nuclear Regulatory Commission	3.11	2.52	1.09	1.10	1.10	1.10	1.10	1.10
Total	97.04	93.25	84.49	77.69	77.69	77.69	77.69	77.69

D. COMPETENCY-RELATED ACTIVITIES

1. Science and Mathematics Education

a. Laboratory Plan for Education Support

Because the success of the DOE and Laboratory missions depends on the availability of a well-educated workforce and a science-literate public, education is an important component of the Laboratory mission. Educational institutions, from elementary to graduate, are the focus of our education efforts. For many years, the Laboratory has maintained an active education program funded primarily by the DOE Office of Defense Programs (DP), a program that supports the DP mission and continues despite shrinking national and local budgets. The Laboratory and DOE 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 Laboratory science education projects are directly connected with our unique resources; they use the technical programs and core competencies as a basis and involve Laboratory technical staff extensively. Many projects are conducted collaboratively or jointly with universities. Most of them involve the application of technologies such as computer networking and use of 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 technical goals by using relevant technical topics as content material, while technical staff present information on programs and science. In some projects, both teachers and students work with Laboratory personnel doing research on goal-related topics. The projects also support the Laboratory's tactical goals in diversity; corporate citizenship; science-based stockpile stewardship; the plutonium future; modeling, simulation, and high-performance computing; and regional economic development.

Many projects are directed toward systemic change in the science and mathematics educational process. For example, teacher enhancement projects spend a significant amount of time on pedagogy, illustrating better ways to teach science and mathematics. We also work with schools and administrators to help teachers gain administrative support for their new techniques. 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 Mathematics 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 leverage our resources, broaden the scope of our efforts, prevent 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 projects emphasize diversity among participants. We recruit extensively to broaden the representation of minorities and women in our projects. In FY97, more than half of the participants were minorities and almost half were female. Figure 17 illustrates this distribution.

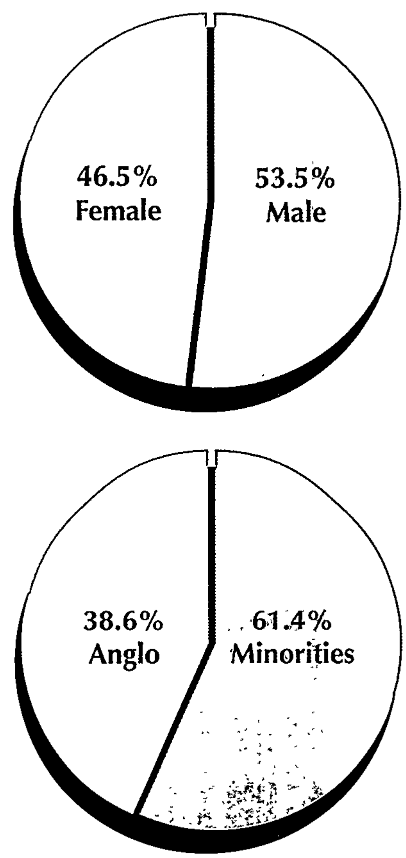


Figure 17. Gender and ethnicity are important considerations in our programs.

b. Project Descriptions and Statistics

In FY98, 24 science education projects are being conducted. Figure 18 shows the distribution of the projects among grade levels. Depending on the project, participants may be any combination of students, teachers, administrators, or parents.

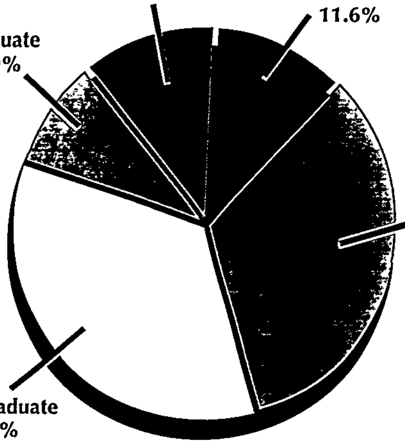


Figure 18. FY98 program funding distribution by grade level.

Several different types of projects are included in the overall Science Education Program, including 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 mathematics 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, mathematics, 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 mathematics; and
- projects that are targeted at increasing the number of minorities and females in the fields of science, mathematics, and engineering.

Figure 19 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.

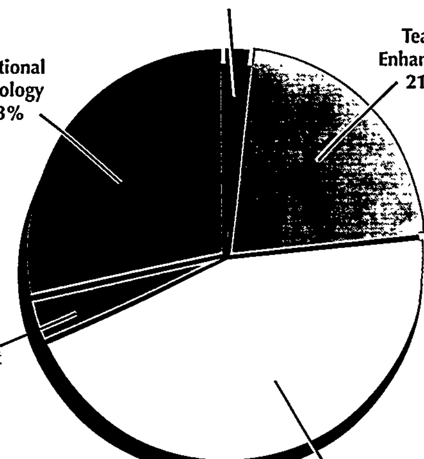


Figure 19. FY98 program funding distribution by categories.

All of the current education programs are described in more detail on the Education Web page at http://education.lanl.gov and also in the brochure, *Science Education at Los Alamos National Laboratory* (LALP-97-148). The recent activities of these education programs are described in the *Los Alamos National Laboratory Science Education Program Annual Report* (LAUR-97-4440).

c. Program Changes and Plans

For the third successive year, we have had to reduce the number of projects and participants in the Science and Mathematics Education Program because of reduced funding. In FY98, funding is provided almost entirely by DP. In previous years, funding was provided by other DOE offices, including Energy Research (OER), Energy Efficiency and Renewables, and Environmental Management. It is important to the success of the Laboratory mission for the funding to at least remain stable. We hope that it may even increase over the next several years.

Every year we evaluate each project internally and have two or three projects evaluated by external experts. The projects are evaluated against a set of criteria provided by DOE and against the project's own goals and objectives. Using these evaluations, we eliminate a few projects, add others, and improve the remaining ones. In FY98, we discontinued four projects and started four new ones. In addition, several other projects were combined for either efficiency of operations or effectiveness of the projects.

We have restructured our flagship teacher enhancement project, Teacher Opportunities to Promote Science (TOPS). In the past, TOPS was for middle school teachers, and two other projects (Regional Teacher Enhancement Project and Science 2000) were for high school and elementary teachers, respectively. Starting in FY98, we have a single teacher enhancement project, TOPS, for teachers of all grade levels. This project is integrated vertically, so that the teachers from all three levels work together when appropriate. We recruit teams of teachers from school districts so that when they return home, they have peer support in using the new techniques they have learned.

One new project is the American Indian Community and Science Education Partnership, a comprehensive project to enhance mathematics and science teaching and learning experiences for American Indian students and their teachers. It is aimed particularly at the secondary level, and involves parents, tribal leaders, and the Pueblo community in the educational process.

Another new project, The Web of Learning, will use the World Wide Web as a communication media for mathematics curricula and tutorials generated by students and teachers participating in the program. The Education Pipeline for Student Initiatives Linked On the Network (EPSILON), a new project that combines the best practices of two former programs, has implications for broader effect on a more diverse population of students. High school teams engage in a problem-solving context for which they must prepare a research project to address a particular scientific research need. In March 1998, in Santa Fe, Los Alamos is cohosting, along with the University of New Mexico, the Fifteenth Annual International Conference on Technology in Education. The conference, typically attended by about 700 to 800 people, 40% of whom are international, will highlight the use of technology in education.

For several years, OER funded a national program called Science and Engineering Research Semester (SERS), a very successful program based on the earlier co-op program, that brought undergraduate students to national laboratories for a one-semester research experience. Although OER no longer funds the SERS Program, Los Alamos has elected to draw on this successful program to create the Undergraduate Research Semester using DP funding.

All 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.

In FY98, the Education Program Office held a series of focus groups to solicit input from the education stakeholders. These focus groups included teachers, parents, administrators, business and community leaders, legislative leaders, State Department of Education personnel, and representatives from the 2- and 4-year colleges and universities. The input from these groups is being used to evaluate the current Los Alamos education project portfolio, to design new projects, and to propose new projects for funding.

The Laboratory has organized a group of educational leaders from the region to advise the Laboratory on its educational programs. This group, called the Northern New Mexico Council for Excellence in Education, is made up of teachers, superintendents, businessmen, and representatives from the four-year and two-year colleges and universities and the New Mexico Department of Education. The group meets monthly and considers educational issues affecting the region and state that the Laboratory might be able to impact.

The Science and Mathematics Education 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 research experiences, educational technology, teacher enhancement, and public understanding of science. In addition, the inclusion and encouragement of minorities and females will continue as an emphasis.

2. Laboratory-Directed Research and Development

The Laboratory-Directed Research and Development (LDRD) program is authorized by Congress as a vehicle by which the Laboratory invests in cutting-edge research that will both maintain and extend our science and technology capabilities which support our mission. The LDRD budget consists of both operating and capital equipment funds that are generated through the application of a uniform assessment to direct-funded (DOE and Reimbursable Work for Others) programs at Los Alamos. The funding available to LDRD each fiscal year is limited by Congress to a maximum of 6% of the Laboratory operating budget.

A breakdown of the LDRD program actual and projected costs from FY97 through FY04 is shown in Table 16 at the end of this section. In FY97, the DOE-approved assessment rate was 6%, and the actual Laboratory operating costs were $1,106 million. The projected costs are based on a DOE-approved rate of 6% and a projected Laboratory operating budget.

The LDRD program is subject to Congressional language, applicable DOE regulations and orders, primarily DOE Order 413.2, and the prime contract between the University of California and DOE. DOE oversight of the LDRD program is conducted by the Institutional Management Team of the Laboratory Programs Division of the Albuquerque Operations Office on behalf of the Defense Programs laboratories. LDRD financial activities are also conducted in accordance with generally accepted accounting principles and cost accounting standards.

a. LDRD Program Structure

The LDRD program at Los Alamos includes three components: Individual Projects (IP), Competency Development (CD), and Program Development (PD). All components are competed, and each proposal is reviewed by scientific management and/or peer review before it is selected for funding. In FY97, LDRD funded 309 projects for a total expenditure of $62.6 million. The funding distribution among the three components (IP, CD, and PD) is nominally one-half, one-third, and one-sixth, respectively.

Individual Projects

This 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 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

The CD component has been the LDRD component most subject to change in recent years; it has now evolved to funding only "scientific thrusts." This component is the one most guided by the longer-term Laboratory strategy and most influenced by the Laboratory's scientific management. Scientific thrusts are a strategic tool utilized by the Laboratory to make a conscious and deliberate investment in innovative science and technology to achieve identified institutional benefit.

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 funded at $1 million per year with a time horizon of up to 5 years but with no project exceeding 3 years in duration.

Program Development

The PD component is intended to fund projects that are generally of shorter duration (often 1 year but occasionally longer) that are intended to bring a scientific development or technology to a point at which a specific sponsor is persuaded to invest further. The funds for PD are divided among the seven program offices based on the strength of a strategy proposal submitted to the Science and Technology Base (STB) Program.Office for review. The program offices are Civilian and Industrial Technology, Department of Defense, Environmental Management, Nonproliferation and International Security, Nuclear Materials and Stockpile Management, Nuclear Weapons Technology, and STB/Energy Research. A very broad range of science and technology is supported from the more fundamental to the very highly applied.

b. Selection of LDRD Projects

The LDRD program is led by the Laboratory Director who has put in place formally managed program at the Laboratory that imposes accountability in the selection, execution, and reporting of projects. Peers or scientific management selects all projects through competition and review. Innovation and scientific excellence are key criteria for selection of projects for funding. All projects must be in science and technology areas that support the Laboratory mission. All decisions on funding are ultimately made by the Director.

The annual LDRD proposal cycle begins in February with a formal call for new proposals for LDRD projects. Detailed guidance is provided along with the calls for each of the three LDRD components. The guidance includes component funding for planning purposes and the research and development areas that will be supported. A statement of work must be submitted yearly for each project.

IP proposals for new starts are reviewed by one of nine LDRD technical category teams. Proposals are evaluated and ranked based on scientific and technical merit. 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 are generally targeted at specific subject matter and organizations. Program directors institute a review process, usually using program managers in their office, to select the most innovative projects for funding that match their programmatic longer-term strategy.

The selection process for new CD thrust proposals also begins with a directed call for proposals that outlines a strategic vision for both the institution and the major programs, written by the Laboratory Director and program directors, respectively. A limited number of ranked proposals are then submitted by the technical divisions in general response to the call for proposals. Appropriate core competency teams and program offices, as well as the STB Program Office, review the proposals. The STB Program Office integrates the reviews and makes a recommendation to the Director, who makes the final decision for thrust funding.

c. The Success of LDRD

The primary mission of Los Alamos National Laboratory is to reduce the nuclear danger. There are four major components of that mission: (1) ensuring that the national nuclear stockpile is reliable and safe; (2) managing the production and use of nuclear materials; (3) ensuring that the environment is both restored from past nuclear activities and minimally impacted by future activities; and (4) developing technology and processes to eliminate the proliferation of nuclear materials and weapons capability. LDRD is a vital tool that supports this mission.

The high quality of research supported by all components of the LDRD program is attested to by the significant number of related awards, scientific publications, and patents. In 1997, LDRD scientists continued to garner national and international recognition for their work, including recognition by the National Academy of Sciences, the IEEE Computer Society, the Optical Society of America, the Guggenheim Foundation, the Packard Foundation, the Bomem Corporation, the Von Humboldt Foundation, the American Geophysical Union, and the Biophysical Society, among others. The number of publications continues to remain very high, and this year LDRD scientists cited some 1,200 publications arising from their work (this number approaches 30% of all Laboratory publications). In addition, LDRD research contributed to 49% of its patent awards, and 67% of the R&D 100 awards. These achievements attest to the far-reaching and groundbreaking nature of the LDRD research, which in FY97 was funded with only 5.7% of the Laboratory's budget. In addition, the LDRD program is a significant proving ground for new talent attracted to the Laboratory through our postdoctoral program. In FY97, 190 postdoctoral staff members participated at significant levels in LDRD projects. Of these, approximately one in four will become permanent Laboratory employees, rejuvenating our workforce and contributing to our central mission.

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. Because of the ban on nuclear testing, we must improve our fundamental understanding of the underlying science of nuclear weapons performance, and LDRD is increasingly needed to provide the most innovative approaches to achieving that understanding. Researchers are making a significant contribution to the development of new ways to making some of the measurements required for stockpile certification and improving the modeling capability of our nuclear weapons codes. The following LDRD projects have been chosen to highlight just a few significant contributions to national security areas.

Dynamic Radiography

LDRD researchers are exploring new ways to make detailed dynamic radiographs of imploding dense objects. The researchers are exploring two complementary approaches. In the first approach, researchers are examining use of high-energy protons as a candidate technology for a possible next-generation advanced hydrotest facility for stockpile stewardship. During this past year, a new proton radiographic experiment was installed at Los Alamos. It included a beam transport, containment vessel, magnetic lens system, and detector system able to image small-scale contained explosions. Together with a simulation and analysis effort, this experiment provided the first dynamic proton radiograph of a shock wave in high explosives, demonstrating proton radiography as a potentially important technology to support science-based stockpile stewardship. This exploratory work by a multidisciplinary team of scientists has very convincingly demonstrated the utility of this method to a previously skeptical community—a perfect example of the value of LDRD. This initial set of experiments provided the proof-of-principle basis for an extensive series of shots for better understanding the performance of high explosives.

In the second approach to radiography exploration, researchers are looking at potential advances in the traditional x-ray approach to hydrodynamic testing. This work examines the fundamentals of algebraic reconstruction of 3-D images from multiview x-ray data. Particular issues under study are determining the limit to resolution imposed by scattering, defining the optimal number of views, and determining the precision with which edges can be located and densities estimated. Other supporting tasks are to develop photocathode technology; develop simulations of the low-energy beam transport, particularly models of the high current beam-cavity interactions; model target bremsstrahlung converters and the target-beam interactions; and finally, develop solid-state detector technology capable of high frame rate with very large frame storage capability.

Both of these radiography initiatives are already succeeding and influencing the way the core programmatic efforts think about future means to addressing stockpile stewardship.

Understanding Dynamic Mix

Another key scientific initiative is the application of what is known as multiscale science to the examination of dynamic mix processes in high-density matter. The term multiscale refers to simultaneously modeling the physics at the atomic scale and the physics up to and including the bulk solid scale. Mix is a word applied to complex high-density mixtures of solid, fluid, or gaseous matter. The goals of this work are to create new approaches to creating validated, predictive models for fluid and materials mix. These approaches are based on microphysical descriptions of key processes. Once such models are understood and verified by experiment, there is the potential opportunity to include the new scientific insight into the codes used in the core stewardship mission.

The work includes such diverse elements as adaptive mesh simulation, multifluid turbulent mixing, experiments on and modeling of solid interactions, statistical representations of mixing, quantum molecular dynamics studies, shock-wave modeling, spall experiments, and several others. This fundamental theoretical and experimental study will be a key element to basic systems modeling for stockpile stewardship.

Gaining a Fundamental Understanding of Actinides

One research effort is focused on determining the electronic structure of highly correlated 5f elements and compounds, with particular emphasis on plutonium. Plutonium is a very complex material and is one of the few materials that has not been successfully understood at a fundamental level and that current models fail to adequately predict behavior. Scientists are using high magnetic fields to produce special states of actinide compounds in which an oscillatory magnetization, known as the de Haas van Alphen effect, yields fundamental information about the material's electronic structure. This work on the static properties is being complemented by investigation of microscopic dynamical phenomena that occur on time scales of 10^{-11} to 10^{-14} seconds. The purpose of these rapid-time-scale experiments is to reveal in unique ways the role of many-body interactions in d- and f-electron systems, of which the latter group includes plutonium.

The above investigation into the physics of actinides is complemented by a separate investigation into the chemistry of actinides, that is, how they react with other materials. Actinide chemistry is critically important, providing the technical basis for plutonium process and separation chemistry and metallurgy. This effort closely integrates chemical synthesis and characterization, spectroscopy, and theory and modeling to understand the chemical properties of actinide materials. The research specifically investigates actinide speciation, structure and chemical equilibrium in aqueous and nonaqueous systems. The result will be an ability to address complex chemical problems associated with the actinides.

These two new fundamental investigations into the nature of these complex actinide materials will provide an important knowledge base to ensure stewardship of the nuclear stockpile.

Looking at the Aging of Polymeric Materials

Researchers are developing a science-based methodology for predicting aging processes of polymeric materials. These polymeric materials are integral to the national defense. The approach being taken is based on characterizing molecular response to mechanisms that cause aging and to extend those responses through various length scales—molecular to mesoscale to bulk material. The effort includes both modeling and experiment. At the atomic and molecular level, the effect of water and hydrogen bonding on polymers are modeled in a three-dimensional, lattice Monte Carlo polymer code based on bond fluctuation models. At the mesoscale level, a model describing microphase island structure has been developed. Researchers have completed preliminary evaluation of network models and viscoelastic response of networks to constant strain experiments. At the bulk material scale, researchers have developed continuum models based on microstructure considerations and evaluated the pressure-volume response and high shear rate response. This work is already influencing thinking about how to monitor the stockpile.

Looking at Metal Deformation under High Strain

Stockpile stewardship requires true predictive capability of implosion dynamics in which the material properties are under extreme conditions (large strain, high strain rates, and high temperatures) and precise knowledge of those conditions is critically important. Researchers are conducting a coordinated experimental, mathematical modeling, and code implementation effort aimed at improving the calibration of strength models using data at elevated temperatures and at very large strains, extending these models to include texture evolution, and employing molecular dynamics to improve the models at intermediate strain rates. Among other achievements, researchers have successfully investigated the intersection process for dislocations and applied a ductile damage model to spallation data. Researchers have also explored the texture and constitutive behavior evolution of steel and incorporated the resulting understanding into physics models. These successes add to our fundamental knowledge of the properties and behavior of key materials in the stockpile.

Fundamental Studies of High Explosives

High explosives (HE) science and modeling lies at the heart of the nuclear mission, and improved approaches to HE reaction modeling will be critical to the success of both stockpile stewardship and the Accelerated Strategic Computing Initiative. A new LDRD study will attack a critical and fundamental piece of this problem, condensed phase chemistry, which is widely recognized as the weakest link in our understanding of the decomposition of energetic materials. New diagnostic methods, combined with a sophisticated modeling effort and an array of associated benchmark experiments, over a broad range of pressure and temperature, will begin to attain truly predictive modeling of HE response. The final product of this work will be an understanding of the fundamental chemistry and a predictive kinetics modeling capability, which is validated by coupled (chemistry and transport) experiments. This work will provide a significant advance in modeling HE reactions.

Table 16. Projected Funding for Laboratory-Directed Research and Development ($M).[1]

Funding Area	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Operating	62.6	66.5	70.0	70.0	70.0	70.0	70.0	70.0
Capital Equipment	1.5	1.8	2.0	2.0	2.0	2.0	2.0	2.0
Total	64.1	68.3	72.0	72.0	72.0	72.0	72.0	72.0

[1]Projected amounts for FY99 and beyond are subject to approval in accordance with DOE Order 413.2.

E. MAJOR NEW INITIATIVES

1. The Delphi Project: Simulation Science Beyond Supercomputing

Because the future challenges us with problems of increasing complexity and consequence, national leaders must make ever more reasoned and rapid choices from available options. Moreover, such decisions must be made with a clear vision of each option's long-term impact. This is particularly difficult in arenas for which full-scale experimentation is politically, economically, or socially impossible. For these arenas, *virtual* experiments of greatly advanced scale and scope are now possible because of the computational and intellectual infrastructure developed for the Science-Based Stockpile Stewardship program. As a result, we now have the potential for providing key decision-makers with the science-based assessment tools they need for taking a realistic approach to complex decisions.

The purpose of the Delphi project is to develop simulation science to a new level of capability, using applications as drivers and cutting across organizational boundaries within the Laboratory and between the national laboratories. Delphi builds on and advances the simulation capabilities that underlie the experience, accomplishments, and investments of stockpile stewardship to create a new infrastructure for addressing complex national and international problems.

Our new vision for simulation science focuses on

- quantifiably predictive modeling of natural and human-based phenomena;
- unprecedented technological capabilities in both software and hardware;
- a well-founded theoretical foundation for simulation science;
- assessment and analysis of time-urgent, surpassingly complex problems of national importance; and
- verification and validation of the simulation tools to the greatest extent possible.

The new era of simulation science is already under way, successfully initiated by stockpile stewardship and the Accelerated Strategic Computing Initiative (ASCI) to ensure the safety and reliability of an aging nuclear deterrent without nuclear testing. Advanced simulation is also applicable to global climate prediction, allowing assessment of strategic national decisions, complementing stewardship, and enriching the nation's scientific enterprise. Additional applications address complex questions in national security, national economic policy, international affairs, disaster mitigation, and science and engineering—questions that cannot be directly answered through the traditional scientific method of theory, experiment, and observation. Hence, we identify the following challenges for the capabilities that Delphi seeks to nurture:

- assuring a safe and reliable U.S. nuclear deterrent without nuclear testing;
- assessing the risk of long-term changes in Earth's climate and the efficacy of proposed solutions;
- mitigating the effects of natural and man-made disasters (e.g., wildfire, terrorist attacks, threats to the nation's infrastructure, epidemics, severe weather, and earthquakes) through forecasting, early detection, contingency planning, and management; and
- determining the requirements and assessing the effectiveness of strategic investments in national infrastructure (e.g., power distribution, transportation, communication, and military force).

Each of these challenges requires quantifiably predictive assessments that far surpass the ability of today's simulation science.

The technology required for nuclear weapons stockpile stewardship, global climate prediction, and other nationally important problems is different in scale, scope, and character from what exists today. Solutions will require computers a thousandfold more capable, exhaustive model verification and validation through comparison with observed data, multidisciplinary modeling and code development, direct involvement of universities and industry, and an investment strategy geared to getting the science and the technology right. We will need scientific, technological, and theoretical breakthroughs if we are to succeed. Scientists must be capable of making critical assessments based on knowledge gleaned from simulation data sets of thousands of terabytes coupled with realistic quantification of the predictive.

The class of problems appropriate for Delphi's focus have certain properties in common:

- They are of high consequence.
- There is a time urgency associated with them.
- They are sufficiently complex to require ASCI-scale computing resources.
- They require a predictive capability.

To address problems of this scope and scale, we have to develop the hardware, systems software, applications, and human expertise to ensure the necessary integrated capability. As part of this initiative, we are seeking out long-term strategic relationships with sponsors who are interested in and need these computing capabilities and infrastructure technologies for policy and budgeting decisions. Agencies with whom we have begun exploratory discussions or are building collaborations include the Department of Defense, the Centers for Disease Control and Prevention, the U.S. Forest Service, and the Federal Emergency Management Agency, as well as other key federal agencies that are concerned with infrastructure security and responses to natural and man-made disasters.

III. INFRASTRUCTURE AND SUPPORT

A. OPERATIONS

Overall responsibility for all operational matters lies with the Deputy Laboratory Director for Laboratory Operations. This Deputy Director has responsibility for leading success in two of the three special provisions: (1) Integrated Safety Management and (2) Environmental Restoration and Waste Management. For more information on these special provisions, see Section I. Laboratory Overview.

The Laboratory's goal to establish operational excellence is as follows:

> The Laboratory will establish performance measures that will require us to demonstrate excellence in all our activities. We will function with standards that will assure the government's and public's trust in our ability to carry out our mission while protecting the environment, ensuring the health and safety of our workers and our communities, and managing our resources effectively.

To achieve this goal, the Laboratory has established five high-level goals:

- practice Integrated Safety Management throughout the Laboratory;
- manage construction projects within approved costs and schedules;
- ensure an effective Security and Safeguards Program;
- achieve "Excellence" on Appendix F Operations Measures; and
- operate Los Alamos National Laboratory in an environmentally sustainable manner.

Supporting goals are in the process of being developed.

In this section, we address four of the five major operational areas of responsibility: Integrated Safety Management; Environment, Safety, and Health Laboratory-wide support; Site and Facilities; and Security and Safeguards. The fifth area, Environmental Management and Waste Management, is addressed in Section II. Science and Technology, as it has programmatic elements as well as operational ones.

1. Integrated Safety Management

Two imperatives drive the implementation of Integrated Safety Management (ISM) at Los Alamos: a moral imperative that we not injure people or the environment and a business imperative that we meet the requirements of the contract between DOE and the University of California (UC) for operation of the Laboratory. The contract supports the moral imperative by requiring us to perform work safely, in a manner that ensures adequate protection for employees, the public, and the environment and by requiring that management of environment, safety, and health (ES&H) functions and activities be an integral but visible part of the work planning and execution process. ISM is the contractual vehicle for meeting the moral and business imperatives for creating an injury-free workplace.

During 1997 and the early part of 1998, we focused primarily on the foundation and framework that are necessary to integrate safety with work. We completed 90 activities that form the ISM framework. These were activities that could be completed by a single individual or a small group of individuals without the involvement of most employees. They included developing the Work Smart Standards that constitute Appendix G of the DOE/UC contract, writing institutional requirements that flow from these standards, completing specific actions at TA-55 and the Chemistry and Metallurgy Research building, and implementing some institutional actions such as the management walk-around program. Completing these actions was relatively simple because of their well-defined scope and focused application within the institution; we have completed the easy part.

Creation of requirements for a more formal, integrated safety system will not bring it into being; successful execution will require management commitment and worker involvement. Management commitment means that managers understand their roles and responsibilities and are willing to be held accountable for meeting them. This commitment applies to line managers who are in the safety-responsible line management chain, program managers who supply the resources for performing work, and support managers who assist the line managers in analyzing hazards and developing controls. Worker involvement means that all work will be performed using the five core safety functions of ISM to create an injury-free workplace (see Figure 20). Safety performance will be part of everyone's performance appraisal. For this system to succeed, the level of employee involvement in creating and sustaining it must exceed any in the previous history of Los Alamos.

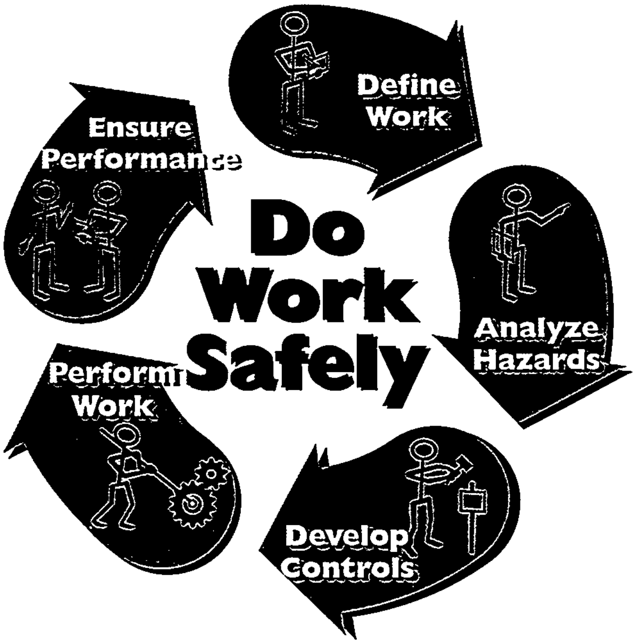


Figure 20. The five-step process for performing work safely at the Laboratory.

Our next steps toward implementing ISM involve all who work at Los Alamos in integrating safety into their work processes. These actions include employees of UC, Johnson Controls Northern New Mexico, Protection Technology Los Alamos, and all other contractors and visitors on our site. Our future institution-wide focus is the sustained execution of safe work performance in our facilities, the use of formal safe work practices in the performance of research and other non-facility-related work activities, including ergonomics, safe performance of electrical work, and industrial-level formality in construction project management. These activities bring a major aspect of ISM to every activity at Los Alamos and will require the support of virtually every employee for full implementation.

Other safety requirements that are not thoroughly implemented, such as biosafety, waste certification, nonionizing radiation, and traffic safety, affect only small portions of the institution. Small teams will work toward the sustained execution of these requirements within their areas of applicability without the involvement of the remainder of the Laboratory. By dividing the effort required for implementation into a small and broad focus, we will be able to address all of the poorly implemented requirements by the end of 1998, with minimal disruption of the ongoing programmatic work.

The moral and business imperatives cover not only worker health and safety but also protection of the environment. Past accidents at Los Alamos have driven a focus on worker health and safety. ISM has always included protection of the environment as one of its elements, but this has not been visible to the employees. As we move forward in the implementation of ISM, we are introducing an increased emphasis on environmental protection as a major element of our safety management system. Systematic integration of waste minimization and pollution prevention, for example, into work practices at all levels is essential to our success.

In summary, we are broadening the focus of ISM at Los Alamos to embrace all of ES&H, and the implementation actions are moving from the responsibility of a few individuals to encompass the entire institution. The next few years will pose the biggest challenge to integrating safety with work.

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. The Director has stated a 2-year goal of a performance rating of "excellent" for operations of the Laboratory by FY00.

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 ES&H core groups or are deployed to partner with Laboratory organizations, and become integral to effective and safe operations. The task of the ES&H generalists and specialists is to aid managers to make informed decisions. Over 200 ESH Division personnel have been deployed to line and program operations. Added deployment of personnel to other Laboratory divisions is continuing as project needs change and future facilities and projects are added to the Laboratory mission.

a. University of California Performance-Based Management System

The University of California (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 will 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 ultimately improvement in the programmatic performance. The performance measures are designed to indicate improvement in ES&H processes in the coming years.

Process performance measures are intended to assess key elements of the Laboratory's Integrated Safety Management system. System outcome measures are intended to be key indicators of the performance of the Laboratory's Integrated Safety Management system as a whole. The 26 performance measures constitute standards upon which the Laboratory's self-assessment is based. UC and DOE evaluate the self-assessment and performance overall 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 and the ES&H Office of the President staff, 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 the active involvement of line and facility managers in developing performance measures and in assessing performance, and reporting that performance to UC and DOE. During FY99 and FY00 the Laboratory expects to have achieved an excellent ES&H performance rating.

The Operations Working Group, a group composed of 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. Current efforts are concentrating on the establishment of benchmarks for the ES&H program and how future performance measures compare to the best-in-class ES&H programs at other U.S. institutions. During FY99 and FY00 the benchmarks will provide DOE with a means to measure progress in performance improvement in ES&H.

b. Worker Safety and Health

Worker safety and health activities in ESH Division concentrate on providing the expertise, tools, support, and services to line management for optimum worker protection. Programs are instituted to provide protection from physical, chemical, and biological hazards. Because Los Alamos National Laboratory has several nuclear facilities, the radiation protection programs are designed to minimize exposure of workers, contain radioactive contamination, and control releases of radioactive materials and radiation to the environment. Radiation measurements of external and internal radiation or radioactivity are included in the program. Radiological engineering, risk assessment and planning, radiation dose evaluation, ALARA (as low as reasonably achievable) programs, and instrument maintenance and calibration support the Laboratory and any off-site activities such as at the Nevada Test Site. Other worker safety concerns are addressed by efforts in criticality safety, industrial safety, industrial hygiene, facility risk management, and hazard analysis services. Criticality safety supports the Laboratory programs involving significant quantities of fissile materials; in addition DOE, DOE facilities, and DoD receive support in this area. Industrial Safety and Industrial Hygiene provides support to operating technical divisions to address chemical and physical hazards. Facility risk management provides input and expertise to facilities and line managers in the management and documentation of ES&H hazards and risks associated with existing and new facilities. Personnel with expertise in the previously described safety and heath protection disciplines are deployed to the operating divisions for day-to-day services.

Other supporting efforts crosscut those in ESH Division and the Laboratory. Occupational medicine provides comprehensive occupational health care services to protect and promote physical and mental health of Laboratory workers. Occurrence investigations support the proper investigation and reporting of abnormal events that occur at the Laboratory. Standards and calibration services are maintained for Laboratory-wide use to support high-quality calibration services and capabilities in a wide variety of physical, dimensional, and electrical measurements. Hazardous materials emergency response for the Laboratory and the County of Los Alamos are maintained. The effort to provide chemical and radiological response goes beyond Los Alamos to provide expertise and support to the DOE Radiological Assistance Program, DOE Accident Response Group, and the DOE Nuclear Emergency Search Team. Quality Assurance and Training programs help ensure that workers across the Laboratory are provided the support, knowledge, and skills needed to safely complete their work.

c. Public Health and Environmental Protection

Public health and environmental protection efforts at the Laboratory are strongly driven by federal and state regulations. Air quality concerns are addressed by programs to ensure compliance with federal and State of New Mexico regulations, environmental surveillance activities, and a community monitoring program. Water quality and hydrology programs provide environmental monitoring of local and regional waters and sediments, regulatory support for the National Pollutant Discharge Elimination System, wastewater characterization, the outfall reduction program, storm water discharge, spill controls, safe drinking water, and ground water protection. Hazardous and solid wastes programs support line organizations for compliance with hazardous and solid wastes storage, treatment, and disposal regulations. Underground storage tanks and toxic substances management, permits, and regulatory interface are provided for the Laboratory. Natural and cultural resources are addressed by study results that are used for environmental assessments, input to DOE National Environmental Protection Act documents, and consultations with affected American Indian tribes. Environmental monitoring programs for soils, foods, fish, and wildlife add to the information from air and water measurements. All of the activities for the environmental compliance and monitoring programs are published in an annual environmental surveillance report.

d. Technology Development, Evaluation, and Application (TDEA) Program

In 1995, ESH Division initiated the TDEA Program by allocating approximately 1% of its annual budget to developing technologies that would ameliorate Laboratory ES&H problems. Program priorities benefit Laboratory workers and the public; support Laboratory mission objectives; build on unique expertise and requirements at Laboratory; achieve success within 3 years; and transfer technology to other DOE sites. The focus of the TDEA Program is on the Laboratory's ES&H needs, problem solving, and applied science. The program is used to anticipate solutions to new ES&H challenges that may result from new projects at the Laboratory or new requirements from regulatory bodies for which applications of technology can result in better ES&H performance or save resources.

3. Site and Facilities

The Laboratory has consolidated facilities planning, documentation, databases, project management and maintenance operations in the Facilities Engineering (FE) Division. The division provides both central and distributed services to the Laboratory. This section provides background on major facilities planning issues the FE Division faces and how the division intends to address those issues.

a. Site and Facilities

Los Alamos National Laboratory is situated on approximately 27,800 acres of land (43 square miles) owned by DOE. We can develop only about 30% of this land because of topographic, environmental, operational, and buffering constraints. We house nearly 10,700 University of California employees, by head count (including full-time, part-time, paid and unpaid affiliate, visiting, and casual status), and an additional 3,000 contract employees, vendors, protective guard force members, and contractor personnel in approximately 5.1 million square feet (over 8.0 million gross square feet) of occupiable floor space. The buildings have an estimated replacement value of $2 billion; this figure increases to over $4.2 billion when we include utilities and capital equipment. Figure 21 and Figure 22 show the net usable-area distribution by use and building type, respectively.

Although the Laboratory seeks to reuse and reallocate present facilities efficiently, 30% of Laboratory facilities are more than 40 years old, and 80% of Laboratory 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 require replacement in the near future (see Figure 23).

b. Comprehensive Planning

Los Alamos developed its first long-range master plan in 1974 and its first site development plan (SDP) in the spring of 1983 and made available a completely updated SDP-Technical Site Information in early 1991. The master plans consider long-range land use; population and facilities; transportation and circulation; security and safeguards; space; utilities; and environment, safety, and health (ES&H) issues. The plans may be adapted and updated as conditions change.

The changing mission of the Laboratory in the 1990s created the need to develop a comprehensive planning process that integrates and coordinates diverse types of

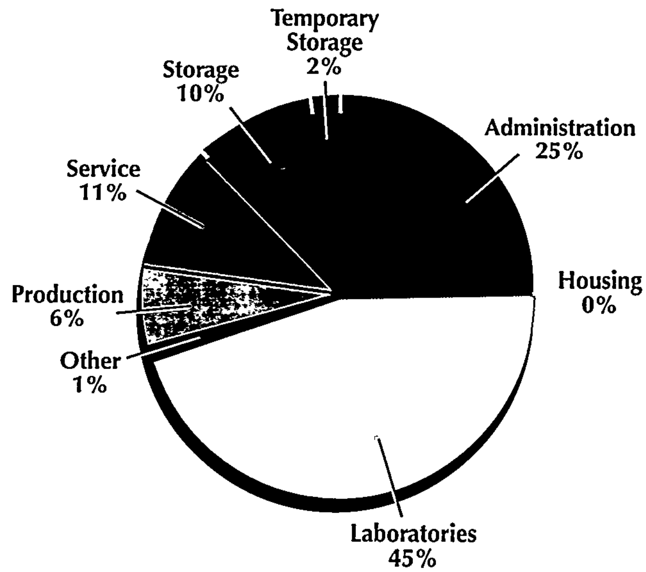


Figure 21. Net usable-area distribution by use.

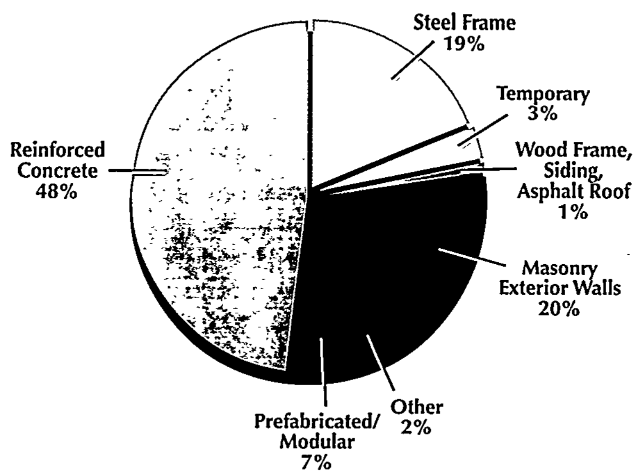


Figure 22. Net usable-area distribution by building type.

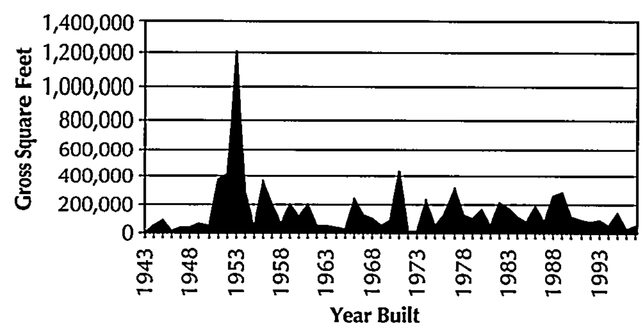


Figure 23. Ages of Laboratory facilities.

 plans into a new Site-Wide Master Plan for the Laboratory. As we develop the new plan, it will include the following:

- A short overview of Los Alamos, including the existing mission and workload, site and regional context, and projections and resource requirements.
- Detailed information divided into eight core-planning elements listed above. These elements will serve as the foundation of the master plan and as the foundation of the various plans for site facilities, technical areas (TAs), or facility management units.
- Implementation strategies through site facilities plans will support the annual budget formulation for the design, construction, modification, operation, maintenance, and disposition of facilities.

Master plans for facility management units and technical areas will become unit plans within the new Site-Wide Master Plan. The long-range goal is to maintain the Site-Wide Master Plan supported by a comprehensive database for conducting up-to-date physical planning activities and for serving as the foundation for the comprehensive planning process, as required by DOE's Land-and-Facility-Use Policy and Life Cycle Asset Management Order.

As the Laboratory moves into the next century, we will continue to address planning issues at the highest Laboratory management levels. In order to deal directly with the institutional planning issues, the new Director and his deputies now serve as the Laboratory Planning Council.

c. Infrastructure and Facilities Revitalization Project

For the past few years, Los Alamos has worked on an initiative to revitalize the infrastructure of the Laboratory. To coordinate the planning of this initiative, the Director formed the Project Office for Infrastructure and Facilities Revitalization in January 1997, with a project leader working very closely with the Director's Office, FE Division, and program and line organizations throughout the Laboratory.

Los Alamos shares the mission of Reducing the Global Nuclear Danger with the other DOE Defense Programs (DP) laboratories. However, Los Alamos has a number of specialized facilities and capabilities that make it unique among the laboratories for addressing this mission. Such 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 some of the oldest in the DOE complex, dating to the 1950s, the need for infrastructure revitalization and facility replacement at Los Alamos is significant and will require sustained capital expenditures. Up-to-date facilities that meet current standards are essential both to accomplish our mission and to operate safely and reliably.

The purpose of the Infrastructure and Facilities Revitalization Project is to define and prioritize facilities projects and to obtain the funding needed to undertake a sustained long-term program in upgrading or replacing aging infrastructure and facilities. The Laboratory has identified the following three basic components of this effort:

- Create an institutional reinvestment funding program at the Laboratory with the amount of funding proposed at $20 to $25 million per year, or 2% of the Laboratory budget, for facilities, grounds, and roads and $4.5 million for utility reinvestments.
- Continue to obtain line-item capital-funding support for specific buildings and experimental facilities necessary for the Laboratory mission assignments. Examples include the proposed Strategic Computer Complex for the Accelerated Strategic Computing Initiative that has been proposed by DP and the Dual-Axis Radiographic Hydrodynamic Test facility supported by DP.
- Allocate appropriate operating funds regularly to ensure that we support maintenance and noncapital line-item projects to meet the Laboratory's central mission of Reducing the Global Nuclear Danger.

The Laboratory has dedicated operating funds for proceeding with specific conceptual design plans (CDPs) for infrastructure upgrades at the Laboratory. Specific projects currently in the CDP stage include the following:

- wastewater 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 completing a comprehensive master plan for TA-3 (see Figure 24). One of the key concepts of the plan is the clearing, rebuilding, and replacement of temporary space within the core area of TA-3 (see Figure 25), a crucial part of the Comprehensive Site-Wide Master Plan for the Laboratory.

We are developing the rationale and appropriate documentation for proceeding with primary 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 should lead the Laboratory and DOE to the adoption of industrial standards and codes whenever possible.

d. 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 response to Pueblo land claims. LAAO supports release of parcels of DOE land to the county and the Pueblo. Section 632 of Public Law 105-119, passed on November 26, 1997, requires that the Secretary of Energy take certain actions with respect to the conveyance or transfer of certain suitable tracts of land at or in the vicinity of Los Alamos National Laboratory.

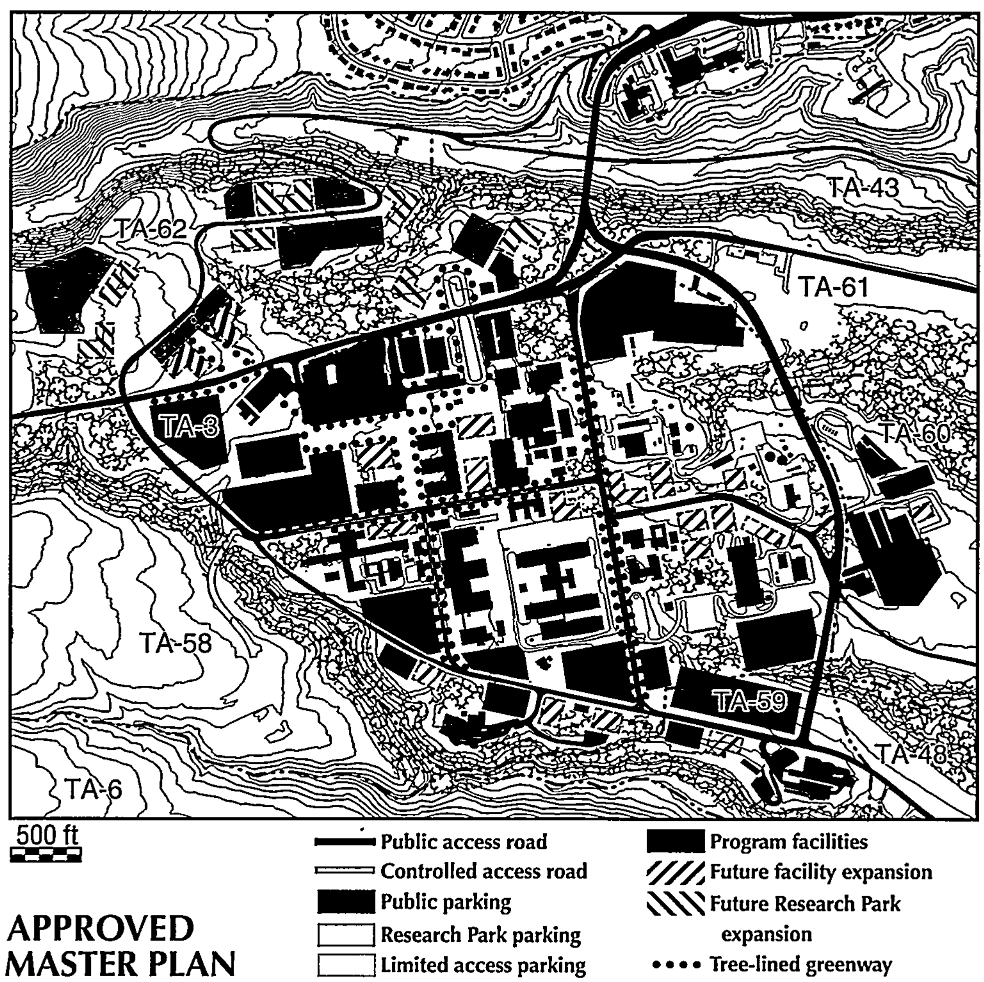


Figure 24. The approved master plan for TA-3 was developed by evaluating the existing physical environment and by taking an inventory of future program and project needs. Analysis of existing constraints in TA-3 and the opportunities of new programs such as the Strategic Computing Complex, the Nonproliferation and International Security project, and the Research Park have helped develop the comprehensive master plan for TA-3.

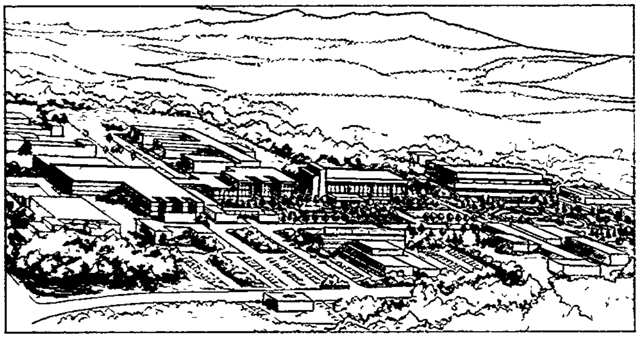


Figure 25. Artist's conception of the approved plan for the core area of TA-3.

Since October 1995, the process to transfer 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 allows the Laboratory to review in detail each parcel in order 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 and again in November and December 1997. The Laboratory identified operational impacts and noted both utility easement requirements and National Environmental Policy Act (NEPA) compliance requirements for all tracts. In addition, the Laboratory noted which tracts are needed to meet our national security responsibilities.

The first action that the legislation requires of the Secretary of Energy is to deliver a report to the congressional defense committees identifying the parcels of land that are suitable for conveyance or transfer within 90 days after the date of enactment of the legislation. In addition, the legislation prescribes that a parcel of land is suitable for conveyance or transfer if it is not required for meeting the DOE national security mission or will not be required for that purpose before the end of the 10-year period beginning on the date of enactment, if it is likely to be conveyable or transferable before the end of the 10-year period and if it is suitable for purposes of historic, cultural, or environmental diversification or for purposes of community self-sufficiency.

The legislation requires the following:

- complete title and survey work to be done within 1 year of the legislation passage,
- a binding agreement established between the County of Los Alamos and the Pueblo of San Ildefonso on who is to receive which tracts, and
- NEPA compliance and identified environmental considerations completed within 21-month requirements.

The Secretary of Energy is to report back to Congress with a list of the lands that can still be transferred and an implementation plan for transfer.

We have identified nine land parcels at or in the vicinity of the Laboratory for possible conveyance or transfer. In addition, DOE recognizes that certain costs will be incurred in order to accomplish the conveyance or transfer of these parcels of land and therefore has made an effort to identify the associated transfer costs. DOE notes that the associated transfer costs differ significantly among the nine tracts, ranging possibly beyond $500 million in estimated costs for TA-21 to significantly smaller amounts for smaller tracts such as the Manhattan Monument site. However, significant portions of these costs (that is, costs of decontamination, decommissioning, and environmental cleanup) may be incurred regardless of the land transfer proposal. The land transfer might result in accelerated costs associated with decontamination and decommissioning within the next 10 years compared with the costs spread over the current, undetermined time period for completing these activities.

Numerous factors affect the determination of transfer costs. To date, no specific study has identified costs of the various activities associated with the transfers; for example, costs associated with the cleanup of known and potential contamination at several of the sites are not fully understood.

The nine parcels of land in the following list have been determined to meet the suitability criteria of Public Law 105-119 after a rigorous review of expected future programmatic requirements between DOE and the Laboratory.

- TA-21 consists of approximately 243.8 acres and is located east of the Los Alamos town site. This site, which is remote from the main Laboratory campus, is considered a prime candidate for conveyance or transfer. However, its level of contamination presents major technical challenges that must be overcome before such action is possible.
- DP Road (north, south, and west) consists of 49.8 acres. It is generally undeveloped except for the west section where the Laboratory archives are currently located.
- The DOE LAAO site consists of 12.9 acres. It is also within the Los Alamos town site and is readily usable.
- The airport site consists of 198.0 acres. Located east of the Los Alamos town site, it is close to the East Gate Business Park.

- The White Rock site consists of 98.7 acres. It is undeveloped except for utility lines and a water pump station.
- Rendija Canyon site consists of 908.7 acres. The canyon is undeveloped except for the shooting range, which serves the local community, and is currently under lease from DOE to the community.
- The White Rock Y site consists of 435.1 acres. It is undeveloped and is associated with the major transportation routes connecting Los Alamos with northern New Mexico.
- Two miscellaneous sites, Site 22 and the Manhattan Monument site, consist of 0.27 acres. Site 22 is a small, town site parcel located on the edge of the mesa overlooking Los Alamos Canyon. The Manhattan Monument site is a small rectangle within Los Alamos County land and adjacent to Ashley Pond, where most of the first Laboratory work was conducted.
- The TA-74 site consists of 2,698.4 acres. It is a large, remote site located east of the Los Alamos town site. Presidential Proclamation 3539 restored this parcel to the public domain on May 27, 1963. Because it is public domain land, transferring it out of federal control may require additional legislative action.

There may be significant costs associated with the conveyance or transfer of the 4,646 acres. In addition, these tracts may, in some cases, require use restrictions that relate to mitigation of environmental, ES&H concerns, or other matters that must be identified and resolved.

e. Research Park

Los Alamos National Laboratory, DOE, and the Los Alamos Economic Development Corporation (LAEDC), with support from the County of Los Alamos, is pursuing the development of a research and development park. The park is proposed to be developed on about 40 acres of land directly north of the Laboratory's main core area, known as TA-3. This land and park are intended to provide a physical location for private industry to develop facilities that will allow and foster scientific and technological exchange between private industry and the Laboratory.

It is planned that in addition to the benefit of scientific research and development to be gained by both the Laboratory/DOE and industry, local and regional economic benefits can be realized. Currently, the DOE LAAO is finalizing a land-lease agreement with the LAEDC; the targeted signing date is October 1, 1998.

A lease agreement in lieu of land transfer is being used to ensure that the DOE and the Laboratory maintain the ability to protect the national security and operational interest of the Laboratory, since the park is proposed to be within the Laboratory's existing operational buffer area. The lease addresses such issues as the ability to repossess property quickly; protection of federal land/resources; protection of federal financial interests; limiting of land uses to research and development and auxiliary activities; and development requirements.

A NEPA environmental assessment has been completed. A Mexican Spotted Owl study completed in June of 1998 resulted in no owls being present on or near the park. Existing cultural resources identified within the proposed park area resulted in a park boundary adjustment to exclude these resources to outside the park boundary. An environmental restoration management review has occurred that is related to the few potential release sites identified within the proposed park boundaries. All the sites within or adjacent to the park have been previously reviewed and recommended for "No Further Action" to the State of New Mexico.

The proposed lease agreement provides for park master planning to be developed by LAEDC and approved by the DOE area manager before any development. The lease agreement contractually requires all development to be subject to County of Los Alamos and State of New Mexico laws, regulations, and codes related to development. This requirement ensures that all development and land uses will conform to local and regional building standards, providing the same public protection required elsewhere within the County of Los Alamos.

In summary, the Research Park is visualized as a joint government/private-effort setup that will benefit all parties in both the short term and the long term. With benefits at the local, regional, and national level, it is hoped and planned that the Research Park will a starting point in a mutually beneficial relationship, both financially and scientifically, to all parties involved.

f. Construction Project Management

Managing construction projects within their established cost and schedules is a primary goal for the Laboratory. In the fall of 1997, a complete review of the Laboratory's capability in this area was completed. The result of this review was an action plan for improving the

 Laboratory's performance in construction project management. The key points of the action plan involved the organization, the existing staff, and the processes.

The Facilities Project Delivery (FE-6) Group provides construction project management expertise to the Laboratory and was reorganized to focus its capabilities on projects and their success. Performance measures have been established to measure the FE-6 Group's success in providing the people, tools, and contractor support to the projects. The existing staff was also reassigned as necessary to ensure the proper focus was placed on the project's success. Training programs are being developed to elevate the staff's capabilities. In addition, the entire set of procedures governing construction project management are in the process of being rewritten to make them accurate and user friendly. This effort will be completed by the end of FY98.

Another significant change has been the release of the Construction Project Management Laboratory Implementation Requirements document (CPM LIR). The CPM LIR defines the minimum acceptable standards for all projects in excess of $500,000. It requires clear definitions for team membership, roles and responsibilities, procedures, and scope, among others, and specifies the minimum set of documentation to support the requirements. The CPM LIR is consistent with DOE requirements and is intended to support the full implementation of DOE Order 430.1.

DOE has been an integral part to the redesign and implementation of the improved construction project management system at the Laboratory. DOE was an active participant in identifying weaknesses in the existing system, providing suggestions on how to improve, and meeting with the University of California on a routine basis to discuss progress and other issues. It is fully recognized by all parties involved that improving construction project management at the Laboratory will take both DOE and the University of California.

The action plan has also been reviewed by the Defense Nuclear Facilities Safety Board and by an independent review team established by the Laboratory Director. Both of these reviews are ongoing. As conclusions and recommendations are made, the Laboratory will take appropriate action as necessary.

g. 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 project documentation. We are reducing the inconsistencies by coordinating various planning efforts. The Construction Table in the Appendix (see Table 21) summarizes funded and proposed line-item construction projects from the current fiscal year through FY04.

General Plant Projects

DOE 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 $5 million per project. Such projects are necessary to adapt facilities to new or improved production techniques, to effect economies of operation, and to reduce or eliminate health, fire, and security problems. They provide for design and construction, other capital alterations and additions, and improvements to land, buildings, and utility systems. They may include construction of small new buildings, replacement of or additions to roads, and general area improvements.

Facilities Maintenance and Repair

The FY98 allocation for the maintenance and repair of institutional property at the Laboratory is $68.7 million, essentially the same as the FY97 allocation. This total includes activities such as management and technical support, snow and waste removal, custodial services, and landscaping.

The Laboratory began to move toward a distributed Facility Management (FM) system during FY94. This currently requires 18 full-time facility managers who have the funding and responsibility for the maintenance of their facilities. Where appropriate, the FM model included transition from the former space-recharge method to direct funding of maintenance from Laboratory programs.

Table 17 lists the components of the maintenance budget as projected for FY98. The maintenance and repair cost is the amount projected for preventive and corrective maintenance ($43.4 million). The custodial support is the amount projected for janitorial services and

Table 17. Facilities Maintenance and Repair ($M).

	FY98	FY99	FY00	FY01	FY02	FY03
Maintenance and Repair	43.4	43.8	44.3	44.7	45.2	45.6
Custodial Support	11.2	11.3	11.4	11.5	11.7	11.8
Management, Engineering, Design Inspection, and Technical Support	9.0	9.1	9.2	9.3	9.4	9.5
Other Maintenance Services	5.1	5.2	5.2	5.3	5.3	5.4
Total	68.7	69.4	70.1	70.8	71.6	72.3

trash removal ($11.2 million). The management, engineering, design, inspection, and technical support cost is the amount required to direct and coordinate the support services contractor ($9.0 million). "Other" is the amount projected for landscaping and snow removal ($5.1 million).

A small amount of new construction and the aging facilities at Los Alamos necessitate increases in the maintenance budget through the year 2003. Therefore, an annual increase of approximately 1% is projected through FY03, based on expected growth and tempered by the reality of declining budgets.

Distributed Facility Management Program

The Facility Management Program at Los Alamos 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 for maintenance management. The intent of the institutional program is to ensure that the Laboratory's physical infrastructure supports programmatic requirements and facility needs and that formality of operations is consistent and appropriately applied across all facilities.

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 facilities activities. Institutional systems and organizations are changing form and culture in support of the Facility Management Program.

Fire Protection

We implement the Laboratory Fire Protection Plan and programs in accordance with the University of California/DOE Contract requirements and the Laboratory Director's Policy DP-118, Fire Protection. DOE transferred administration of the current Los Alamos County/DOE contract for fire department services to the Laboratory on December 1, 1997. Fire Protection and Emergency Management and Response personnel are the technical administrators for day-to-day fire department operations. The new statement of work for a follow-on contract with Los Alamos County is still in the developmental stages. In addition, the Fire Protection Group and the Ecology Group coordinate the wildfire prevention aspects of fire protection and facility inspections for property loss and risk evaluation.

The Fire Protection Group is restructuring the fire protection program for the Laboratory. The results will be a Laboratory implementing requirement for fire protection and a Laboratory implementation guide or fire protection manual. Each facility management unit will establish a contract with the Fire Protection Group for those fire protection program requirements identified as the responsibility of each facility manager. A fire marshal function will be established for the oversight of the entire fire protection program for the institution. Finally, Facilities Engineering Division is pursuing an upgrade to the Laboratory's sitewide alarm system—BRASS (Basic Rapid Alarm Security System)—to separate fire alarms from the security alarms. The upgrade will result eventually in a stand-alone fire alarm system that meets Underwriters Laboratories listing requirements.

4. Security and Safeguards

In his March 1998 testimony to the Senate Subcommittee on Strategic Forces of the Committee on Armed Services, the Laboratory Director identified for special attention a goal to improve security at the Laboratory, particularly in the areas of facilities and classified information. To this end, safeguard and security functions will be conducted at a division level under a newly appointed Director of Security and Safeguards. The new director will report to the Deputy for Operations, who has established the ensuring of an effective Security and Safeguards Program as one of his top five goals. The Director of Security and Safeguards will focus on the security of our nuclear facilities, our computing, and information. The director will also be responsible for the emergency management operations.

The basic security and safeguards 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 using threat analysis, risk assessments, and cost/benefit analysis.

The Laboratory ensures that all security and safeguards interests, including classified and sensitive unclassified material and information, nuclear material, and other U.S. government property, are protected against threats as outlined in the DOE-designed Basis Threat. The threats include compromise, loss, theft diversion, espionage, sabotage, subversion, and other malevolent or inadvertent acts that may cause unacceptable risks to national security, employee or public health and safety, and the environment. The Laboratory provides protection in a graded manner that is consistent with potential risks. Assurance of effective security and safeguards operations is maintained by comprehensive programs of 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 five years. The current control system serves as both a fire alarm and a security-intrusion detection system. The new security control system will employ state-of-the-art technology and will be capable of supporting the projected missions of the Laboratory well into the twenty-first century.

The Laboratory has initiated and is committed to quality management practices to ensure

- innovative, creative, safe, cost-effective, and credible security and safeguards programs;
- consolidation (and where practical, reduction) of classified matter;
- increased use of technologies such as automated access and automated validation systems that promote effective, efficient, and reliable security and safeguards operations;
- standardization of protection system, including weaponry, alarm hardware, and computer hardware; and
- effective training that ensures that security and safeguards personnel are well qualified and knowledgeable.

The Laboratory is committed to partnering with DOE security and safeguards managers and staff through jointly sponsored initiatives (working groups, task forces, and assessments). The Laboratory strives for continuous quality improvement in an effort to achieve and maintain credible security and safeguards operations that promote the DOE and Laboratory ideals of openness, customer satisfaction, efficiency, and cost-effectiveness. Security and safeguards strives to excel in all performance measures as outlined in Appendix F of the University of California contract with DOE.

B. BUSINESS ADMINISTRATION AND OUTREACH

The Deputy Laboratory Director for Business and Administration and Outreach (BAO) has Laboratory-wide responsibility for the institution's business affairs. This Deputy Director is the line manager for eight Laboratory organizations: Business Operations, Human Resources, Community Information and Outreach, Public Affairs, Audits and Assessment, the Laboratory Legal Office, the Diversity office, and the Ombuds Office. BAO also has performance-management (Appendix F) responsibility for all business administrative matters, including the regional economic development (Civilian and Industrial Technology Programs Office, Science and Technology Base Program/Science Education Program Office) and business information systems (Computing, Information, and Communications Division) that are under the line-management responsibility of the Deputy Director for Science and Technology.

In addition to Appendix F performance management responsibility, BAO is responsible for championing success in the special provision on regional involvement. For more information on this special provision and its related goals, see Section I. Laboratory Overview.

To attain the Laboratory goals of excellence in all relevant areas of Appendix F and success in the regional involvement special provision, BAO is developing performance measures with all division and office directors that contribute to six key focus areas described in Section I.

Described in this section of the document are high-level plans for six areas of BAO responsibility: human resources, business operations, community involvement and outreach, public relations, information management, and audits and assessments.

1. 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. HR 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, not only to 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.

We employ the use of an external advisory committee composed of senior leadership and human resources experts from benchmark companies and academic institutions. The committee reviews current HR operations and ascertains what the expectations of HR's customers are by reviewing HR-collected data.

a. Workforce Management Tools for Alignment with Laboratory Direction

A key responsibility we have assumed in HR 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 4 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 spectrum of workforce issues, ranging from performance evaluation to employee pride and morale. Generally, questions remain the same on the survey to track trends; however, items will occasionally be added as the institutional focus changes or other workforce issues become manifest so that the resulting data is pertinent.

A proposed Laboratory Performance Management System for all Division and Office Directors is set to be implemented. The system will increase accountability, align change to new institutional direction, and provide better service and products to our customers. Components of the system include the following:

- Management imperatives—objectives and measures that must be met in order to continue as a manager at the Laboratory;
- Mission—objectives and measures that define "what" the organization needs to accomplish to meet its customer expectations; and
- Administrative—objectives and measures that define "how" the organization accomplishes its work.

The current nonmanager performance system is expected to be upgraded early next year to match the performance system for managers. Currently, employees work with their managers to determine their own "Individual Performance Goals" 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 on their organization's objectives.

We understand that how a result is achieved is as important as what is achieved. That is why employees are assessed on how well they exhibit behaviors that support the Laboratory's guiding principles. 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; this should have the mutual benefit of allowing the workforce to have greater mobility among projects and enabling the Laboratory to respond quickly in allocating resources to projects. We will also be investigating other reward mechanisms such as nonmonetary awards and variable pay.

b. 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.

In December 1997, a Career Development Advisory Committee (CDAC) was established to advise management on Laboratory career development issues and to help define our career-planning process. Although the Laboratory has had some career development activities in place, CDAC's function was to ensure a coordinated approach to career development through implementation of a system designed by the Laboratory Leadership Council Action Team.

A Career Development Project Team provides tools and resources that promote growth and help employees develop the necessary characteristics, skills, and behaviors needed to accomplish programmatic goals. Specifically, one of the efforts has been focused on developing a mentoring program to help retain critical knowledge, to foster mobility, and to help employees better understand Laboratory culture, changing requirements, and complex customer needs. A discussion series was televised to inform the Laboratory about current issues and available resources in career development and training modules for managers and employees that address individual development plans, skills assessment, and strategic career planning. The Performance Management System included clear guidelines for how to align employee development with organizational objectives and assure that an assortment of development options are available to promote professional growth. A systematic approach to ensure continuity of leadership—with emphasis on diversity and expedited development—has been started.

In December 1997, the Laboratory implemented a system to allow employees to comment on proposed policy changes that affect their terms and conditions of employment. This Web-based system allows employees to enter their own comments and to view comments submitted by others. A summary of the comments and their final disposition is posted before the policy becomes effective.

HR has also been working with the Diversity Office as well with the Science Education Office in the Science and Technology Base Program Office 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. For more information on this topic, see Section II.D.1. Science and Mathematics Education Programs. Table 18 at the end of this section provides information on the composition of the Laboratory workforce.

c. The Laboratory Training Program

The Laboratory Training Program is coordinated by the HR Training Integration Office, which serves as the single point of contact for the Laboratory's decentralized training services. Line organizations from across the Laboratory deliver training focused on workforce development and Laboratory operations, with operations training being subdivided into safety- and security-related training and division- or facility-specific training. Although the delivery of training is decentralized, all Laboratory training meets the standard of performance-based, graded, and systematic training and has a unified focus to support Laboratory directions and key focus areas.

Current Laboratory directions have required that operations training and training tools focus on Integrated Safety Management (ISM) implementation, the Facility Management model, and necessary and sufficient standards, and on providing greater access to both instruction and training records. Training record access is primarily driven by the need to have a readily available institutional tool for worker authorization in support of ISM. As such, the Laboratory Training Program has redirected funds and staff to develop, implement, and evaluate, in cooperation with the Audits and Assessments Office, the following: a Safe Work Practices training program; facility management training; and the Laboratory Implementation Requirement titled, "Laboratory Training Program—a Graded and Systematic Approach to a Qualified Workforce," which uses necessary and sufficient standards. The Laboratory Training Program has also developed a Virtual Training Center, an on-line training questionnaire that creates worker training plans for workers, Web-based training reports and transcripts, Web training templates, and moved more than 35 low-risk, knowledge-based courses to the Web.

As the Laboratory continues to evolve its direction and focus, the Laboratory Training Program will redirect itself to continue to support the Laboratory's programs and goals.

d. 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 requires 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 guiding principles used 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 guiding principles 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 with work-related 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 contributing 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 26 portrays the HR system through which the Laboratory's workforce priorities will be addressed. It illustrates the three primary activities of the HR 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 by 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.

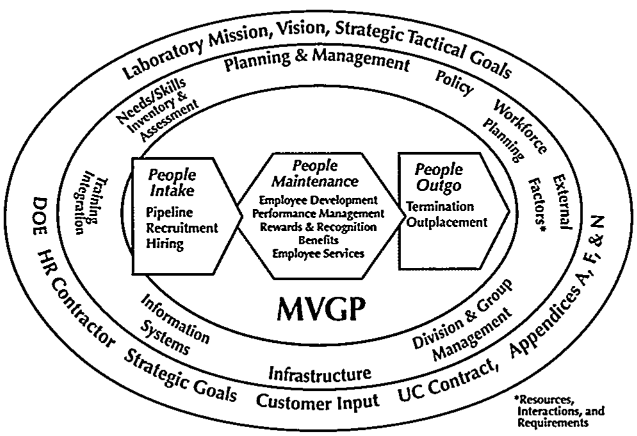


Figure 26. Human Resources—a systems view.

Table 18. Affirmative Action and Equal Employment Opportunity.

Regular Employees (including personnel on leave)[1]

Occupational Category	Total M	Total F	Minority M	Minority F	White M	White F	Black M	Black F	Hispanic M	Hispanic F	Native American M	Native American F	Asian M	Asian F
Officials and Managers														
Managers	372	75	43	9	324	65	1	1	33	7	4	0	5	1
Supervisors	750	203	157	63	584	140	2	2	134	52	7	3	14	6
Professional														
Scientists and Engineers	2,000	326	260	55	1,704	267	12	1	141	33	22	1	85	20
Administrative	339	485	128	178	208	302	2	1	119	158	5	12	2	7
Technicians	932	282	507	133	414	147	4	0	474	120	26	7	3	6
Office and Clerical	75	634	61	418	14	212	0	0	58	396	3	18	0	4
Crafts	96	6	48	4	47	2	0	0	43	4	5	0	0	0
Operatives	13	12	11	11	2	1	0	0	11	10	0	1	0	0
Total	4,577	2,023	1,215	871	3,297	1,136	21	5	1,013	780	72	42	109	44

Limited-Term and Casual Employees[2]

Occupational Category	Total M	Total F	Minority M	Minority F	White M	White F	Black M	Black F	Hispanic M	Hispanic F	Native American M	Native American F	Asian M	Asian F
Officials and Managers														
Managers	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supervisors	3	1	1	0	2	1	0	0	1	0	0	0	0	0
Professional														
Scientists and Engineers	159	24	23	9	130	14	1	0	4	3	0	0	18	6
Administrative	4	8	2	1	2	7	0	0	2	1	0	0	0	0
Technicians	16	15	10	5	6	10	0	1	9	3	0	0	1	1
Office and Clerical	2	26	2	10	0	16	0	0	2	10	0	0	0	0
Crafts	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operatives	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	185	82	38	25	141	56	1	1	18	17	0	0	19	7

Special Employment Program Employees (includes casual employees)[3]

Occupational Category	Total M	Total F	Minority M	Minority F	White M	White F	Black M	Black F	Hispanic M	Hispanic F	Native American M	Native American F	Asian M	Asian F
High School Co-op	37	59	17	47	19	10	1	0	14	46	1	1	1	0
Undergraduate	399	383	169	224	206	141	4	9	138	177	10	14	17	24
Graduate Research Assistant	271	121	64	35	190	77	5	5	25	15	2	3	32	12
Postdoctoral	285	60	81	14	177	42	1	0	8	4	1	0	71	10
JR Fellow	4	2	2	0	2	2	0	0	1	0	0	0	1	0
Total	996	625	333	320	594	272	11	14	186	242	14	18	122	46
Total Employees	5,758	2,730	1,586	1,216	4,032	1,464	33	20	1,217	1,039	86	60	250	97

[1]65 males and 16 females who are counted in the total male and total female columns did not specify their ethnicity.
[2]6 males and 1 female who are counted in the total male and total female columns did not specify their ethnicity.
[3]69 males and 33 females who are counted in the total male and total female columns did not specify their ethnicity.

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2. Business Operations

At Los Alamos National Laboratory, the Business Operations (BUS) Division serves as a support organization, enabling the Laboratory to achieve its mission and goals by developing and implementing policy and by providing products and services such as accounting, budgeting, procurement, property management, materials management, and transportation. BUS Division has set its sight on the year 2000 and expects 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.

In FY98, we developed a 2-year business plan that focuses on goals aligned with the Laboratory's tactical goals. Safety remains the primary goal. Additional goals include workforce management (people), customer satisfaction and productivity, corporate citizenship, and integration of various business functions.

a. Management Framework and Core Functions

BUS Division continues to endorse the concepts of empowerment and accountability. Our 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.

Our division comprises designated groups that perform the core functions of budgeting, accounting, property, transportation, and procurement. These five groups support effective business operations at the Laboratory by establishing appropriate policies and procedures; the group members ensure that these Laboratory policies and procedures comply with relevant DOE orders and statutory regulations. In addition, BUS Division is made up of two other groups. The Systems Support Group facilitates the use of automated systems and is focusing on FY00 upgrades. The Materials Management Group is responsible for operation of the liquid- and compressed-gas facility, materials receipt and distribution, and stores inventory.

b. Model of Distributed Services

BUS Division remains a champion of decentralized (or "field") financial, procurement, and property services via the Distributed Team Model. By assigning distributed business teams to our technical customers, we have continued to enhance and strengthen our relationships with customers and have been able to better respond to and anticipate customer needs. Customers pay only for the services that they receive.

Using the Voice of the Customer mechanism, we continue to obtain customer and employee feedback. The process begins with a series of one-on-one interviews with customers. Themes obtained from these interviews result in Web-based surveys intended to collect importance/satisfaction perceptions from customers. Analysis of survey results identify customers' most important/least satisfying issues, enabling understanding and identification of customer priorities and areas for improvements. BUS Division and its customers then work together to develop an action plan to determine the best method for improving customer satisfaction. Ultimately, these results becomes an integral part of our business plan.

c. Financial Management

Financial management at the Laboratory includes accounting and direct and institutional budgeting. The Laboratory's annual budget includes $1.2 billion in operating costs and more than $100 million in capital and construction costs. To achieve success in meeting its budgeting requirements, the Laboratory

- uses the resource planning module (RPM) to enhance forecasting capabilities and is currently in the process of developing the allocation module that, when combined with the RPM, will provide managers with a state-of-the-art planning and budgeting tool;
- continues to streamline the process for formulating the direct budget by using an on-line budget estimating tool for all proposals and using World Wide Web technology to obtain and disseminate those budget guidances;
- uses documented charging guidelines, cost transfer, and several other policies, and provides training as necessary;
- continues to streamline the indirect budget formulation and functional cost processes;
- instituted the new facility management process, which is expected to provide better and timely information to both the direct and indirect budget processes;

- has implemented several initiatives in accounting, such as on-line invoice approval system, negotiations with airlines, management of precious metals, computerized maintenance management, and travel provider services, all of which have taken work "off the table" and have cut process cycle time; and
- has partnered with the DOE Albuquerque Operations Office (DOE/AL) on Appendix F performance measures to better understand DOE/AL's expectations and to enhance DOE/AL's awareness of Laboratory operations. This effort has streamlined the Business Management Oversight Review process and resulted in a fair assessment of the Laboratory's performance.

d. Procurement Opportunities

BUS Division is responsible for the procurement of goods and services to meet the Laboratory's programmatic needs. The Procurement Group ensures that required supplies and services are obtained in an economical, efficient, and timely manner.

Socioeconomic Program

The Laboratory has distinguished itself as a leader in providing subcontracting opportunities and programs to small, small disadvantaged, and women-owned businesses. Numerous approaches, such as set-aside programs and specific business development initiatives, ensure that small businesses have the maximum opportunity to compete for Laboratory subcontracts.

Northern New Mexico Initiatives to Increase Procurement Activities

One of the six specific regional involvement requirements of the Special Assessments of the Laboratory as defined in clause 5.1 of the contract between DOE and the University of California requires that the Laboratory increase procurements in northern New Mexico. Procurements have increased substantially, and the Laboratory is on target to attain this goal.

The Laboratory spent $224.7 million (37%) of the total $601.8 million budget for unconstrained procurement from northern New Mexico businesses. The Laboratory is aggressively engaged in outreach activities and development of the following programs to assist and maximize procurement opportunities in the local northern communities.

- *Leveraging of major subcontracts through financial incentives.* Major support subcontractors are encouraged, through performance goals tied to financial incentives, to subcontract in a manner that—to the maximum extent possible—promotes regional diversification.
- *Establishment of a Northern New Mexico Procurement Advisory Council.* The council is composed of representatives from Española, Santa Fe, the Eight Northern Indian Pueblo Council, and Los Alamos. The council is consulted in connection with major decisions regarding the implementation and changes to the northern New Mexico procurement preference program.
- *Implementation of a northern New Mexico procurement preference program in the counties of Rio Arriba, Santa Fe, Taos, Los Alamos, Mora, San Miguel, and Sandoval, as well as the Pueblos located in these counties.* The preference program applies to all acquisitions of commercial items costing $5 million or less. Acquisitions are reserved for participation among northern New Mexico concerns when there is a reasonable expectation of obtaining the best value for the Laboratory, considering such factors as pricing, quality, and delivery terms.
- *Business Alliance Committee.* The purpose of this alliance is to increase business opportunities for local suppliers in order to meet the Laboratory's procurement and outsourcing requirements. In addition, the alliance promotes partnering among its members, provides training and services to enhance member business skills, and collaborates with local economic development agencies and chambers of commerce.
- *Multiyear subcontracts.* When appropriate, the Laboratory awards subcontracts with multiple-year terms to create more stable business relationships with regional suppliers and to make capital more available from commercial sources.
- *Outreach/training programs.* The Laboratory conducts or sponsors outreach activities for networking purposes. These activities include expositions, the Procurement Fair, the Information Fair, and Meet the Buyer sessions.
- *Small Business Database.* The database includes information on 4,000 New Mexico suppliers, including 425 from northern New Mexico. It also provides companies with information on how to do business with Los Alamos.

- *Northern New Mexico assessments.* The Small Business Office partners with the Laboratory's Environment, Safety, and Health Division and the nonprofit Industry Network Corporation to perform competitiveness reviews, at no cost, for small businesses. These reviews help the companies identify strengths and weaknesses.
- *Subcontractor transition.* The Laboratory requires that in the event of a change in on-site subcontractors, the subcontractor is required to transition the existing workforce.
- *Subcontracting for research at New Mexico colleges and universities.* The Laboratory has established blanket agreements with several New Mexico colleges and universities for research efforts to support Laboratory programs.
- *Outreach Centers in Española, Santa Fe, and Los Alamos.* Business coordinators from the Laboratory take turns staffing the outreach centers. The coordinators are available to discuss procurement opportunities or any other concerns.
- *Mentor/Protégé Program: "Adopt a Vendor."* The purpose of the program is to mentor regional vendors to enable them to compete effectively for Laboratory contracts and obtain assistance with the development of business systems (for example, procurement, marketing, business development, finance and accounting, and safety).
- *On-site tours of northern New Mexico small businesses.* These tours identify products or services offered by northern New Mexico small businesses for use at the Laboratory.
- *Information sessions on Laboratory programs.* Project leaders and purchasing staff occasionally conduct Info Fairs to provide the small business community with an understanding of current and future projects at the Laboratory, anticipated procurement expenditures, and identification of goods required.
- *Other initiatives.* Our other initiatives include the 8(a) program, live radio talk shows, a toll-free telephone number, and working relationships with the chambers of commerce in Española and Los Alamos.

e. Property Management

The Laboratory has a personal Property Management program that provides good asset management for supporting government and Laboratory property goals, while fully complying with laws and regulations. The program coordinates and oversees the implementation of property policies and procedures to ensure maximum, economical, and safe use, as well as control, of government property. Property management professionals upgrade their knowledge and skills through training, networking, and membership in professional organizations. They continue to lead, and participate on, teams that partner with Laboratory organizations, DOE contractors, and DOE offices and headquarters.

To lower the costs of meeting DOE property management requirements, the Property Management Team

- will be using the new DOE-approved threshold of $1,000 (changed from $300) for attractive items, which could result in a cost reduction of $200,000;
- is using statistical sampling instead of the wall-to-wall inventory process, thereby streamlining the process and minimizing customer involvement;
- has implemented the new billing system for fleet management that will be used by all agencies in the General Services Administration; and
- has implemented a successful property customs program in high-risk importing/exporting arena that is being adopted by other laboratories.

DOE and the Laboratory, in partnership, continue their efforts to identify and implement process improvements to the Laboratory's property management system—to make it the best. The Laboratory intends to sustain its excellent Property Management Program while implementing better, less costly processes in response to the needs of internal and external customers.

f. Materials Management

Materials management encompasses a variety of functions, including receiving, warehousing, and distribution operations, a customer service center, a laundry operation, a liquid- and compressed-gas facility, a transportation and shipping operation, mail services, and a host of additional logistics-related activities. Recent activities that provide continuing improvement include the following:

- We implemented a classified delivery team that specializes in processing and delivering classified documents and shipments.
- The Laboratory's mailroom was transferred to BUS Division. Coordination of similar functions has given us more flexibility in workload assignments
- The Customer Service Center coordinated enhancements to Web-based functions for the just-in-time catalog and material ordering. The center also initiated on-line reporting of purchasing activities in the Data Warehouse to streamline the process.
- We improved receiving and distribution performance. More than 97% of all incoming packages are delivered the same day they are received.
- We implemented the Hazardous Materials Shipper Authorization Program.
- Working in conjunction with DOE and the Laboratory's transportation organization, we coordinated the definition of the Laboratory's transportation safety standards and are currently implementing them.

g. University of California Performance-Based Management

The Business Operations portion of the Appendix F requirements, which are implemented by various functional managers, include approximately 50 different performance measures that are assessed each year. Last year, BUS Division continued to demonstrate successful performance by achieving excellence in the areas of finance, procurement, and property. Table 19 shows the performance measurement results for FY93 to FY97. The improvement processes and enhancements discussed previously lead us to expect continued improvement in the future.

h. Continuous Quality Improvement (CQI) and Cost Reduction Initiatives

BUS Division uses total quality management combined with continuous quality improvement (CQI) as the foundation for business performance. The past year was one of excellent achievements and performance for BUS Division, reflecting across-the-board improvement in our business. Last year's CQI efforts in BUS Division led to several initiatives:

- development of the resource planning module;
- improvement of the space-recharge system;
- control self-assessments to meet Appendix F requirements;
- a cost correction team to revise related policies;
- an integration team to enhance communications among various business functional groups;
- an indirect process improvement team to streamline the indirect budget formulation process;
- a division-wide property improvement team;
- a fleet team to implement the new billing system; and
- a mailroom process improvement team.

These CQI initiatives and many others have resulted in cycle time reduction and cost savings. We will continue to improve on the processes for managing Laboratory by including the risk/benefit assessment process. This reengineering effort aims to (1) achieve greater efficiencies at lower costs for functions performed within the Laboratory or (2) to outsource functions when comparable or better services are less costly in the commercial sector.

Table 19. Appendix F Performance Measures for BUS Division (DOE Scores).

	FY93	FY94	FY95	FY96	FY97
Financial Management	69.0	74.3	80.0	86.0	88.0
Procurement	80.0	83.0	88.7	96.0	92.0
Property Management	45.0	73.0	87.4	95.4	90.0

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3. Community Involvement and Outreach

The Laboratory shares more than 50 years of history with the people of northern New Mexico. It recognizes that a decline in public trust resulting from poor performance and communication will lead to the inability to conduct our national mission and will adversely impact the economic well-being of northern New Mexico. Recently, the importance of community relations and customer/stakeholder relationships were identified as strategic goals by the new Laboratory Director, John Browne. Two of his goals state that in 2 years, "communities should value and visibly support Laboratory outreach activities," and that "our customers and stakeholders are educated and informed about the Laboratory." In addition, the Laboratory's recently renewed contract with the University of California (UC) contains specific requirements in the area of community relations. In particular, the contract includes a "special provisions" clause, which requires that the Laboratory meet, within 2 years, a set of performance objectives in the area of community relations. The Community Involvement and Outreach (CIO) Office has a major responsibility in ensuring that the Director's strategic goals and the UC contract requirements are fulfilled.

The Laboratory has established the CIO Office to ensure that the Laboratory is seen as a good corporate citizen by the communities of north-central New Mexico.

The vision of CIO is as follows: *By the year 2000 Los Alamos National Laboratory will be valued as a respectable and responsible corporate neighbor in northern New Mexico.*

The mission of this organization is the following: *To clearly understand the needs of the communities of north-central New Mexico and to implement programs and initiatives that are mutually beneficial to the Laboratory and these communities.* CIO is also responsible for chairing the Laboratory's Outreach Coordination Council, a group of individuals representing all the Laboratory's outreach organizations. This council ensures that the Laboratory's community outreach activities are coordinated and that its resources are leveraged.

To help CIO and the other Laboratory research organizations understand and be able to respond to the needs of these communities, CIO conducts surveys of the relevant communities to clearly understand their needs, manages a variety of initiatives designed to satisfy these prioritized community needs, and communicates information about the Laboratory's programs. The four critical community needs are as follows:

- *Need #1—Education.* Workforce development, mentors/tutors, and K–12 and postsecondary education.
- *Need #2—Economic Development.* Business creation/retention, recruitment, expansion, infrastructure, and jobs.
- *Need #3—Community Development.* Corporate giving, mentoring, and civic activity.
- *Need #4—Communications.* Environment, Laboratory mission, programs, plans, and issues management.

A list of programs that support these needs are described in detail in the program matrix (see Table 20). The following Laboratory outreach organizations also support these identified needs:

- The Civilian and Industrial Program Office works on regional economic development projects (see Regional Economic Development in Section II.C.3. Civilian and Industrial Technology Programs).
- The Business Operations Division has initiatives in place to maximize the procurement opportunities available in the local northern communities. In addition, major subcontractors to the Laboratory are required as part of their contracts to participate in economic development initiatives (see Procurement Opportunities in Section III.B.2. Business Operations).
- Science Education Programs focus on education projects that enhance science, mathematics, engineering, and technology learning (see Section II.D.1. Laboratory Plan for Education Support in Section II.D.1. Science and Mathematics Education).
- The Public Affairs Office is responsible for communications with the local media (see Section III.B.4. Public Affairs).

In 1997, the Laboratory established a nonprofit foundation to promote and fund a broad range of educational and public-service activities in northern New Mexico and to invest in the communities where Laboratory and corporate partner employees work and reside. To date, more than $1.8 million has been allocated to educational and community institutions.

CIO's formal objectives for 1998 and the program matrix are as follows:

- *Objective 1: Community and Tribal Needs Assessment.* Systematically identify community and tribal needs and concerns and assure institutional understanding of them.
- *Objective 2: Community and Tribal Needs Satisfaction.* Based on community/tribal needs assessment, develop, implement, and manage initiatives and programs (based on community/tribal needs assessment) designed to satisfy identified and prioritized community/tribal needs.
- *Objective 3: Public Involvement.* Engage the public through education and dialogue about the Laboratory's purpose, programs, and directions.
- *Program Matrix.* CIO has a variety of programs in place to help support our objectives and community needs (see Table 20 for a matrix of CIO programs). These programs are long-term efforts that help strengthen relationships and build trust with our community stakeholders.

Table 20. CIO Programs.

Program	Purpose	Community Need	CIO Objective
Annual Surveys	CIO surveys key customers/clients in order to gain a better understanding of regional issues and to design more effective community outreach programs.	- Communications	#1: Needs assessment
Bradbury Science Museum	A Laboratory facility with regional, national, and international audiences which provides programs and exhibits on Laboratory history, programs, and mission.	- Education - Communications	#2: Needs Satisfaction #3: Public Involvement
CIO Annual Report	CIO reports successes specific to each program within CIO in a format that documents results and value to both the community and the institution.	- Communications	#2: Needs Satisfaction #3: Public Involvement
Community Giving Clearinghouse Program	CIO will develop and lead an institutionally coordinated corporate-giving and membership support process in partnership with OCC member organizations, the Laboratory Foundation, and targeted employee action groups.	- Education - Community Development	#2: Needs Satisfaction
Community Outreach Managers (COMs)	COMs are responsible for specific community customer segments. They are tasked with building and fostering positive relationships with groups and individuals both public and private; understanding community needs; delivering appropriate Laboratory resources; and ensuring Laboratory responsiveness and accountability regarding community needs and the range of issues of community concern.	- Education - Economic Development - Community Development - Communications	#1: Needs Assessment #2: Needs Satisfaction #3: Public Involvement
Community Reading Room	The Laboratory Community Reading Room is maintained in order to provide public access to Laboratory/Department of Energy documents and Internet sites, with a general focus on environmental documentation and institutional plans.	- Communications	#1: Needs Assessment #2: Needs Satisfaction #3: Public Involvement
DOE/Laboratory Annual Report	CIO develops and distributes an institutional report on the Laboratory's regional investments in the communities.	- Communications	#1: Needs Assessment #2: Needs Satisfaction #3: Public Involvement
Laboratory Foundation—Alternate Employee-Giving Campaign	CIO will establish and institutionalize a program that cultivates Laboratory employee support of the Laboratory Foundation.	- Education - Community Development	#2: Needs Satisfaction

Table 20. CIO Programs. (Continued)

Holiday Drive	CIO manages and promotes an annual drive for employees to donate food, clothing, blankets, and toys for distribution to the less fortunate in northern New Mexico.	- Community Development	#2: Needs Satisfaction
Issues Management	CIO provides opportunities for citizens, elected officials, Native American tribal governments, and other interested parties to engage in dialogue about Laboratory and community issues and to be responsive to concerns.	- Communications	#1: Needs Assessment #2: Needs Satisfaction #3: Public Involvement
Outreach Coordination Council	CIO chairs this Council, which is set up to ensure coordination and resource optimization of all Laboratory outreach activities.	- Communications	#1: Needs Assessment #2: Needs Satisfaction
Outreach Events Calendar	CIO compiles, maintains, and disseminates information regarding regional community and tribal events that the Laboratory is engaged in or that the community has identified as significant.	- Communications	#1: Needs Assessment
Queries	CIO provides appropriate answers to people who call or write the Laboratory/CIO with queries. Often, literature searches or contact with subject matter experts is required.	- Communications	#1: Needs Assessment #2: Needs Satisfaction #3: Public Involvement
Speakers Bureau	COMs arrange for Laboratory scientists and employees to speak on a broad range of issues at educational institutions, businesses, and community-based organizations in northern New Mexico.	- Communications	#2: Needs Satisfaction #3: Public Involvement
Technical and Professional Assistance	CIO is establishing a program that provides regional businesses, institutions, and communities with access to Laboratory expertise.	- Education - Economic Development - Community Development	#2: Needs Satisfaction
Tours	COMs and Tribal Relations Managers will coordinate tours of specific Laboratory sites and facilities for northern New Mexico stakeholders.	- Communications	#2: Needs Satisfaction #3: Public Involvement
Tribal Relations Managers (TRMs)	TRMs are responsible for developing, maintaining, and strengthening cooperative relationships between the Laboratory, the University of California, and the tribes through resolution of issues and implementation of educational, economic-development, and other mutually beneficial initiatives.	- Education - Economic Development - Community Development - Communications	#1: Needs Assessment #2: Needs Satisfaction #3: Public Involvement
United Way Campaign	CIO manages the Laboratory's annual Los Alamos/northern New Mexico United Way campaign.	- Community Development	#2: Needs Satisfaction
Volunteer Program	CIO will document employee involvement in the community and will establish a Laboratory volunteer program that provides opportunities for employees to become engaged in community-related and education-related activities.	- Community Development	#2: Needs Satisfaction

4. Public Affairs

Public communication at the Laboratory is directed through the Public Affairs Office. Public Affairs programs include strategic communication planning, media relations, employee communications and special projects that include radio outreach and producing publications for both internal and external customers. Public Affairs also directs the Laboratory's conference and visitor management program.

This year, Public Affairs has taken an aggressive approach to communicating the Laboratory's progress with the special provisions in the contract between the University of California and DOE for managing the Laboratory and to helping educate internal and external audiences about the institution's efforts in meeting and exceeding these requirements.

Among these Public Affairs efforts is the production, in conjunction with the Community Involvement & Outreach Office, of a new publication called *Partners*. *Partners* reports on Laboratory outreach activities in northern New Mexico. It is distributed to key external audiences and is available on-line to Laboratory employees. Public Affairs also reports on and assists in planning other corporate citizenship activities that are required under the new contract.

Public Affairs operates an Integrated Safety Management Communications Program to ensure a deep, crosscutting understanding of environmental safety and health issues throughout the Laboratory. This initiative is part of the Integrated Safety Management special provision. Public Affairs also keeps internal and external audiences abreast of news on environmental management and environmental restoration programs.

In addition, this office supports the Laboratory's science and technology programs through strategic communication programs, including media outreach and employee education initiatives.

5. Information Management

Information Management at Los Alamos includes computing resources and software for both telecommunications and for scientific and administrative functions; printing, library services, photography, and writing and editing; and records management and document control. The goal of Information Management is to provide 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.

a. Managing the Year 2000 Risk at the Laboratory

The Laboratory's Computing, Information, and Communications (CIC) Division and the Information Architecture (IA) project are coordinating many Laboratory initiatives to ensure readiness for the Year 2000. The Year 2000 problem affects computer software that uses two-digit years ("98") instead of four-digit years ("1998"), which can lead to problems ranging from missorting to outright systems failures. Such software can mistakenly think that 2 years from now is in the past instead of the future since "00" is smaller than "98."

Given the Laboratory's high level of automation, it is important to ensure that potential vulnerabilities are recognized and prioritized. We are working on identifying the problems and, once the problems have been identified, applying a process for solving those problems, as described in this section.

Identifying Problems

Los Alamos identified four DOE mission-essential automated systems in the summer of 1997. A Laboratory-wide Year 2000 Council performed an inventory to determine additional Laboratory-critical systems. Both the mission-essential and Laboratory-critical systems are included in the planning effort, and plans are updated monthly or more frequently as events require.

The four systems essential to the DOE's mission are the Secure Integrated Computing Network (Secure ICN), the Basic Rapid Alarm Security System (BRASS), the Nuclear Material Accountability and Safeguards System (MASS), and computer-assisted retrieval at Los Alamos (CARLA). The Secure ICN consists of the supercomputers, networks, print services (the Print and Graphics Express Station), and storage services used by the weapons designers and code-development teams at the Laboratory. The Secure ICN relies primarily on vendor-supplied operating systems and tools for renovation although additional tools that have been developed by CIC Division staff supplement the vendor systems. BRASS controls the badge and palm reader systems that grant access to Los Alamos facilities, and MASS accounts for the nuclear material inventory and controls all shipments of these materials into, out of, and within the Laboratory. BRASS and MASS are being repaired to solve the Year 2000 problem. CARLA contains an index of all classified documents. The CARLA system is planned for implementation in June 1998 and uses new technology to replace the existing VAX system. Thus, part of the planning and implementation effort for CARLA includes addressing the Year 2000 issue before it becomes a problem.

The Laboratory-critical systems are identified by the Year 2000 Council, which includes a representative from each major division and program office. The Year 2000 Council reports to the CIC-Division Director and is chaired by the IA project leader. To identify Laboratory-critical systems, the Year 2000 Council coordinates an inventory and assessment for each organization and, based on that assessment, generates the list of Laboratory-critical Year 2000 systems. The assessment starts with a list of all Laboratory systems. Each system is evaluated for Year 2000 vulnerability and Laboratory criticality (critical, important, or noncritical). Since Year 2000 issues continue to surface, this comprehensive list provides a way to continually reassess existing systems for newly discovered vulnerabilities. The cost associated with Year 2000 activities is also identified by the council. The readiness of any system identified as Laboratory-critical is then tracked using a consistent set of milestones for planning, test planning, repair, validation, implementation, and contingency planning.

The Year 2000 Council also shares information and raises awareness as part of the IA Year 2000 campaign. The IA project has developed a Year 2000 Web site, which includes links to many Year 2000 sites of software and hardware companies and government agencies so that the latest status and requirements can be obtained easily. The site facilitates access to the Year 2000 assessment database as well as to an information-sharing area. The address of the Year 2000 IA site is http://www.lanl.gov/projects/ia/year2000/. The Year 2000 effort is a critical focus area for the IA for the next few years.

Applying a Learned Approach to Solutions

A systematic process has been established for solving problems once they are identified. The four steps are described in this section.

Step 1. A Risk-Based Approach

IA is advising both the Laboratory and DOE that the Year 2000 issue be addressed using a risk-based approach so that when the Year 2000 comes, all critical and important systems will be completely operational. This approach ensures that systems bearing the most risk are managed and tracked accordingly. A critical system is one in which

- a disruption in the system can result in the inability to perform a software program;
- death, major illness, or injury may be caused by the failure of safety or containment functions;
- a major security concern is raised;
- irreversible or major environmental damage may occur; or
- significant loss of property or property damage may occur.

As part of this step, we are working to ensure that we do not miss a critical system in our evaluation or implementation.

Step 2. Phases and Iteration

The five recommended Year 2000 phases are assessment, planning, renovation, validation, and implementation. These efforts will not be done just once but will become iterative phases as more issues and information surface. Testing particular systems with unique combinations of hardware, operating systems, commercial off-the-shelf software, and custom software is a learning loop. Year 2000 status is dynamic and, therefore, changes as we learn more and the vendors learn more. These changes will sometimes require us to iterate back to prior steps and reevaluate our position.

Step 3. Year 2000 Layers

Components and tools used by the application systems prove to be a good way to frame the approach to the Year 2000 issue. Making sure that all these "layers" work independently and as a unit is the goal. Until all the layers are fully Year 2000-ready, one cannot be certain that the application will correctly function in the next century. One must also ensure that the various off-the-shelf software products and custom software work in tandem. The component and tool layers are listed here and are shown graphically in Figure 27.

- The bottom layer is hardware—the chip itself.
- The next layer is the operating system (OS). The OS is the main control program for the computer.
- The middle layer is off-the-shelf software purchased from software companies.
- The fourth layer is software developed at the Laboratory.
- The top layer is data exchange.

Step 4. Share Solutions to Common Problems

As the Laboratory progresses to the Year 2000, we find that we have common problems. An example is that all PCs need the hardware checked to ensure that the date will function correctly.

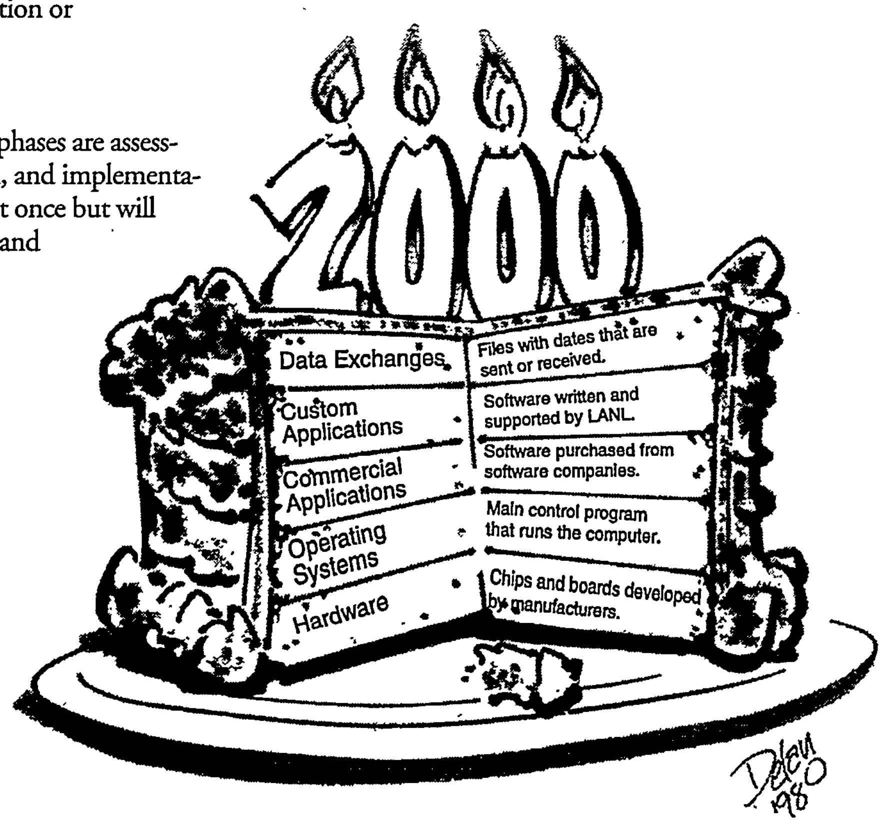


Figure 27. We must ensure the component and tool "layers" used by the application systems are Year 2000-ready.

Helping the Desktop Computer User

While Macintosh hardware is Year 2000 ready, that is not necessarily true for even newer models of the thousands of PCs used at the Laboratory. IA and members from the IA Desktop Support Team are working together to evaluate and standardize a Year 2000 testing tool for PCs. We use the normal procurement and distribution channels to distribute the tool, while members of the Year 2000 Council help people in their organizations use the tool. Users can also link to manufacturers' Year 2000 product compliance information through the IA Year 2000 Web site. IA also tracks and maintains links to current status and fixes for Macintosh, PC, and Unix software. With the help of their Year 2000 Council representative, each group or division decides how its Year 2000 fixes will be accomplished. The solutions may include replacing systems and software or installing patches and upgrade packages.

More information about this effort is available at the following Web site: http://www.lanl.gov/projects/ia/year2000/.

b. Information and Records Management Program

CIC Division has embarked on two major projects, described in this section, that will provide the basis for a Laboratory-wide Information and Records Management (IRM) program. These two projects provide opportunities for fulfilling the IRM program's institutional charter for the development, implementation, and approval of all information and records management programs at Los Alamos. More importantly, these projects will enable the Laboratory to

- identify, manage, and preserve past and current information in support of its programmatic, business, and legal operations and requirements;
- archive its nuclear weapons information;
- prevent the loss of its corporate memory;
- protect its vital records; and
- preserve its role in the nation's history.

Records Inventory Project

The Records Inventory (RI) project team has been chartered to work with the Laboratory's divisions and program offices to review and analyze their official records holdings. The RI project will serve as the foundation piece for the development of a consistent, Laboratory-wide IRM program. The three phases of the RI plan are shown in Figure 28.

The first phase will include the initial inventory of the Laboratory's records and the development of a retention schedule for Laboratory-specific records. The second phase will be implementation of an ongoing IRM program in each program and division. The third phase will result in a Lab-wide integration model to ensure that the Laboratory's official records can be readily identified, managed, and accessed, regardless of their location. Because of the vast record holdings of the Laboratory, the RI project plan schedule spans 5 fiscal years, FY98 through FY02.

Knowledge Management System Project

The Laboratory and Xerox Corporation signed a letter of intent in December 1997 to work cooperatively to develop a knowledge management system capable of efficient capture, storage, and retrieval of weapons and production information essential to the Laboratory's Science-Based Stockpile Stewardship mission.

The project will take a phased approach, beginning with the development of a system to handle legacy data for use in stockpile assurance. That step would be followed by the development of systems that ensure that transitional knowledge is maintained across generations of weapons scientists. The design and implementation of this project is expected to take 3 to 5 years. Some attributes of the system will include the following:

- more efficient records management through systematic indexing and storage;
- a digitized library of historical information;
- on-line access of records, documents, and drawings;
- linkages to other Laboratory and weapons complex information systems; and
- development of cognitive learning technology for transfer of knowledge from current to future generations of weapons scientists and engineers.

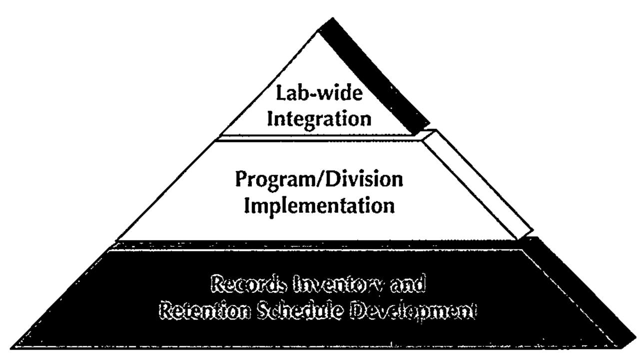


Figure 28. Three phases of the Records Inventory project plan.

The IRM program's Central Weapons/Production Information Center (CWIC) will serve as the central organization for the development and use of the system. CWIC is responsible for the management of over 24 million pages of documents, including more than 1 million aperture cards, 3 million radiographs, and other records on various media types. The project will eventually expand to cover weapons records in various divisions of the Laboratory.

During this first year of the partnership, many of the foundation pieces of the project are being developed, such as a requirements document and a project and schedule plan, which includes task descriptions and deliverables. A funding model, approved by the Laboratory's major programs, will determine the short- and long-term scope of the project.

c. Going Electronic

The Los Alamos Research Library has set its sights on two goals that support DOE's objective of building an information bridge to the world. These two goals are (1) delivering digital information to the desktop and (2) creating a network of knowledge systems that helps researchers collaborate. The library calls this effort the Library Without Walls Project.

To date, more than 1,000 electronic journals are available on-line through the library's Web page at http://lib-www.lanl.gov/cgi-bin/cwelcome_c.cgi. This is triple the number available last year. This year, the library has partnered with many publishers, including Elsevier Science and Academic Press, to link more than 600,000 journal articles to citation databases in Biosis®, the DOE Energy database, INSPEC®, and SciSearch®. Through contractual agreements, the library is granted the right to use these databases for noncommercial purposes.

In addition to using databases, a researcher or member of the public can find and access electronically from the library's Web page the entire collection of 13,000 formal, unclassified Los Alamos technical reports from 1943 to the present.

In addition to making the Laboratory's own collection of reports available electronically, the library recently has added three new items to its repertoire of more than 40 databases. INSPEC is the world's largest and most comprehensive English-language database for physics, electronics, and computing. GeoRef was established by the American Geological Institute and is the most comprehensive geoscience database with more than 1.8 million references to articles, books, maps, conference reports, reports, and theses. The MATH database covers 1931 to the present and includes both theoretical and applied mathematics. These resources are available from the Library's home page.

The library also partners with vendors and suppliers such as the Academic Press, Geac Computers, Elsevier Science, and HighWire Press to integrate sources of digital information. Through cooperative agreements, researchers at Stanford University, the University of New Mexico, Sandia and Lawrence Livermore national laboratories, the Air Force Research Laboratory, New Mexico State University, and the New Mexico Institute of Mining and Technology have access to the same electronic resources as Los Alamos researchers.

d. Remote Electronic Desktop Integration Project

Desktop computers are increasingly vital to business success worldwide. As software becomes more complex and updates are more frequent, the cost of owning desktop computers grows. Enterprises large and small adopt measures to manage the cost of owning and maintaining growing systems at a reasonable cost. Studies show the cost of owning a desktop computer averages $8,300 per year over a 5-year period. End-user down time and self-maintenance accounts for $4,570, and technical support and maintenance accounts for another $1,410. Procurement/property management tasks and hardware/software costs each claim an additional $1,160.

Through the Remote Electronic Desktop Integration (REDI) Project, the Laboratory embraces the challenge to reduce the cost of owning computers through two initiatives. The first initiative, Electronic Software Distribution (ESD), provides easy access to software: users can purchase and install new software and upgrades from the web directly onto their computers. ESD is the Laboratory's "warehouse" for Lab-wide software distribution. Currently, ESD has over 170 products available. By offering software electronically, ESD ensures the following:

- discount prices provided by the Laboratory's volume purchase agreements,
- immediate delivery, and
- validation of the right (the license) to use the software without having to store boxes and disks.

Systems administrators can increase productivity by using the ESD License Utility, a service through which users transfer, upgrade, download, and return licenses.

 The License Utility also maintains software accountability records by generating a list of all licenses purchased through ESD.

During FY97, the first year of full deployment, ESD realized a $4 million savings by buying software in bulk and delivering it electronically. In addition, the cost per system for technicians to maintain a computer decreased from $1,670 to $1,250. ESD is increasing productivity and decreasing support costs while moving the Laboratory toward an electronic environment.

REDI's second initiative is to move to an enterprise solution for managing Laboratory desktop computers using Microsoft's Software Management Systems (SMS). SMS provides a comprehensive solution for centrally managing personal computers on a network. SMS tools are installed on a desktop computer or server to do the following:

- automatically collect hardware and software inventories;
- automatically distribute/install software to the desktop/server according to customer requirements; and
- aid technicians with remote troubleshooting and user assistance without making a site visit.

SMS enables network administrators to detect every computer on the network, to inventory software and hardware configurations, and to access this information from a central database. SMS is currently in development—three prototype pilots were conducted during FY97, and deployments pilots are underway in FY98.

Advanced systems-management tools such as ESD and SMS can simplify software management by automating routine tasks and increasing productivity.

6. Audits and Assessments

The Audits and Assessments Office (AA) provides an independent review capability for the Laboratory Senior Executive Team. As such, AA is a key element in the management of the Laboratory. The AA mission is to provide managers with reasonable assurance through audits, assessments, and evaluations that Laboratory operations and business practices are continuously improving, which results in legal and contractual compliance and ever-improving effectiveness and efficiency of operations.

AA provides the following services as part of the system of controls at the Laboratory:

- internal audits that assess the economy, efficiency, effectiveness, and financial integrity of Laboratory programs;
- internal assessments that independently evaluate the Laboratory's performance in the areas of environment, safety, quality assurance, maintenance, security, and facility management;
- evaluations of allegations of fraud, waste, abuse, and mismanagement;
- management of the Whistleblower program for the Laboratory;
- liaison with external auditors, assessors, reviewers, and regulators; and
- contract audits of subcontractor proposals and claims.

a. Strengthening the Control Systems at the Laboratory

The Audits and Assessments Office has several initiatives underway to strengthen the control systems at the Laboratory and to improve the Laboratory's ability to understand and communicate the status of its operations.

Performance Assurance

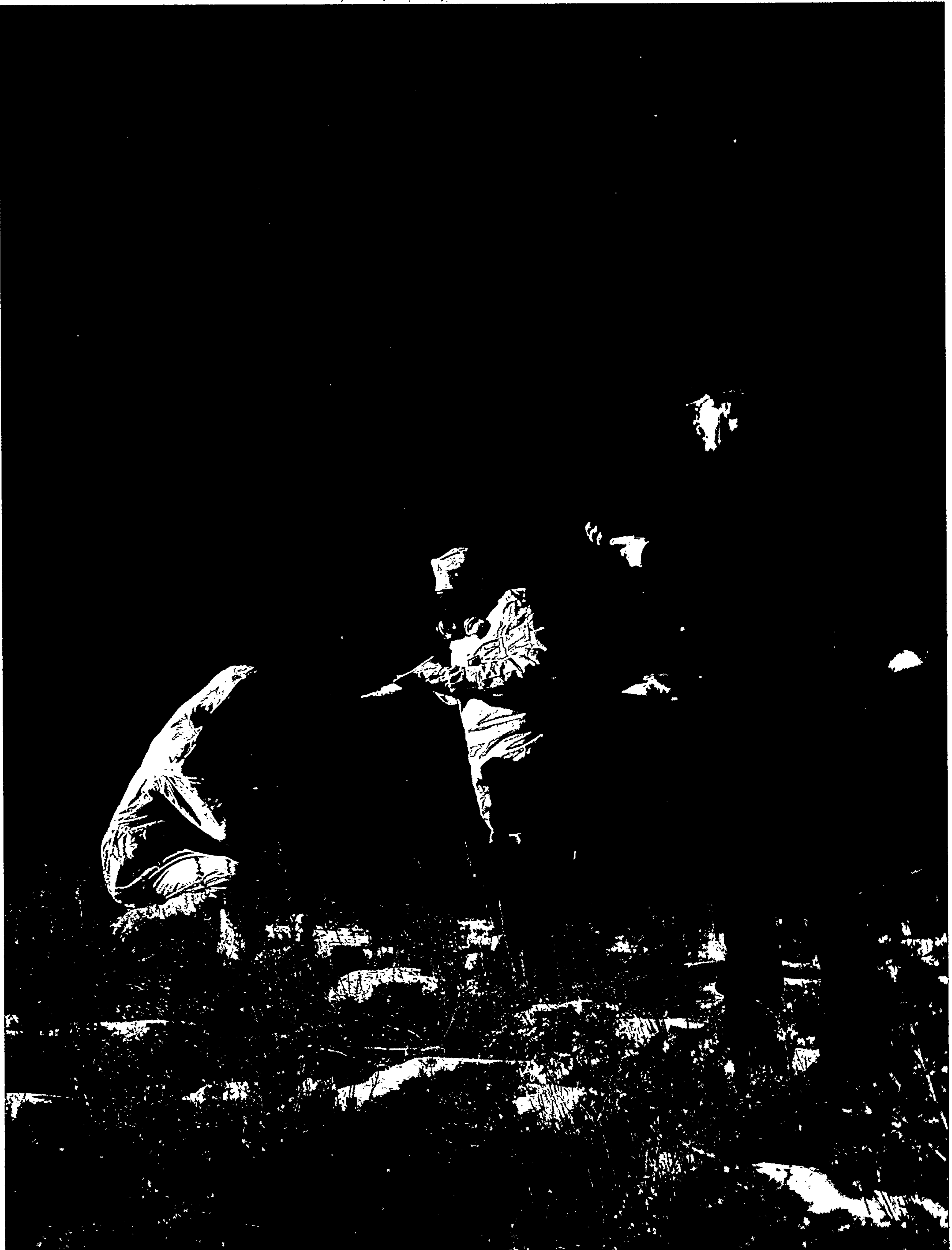
Managers, supervisors and workers need to continuously evaluate and improve their work activities to ensure that work is performed safely, securely, reliably, and cost effectively. The Laboratory's performance assurance program is designed to meet that requirement through a combination of independent internal assessments and self-assessments by both line and functional managers. The combination of these three processes helps ensure that trends in performance are identified, analyzed, and used to establish performance measures and goals; root causes of problems are identified; process improvements and corrective actions are planned, implemented, and evaluated for effectiveness; unsafe events and conditions are immediately corrected or work is stopped; and lessons from operational experience within and outside the Laboratory are developed and communicated for use in work planning and performance.

A key element of the effectiveness of the performance assurance program is the management walkaround program, which is designed to assure that the hazards associated with Laboratory work are understood and controlled by those supervising and performing the work. During walkarounds in their work areas, managers and supervisors communicate their safety expectations to workers, assess compliance with those expectations, and take appropriate actions to improve operations

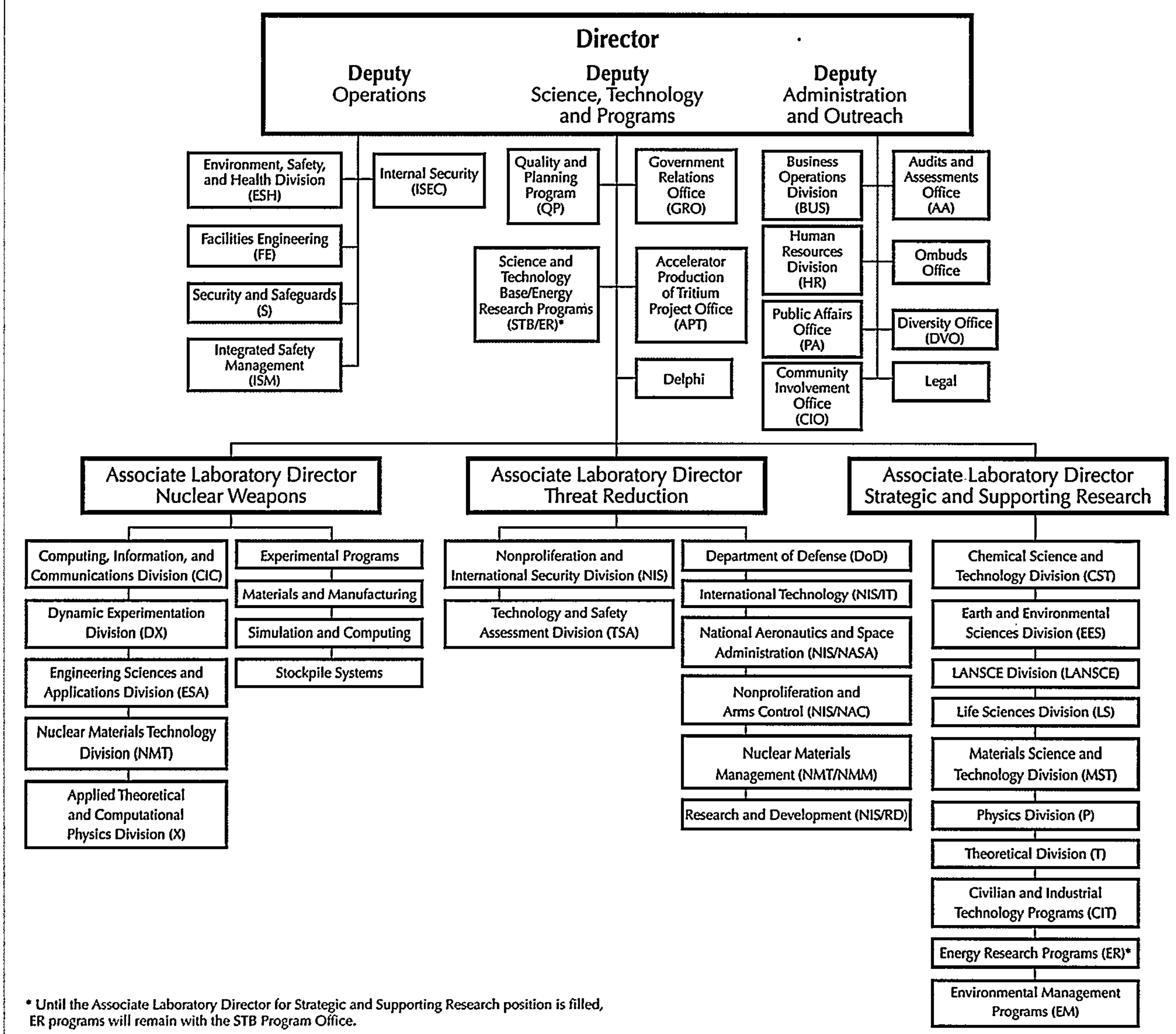
Control and Risk Self-Assessment

The Audits and Assessments office is spearheading the deployment of improved processes for control and risk self-assessment in the Laboratory. Control and risk self-assessment is a team-driven business process used by organizations to define business or quality objectives, construct a clear picture of where they are relative to what they want to achieve, and improve the quality of all business processes. The process helps managers focus on countering major threats to the achievement of institutional and organizational objectives and reinforces managers' accountability for designing, revising, and maintaining controls at all levels of their organizations.

IV. APPENDIX



A. ORGANIZATIONAL CHART



* Until the Associate Laboratory Director for Strategic and Supporting Research position is filled, ER programs will remain with the STB Program Office.

B. CONSTRUCTION TABLE

1. Funded and Proposed Line-Item Construction Projects

Table 21 summarizes funded, budgeted, and proposed line-item construction projects for FY98 to FY04. This list is based on FY00 budget submissions and the most current 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, there is one or more of the following drivers: Health and Safety; Environmental; Security and Safeguards; and/or Mission/ Investment.

General Plant Projects are not displayed because of the volatility of their funding and the large number of projects.

Projects labeled 1998 and before are funded. Projects labeled 1999 and 2000 are budgeted. Projects labeled 2001 and beyond are proposed.

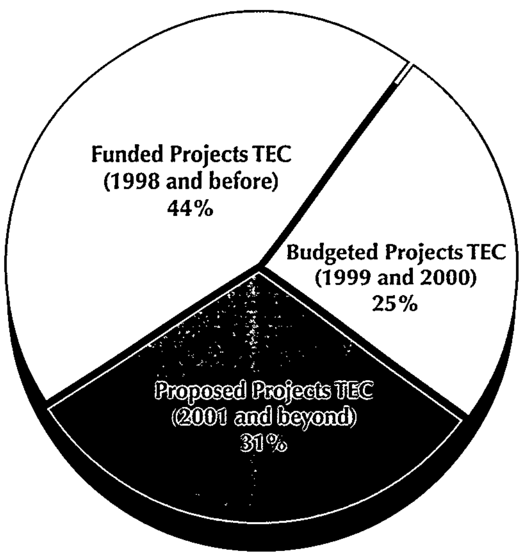
Table 21. Funded and Proposed Line-Item Project Construction ($M).

Project	Total Estimated Cost	Prior Years	1998	1999	2000	2001	2002	2003	2004	2005 Plus
DARHT Facility, 1988	259.7	81.4	46.3	36.0	61.0	35.0				
Chemistry and Metallurgy Research Building Upgrades, 1995	166.9	60.5	5.0	16.0	20.0	20.5	17.4	15.8	11.7	
Water Well Replacement, G1 Thru G4, 1996	16.8	11.2	4.5	1.1						
Atlas, 1996	43.3	23.5	13.4	6.4						
Fire Protection Improvements, 1996	17.0	6.6	5.5	4.9						
Nuclear Materials Storage Facility Renovation, 1997	45.3	4.0	9.2	9.2	18.2	4.7				
Isotope Production Facility, 1999	13.4			6.0	7.4					
Central Health Physics Calibration Facility, 1999	4.0			4.0						
Nuclear Materials Safeguards and Security Upgrade Project, 1999	60.7			9.7	14.3	15.0	11.8	9.9		
Strategic Computing Complex, 1999	100.0			14.0	53.0	33.0				
Radioactive Liquid Waste Treatment Facility, 2000	25.0				6.0	12.0	7.0			
Low-Level-Waste Volume Reduction Facility, 2000	3.5				1.0	2.5				
Electrical Infrastructure/Safety Upgrades, 2000	39.7				1.0	6.0	7.8	8.0	8.3	8.6
Nonproliferation and International Security Center, 2000	59.7				6.0	12.0	24.0	17.7		
Capability Maintenance and Improvements, 2001	243.4					13.0	35.0	35.0	35.0	125.4
Tritium Consolidation, 2001	25.0					10.0	7.0	8.0		
Administration Complex, 2002	55.0						2.0	15.0	22.0	16.0

Table 21. Funded and Proposed Line-Item Project Construction ($M). (Continued)

Project	Total Estimated Cost	Prior Years	1998	1999	2000	2001	2002	2003	2004	2005 Plus
Electrical Reliability Upgrades (3rd Line), 2002	22.0						6.0	8.0	8.0	
Dynamic Experiment Laboratory at LANSCE, 2002	30.0						4.0	10.0	11.0	5.0
Funded (1998 and before)	549.0									
Budgeted (1999 and 2000)	306.0									
Proposed (2001 and beyond)	375.4									
Total	1,230.4									

Figure 29. 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 22 and 23) and breakdown by various Secretarial Officer (Tables 24 and 25) and by major program categories (Budget and Reporting, level 2 [B&R2]) within each Assistant Secretary or office (Tables 26–38). Tables 39 and 40 reflect projected subcontracting and procurement data.

The data reflect the actual funding and full-time equivalents (FTEs) for FY97 and the Laboratory's funding and FTE projections for FY98. The projections for FY99 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–FY04.

For the FY99–FY04 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 FY99–FY04 assume that only some Laboratory proposals and initiatives will be funded.

1. Resource Summaries

Table 22. Laboratory Funding Summary ($M).

Funding ($M)	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
DOE Funding[1]	990.9	1,106.0	1,243.9	1,225.4	1,265.7	1,326.4	1,356.4	1,380.0
Work for Others	114.5	112.1	98.5	97.7	102.7	107.7	114.7	114.7
Subtotal Operating Funding	1,105.4	1,218.1	1,342.4	1,323.1	1,368.4	1,434.1	1,471.1	1,494.7
Program Capital Equipment	71.5	61.8	65.0	57.2	57.6	57.0	57.0	57.0
Program Construction[2]	62.3	79.1	101.0	181.0	157.0	115.0	121.0	89.0
General-Purpose Facilities[2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	10.0	7.1	8.0	8.0	8.0	8.0	8.0	8.0
General-Purpose Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Laboratory Funding	1,249.2	1,366.1	1,516.4	1,569.3	1,591.0	1,614.1	1,657.1	1,648.7

[1]DOE funding includes net of transfers to other DOE contractors.
[2]DOE's policy change requiring full funding of all construction projects before work begins means that estimates of future construction funding are included in the BA estimate.

Table 23. Laboratory Personnel Summary (FTEs).

Personnel (FTEs)	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Direct[1]								
DOE Effort	3,048	3,179	3,145	3,088	3,075	3,088	3,049	2,994
Work for Others	414	392	341	332	347	362	383	383
Subtotal Direct for Program Effort	3,462	3,571	3,486	3,420	3,422	3,450	3,432	3,377
Program Capital Equipment	14	10	13	11	11	11	11	11
Program Construction	109	130	164	285	249	186	194	147
Total Direct	3,585	3,711	3,663	3,716	3,682	3,647	3,637	3,535
Indirect	3,270	3,410	3,410	3,410	3,410	3,410	3,410	3,410
Total Personnel	6,855	7,121	7,073	7,126	7,092	7,057	7,047	6,945

[1]Categorization of direct personnel is optional and need not be provided. If no breakdown of direct is shown, do not include "Total Direct." Indirect personnel may also be categorized at the option of the Laboratory.

2. Resources by Secretarial Officer

Table 24. Funding by Secretarial Officer ($M).

	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Defense Programs								
Operating	564.2	653.7	824.3	770.7	810.1	848.1	868.5	880.6
Capital Equipment	54.9	36.3	51.5	43.2	43.2	43.2	43.2	43.2
Construction	67.7	85.0	102.9	175.8	153.0	99.3	111.0	97.3
Subtotal	686.8	775.0	978.7	989.7	1,006.3	990.6	1,022.7	1,021.1
Energy Efficiency and Renewable Energy								
Operating	13.4	13.5	14.0	15.6	15.6	15.6	15.6	15.6
Capital Equipment	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	13.8	13.5	14.0	15.6	15.6	15.6	15.6	15.6
Environment, Safety, and Health								
Operating	1.0	0.9	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	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Environmental Restoration and Waste Management								
Operating	134.3	150.6	98.1	123.1	125.3	147.2	151.6	157.9
Capital Equipment	4.6	5.9	0.4	0.4	1.0	0.4	0.4	0.4
Construction	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	141.9	157.6	98.5	123.5	126.3	147.6	152.0	158.3
Energy Research								
Operating	71.0	64.7	67.9	72.3	72.3	72.3	72.3	72.3
Capital Equipment	3.3	8.9	9.9	10.5	10.5	10.5	10.5	10.5
Construction	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	75.7	73.7	77.8	82.8	82.8	82.8	82.8	82.8
Fossil Energy								
Operating	4.0	4.6	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	4.0	4.6	6.0	6.0	6.0	6.0	6.0	6.0
Human Resources and Administration								
Operating	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1
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	0.1	0.1	0.1	0.1	0.1	0.1
Fissile Materials Disposition								
Operating	20.8	28.4	36.5	36.5	36.5	36.5	36.5	36.5
Capital Equipment	2.9	2.0	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	23.7	30.4	36.5	36.5	36.5	36.5	36.5	36.5
Nuclear Energy								
Operating	17.4	14.1	14.9	15.6	15.6	15.6	15.6	15.6
Capital Equipment	1.2	4.6	0.5	0.7	0.7	0.7	0.7	0.7
Construction	0.0	0.0	6.0	7.4	0.0	0.0	0.0	0.0
Subtotal	18.6	18.7	21.4	23.7	16.3	16.3	16.3	16.3

Table 24. Funding by Secretarial Officer ($M). (Continued)

	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Nonproliferation and National Security								
Operating	101.4	110.8	114.5	117.8	116.5	117.3	122.5	127.7
Capital Equipment	4.4	4.1	2.7	2.4	2.2	2.2	2.2	2.2
Construction	0.0	0.0	0.0	6.0	12.0	24.0	17.7	0.0
Subtotal	105.8	114.9	117.2	126.2	130.7	143.5	142.4	129.9
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
Chief Financial Officer								
Operating	1.9	2.5	2.6	2.7	2.7	2.7	2.7	2.7
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	1.9	2.5	2.6	2.7	2.7	2.7	2.7	2.7
Miscellaneous DOE Programs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other DOE Facilities	61.5	62.0	65.0	65.0	65.0	65.0	65.0	652.0
Net Reimbursable DOE Work	61.5	62.0	65.0	65.0	65.0	65.0	65.0	652.0
Subtotal DOE Operating[1]	990.9	1,106.0	1,243.9	1,225.4	1,265.7	1,326.4	1,356.4	1,380.0
Work for Others								
NRC	3.1	2.5	1.1	1.1	1.1	1.1	1.1	1.1
DoD	54.3	45.4	37.8	40.0	40.0	40.0	40.0	40.0
HHS/NIH	10.4	10.5	10.5	9.8	9.8	9.8	9.8	9.8
NASA	5.9	6.5	9.5	4.7	4.7	4.7	4.7	4.7
EPA	0.5	1.1	0.5	0.8	0.8	0.8	0.8	0.8
Other Federal Agencies	22.8	27.2	25.1	21.3	21.3	21.3	21.3	21.3
Private Industry	15.7	16.0	12.0	18.0	23.0	28.0	35.0	35.0
All Other Nonfederal	1.8	2.9	2.0	2.0	2.0	2.0	2.0	2.0
Subtotal Work for Others	114.5	112.1	98.5	97.7	102.7	107.7	114.7	114.7
Total Program Funding	1,105.4	1,218.1	1,342.4	1,323.1	1,368.4	1,434.1	1,471.1	1,494.7
Program Capital Equipment	71.5	61.8	65.0	57.2	57.6	57.0	57.0	57.0
General-Purpose Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Capital Equipment	71.5	61.8	65.0	57.2	57.6	57.0	57.0	57.0
Program Construction[2]	62.3	79.1	101.0	181.0	157.0	115.0	121.0	89.0
General Plant Projects	10.0	7.1	8.0	8.0	8.0	8.0	8.0	8.0
General-Purpose Facilities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Proposed Construction[3]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total GPP/Construction[4]	72.3	86.2	109.0	189.0	165.0	123.0	129.0	97.0

[1]DOE funding includes net of transfers to other DOE contractors.
[2]Program construction does not include any proposed construction.
[3]Proposed construction is an optional estimate of future construction funding.
[4]Total GPP/Construction is also included in the individual program construction funding.

Table 25. Personnel by Secretarial Officer (FTEs).

Description	Actual FTEs FY97	Projected FTEs FY98	FTEs FY99	FTEs FY00	FTEs FY01	FTEs FY02	FTEs FY03	FTEs FY04
Defense Programs	1,826	1,972	2,038	1,942	1,959	1,965	1,937	1,890
Energy Efficiency and Renewable Energy	42	40	35	40	40	40	40	40
Environment, Safety, and Health	4	4	0	0	0	0	0	0
Environmental Restoration and Waste Management	297	319	197	227	222	248	248	248
Energy Research	240	212	212	218	212	206	200	194
Fossil Energy	12	12	14	14	14	14	14	14
Human Resources and Administration	0	0	0	0	0	0	0	0
Fissile Materials Disposition	64	84	104	100	96	92	88	85
Nuclear Energy	39	32	31	32	30	28	26	26
Nonproliferation and National Security	317	309	310	311	298	291	292	293
Policy, Planning and Program Evaluation	0	0	0	0	0	0	0	0
Chief Financial Officer	1	2	2	2	2	2	2	2
Other DOE Facilities (Reimbursable DOE Work)	206	193	202	202	202	202	202	202
Subtotal DOE Programs	3,048	3,179	3,145	3,088	3,075	3,088	3,049	2,994
Work for Others								
NRC	11	8	4	4	4	4	4	4
DoD	155	124	103	109	109	109	109	109
HHS/NIH	49	48	48	45	45	45	45	45
NASA	22	24	35	17	17	17	17	17
EPA	2	4	2	2	2	2	2	2
Other Federal Agencies	72	85	78	66	66	66	66	66
Private Industry	58	48	36	54	69	84	105	105
All Other Nonfederal	45	51	35	35	35	35	35	35
Subtotal Work for Others	414	392	341	332	347	362	383	383
Total Direct Personnel for Program Effort	3,462	3,571	3,486	3,420	3,422	3,450	3,432	3,377
Program Capital Equipment	5	10	13	11	11	11	11	11
Program Construction	99	111	145	266	230	167	175	128
General-Purpose Equipment	0	0	0	0	0	0	0	0
General Plant Projects	1	1	1	1	1	1	1	1
General-Purpose Facilities	18	18	18	18	18	18	18	18
Proposed Construction	0	0	0	0	0	0	0	0
Total Direct Personnel	3,585	3,711	3,663	3,716	3,682	3,647	3,637	3,535
Total Indirect Personnel	3,270	3,410	3,410	3,410	3,410	3,410	3,410	3,410

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3. Resources by Subprogram

Table 26. Chief Financial Officer ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
WN – Cost of Goods Sold								
Operating	1.9	2.5	2.6	2.7	2.7	2.7	2.7	2.7
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	1.9	2.5	2.6	2.7	2.7	2.7	2.7	2.7
Direct Personnel (FTEs)	1	2	2	2	2	2	2	2
Totals for Chief Financial Officer								
Operating	1.9	2.5	2.6	2.7	2.7	2.7	2.7	2.7
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
Total	1.9	2.5	2.6	2.7	2.7	2.7	2.7	2.7
Direct Personnel (FTEs)	1	2	2	2	2	2	2	2

Table 27. Defense Programs ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
DP01 – Stockpile Stewardship								
Operating	271.0	313.4	448.3	413.8	447.8	484.4	493.8	499.5
Capital Equipment	50.2	30.9	49.5	41.2	41.2	41.2	41.2	41.2
Construction	53.1	74.7	82.4	142.0	119.0	51.2	64.8	61.0
Subtotal	374.3	419.0	580.2	597.0	608.0	576.8	599.8	601.7
Direct Personnel (FTEs)	871	930	930	930	968	1,007	987	960
DP02 – Inertial Confinement Fusion								
Operating	21.6	21.7	22.0	22.6	28.3	29.0	29.8	30.1
Capital Equipment	0.6	1.4	0.2	0.5	0.5	0.5	0.5	0.5
Construction	2.3	1.1	1.6	1.3	1.3	1.3	1.3	1.3
Subtotal	24.5	24.2	23.8	24.4	30.1	30.8	31.6	31.9
Direct Personnel (FTEs)	78	75	73	72	87	86	85	83
DP03 – Technology Transfer and Education								
Operating	17.3	16.8	23.6	13.6	13.6	13.6	13.6	13.6
Capital Equipment	0.2	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	17.5	16.8	23.6	13.6	13.6	13.6	13.6	13.6
Direct Personnel (FTEs)	55	52	70	39	38	37	36	35
DP04 – Weapons Stockpile Management								
Operating	250.7	293.1	327.7	318.0	317.7	318.4	328.6	334.7
Capital Equipment	3.9	4.0	1.8	1.5	1.5	1.5	1.5	1.5
Construction	12.3	9.2	18.9	32.5	32.7	46.8	44.9	35.0
Subtotal	266.9	306.3	348.4	352.0	351.9	366.7	375.0	371.2
Direct Personnel (FTEs)	813	893	960	896	861	830	824	807

Table 27. Defense Programs ($M). (Continued)

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
DP05 – Program Direction								
Operating	3.1	8.0	2.0	2.0	2.0	2.0	2.0	2.0
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	3.1	8.0	2.0	2.0	2.0	2.0	2.0	2.0
Direct Personnel (FTEs)	9	22	5	5	5	5	5	5
GB1017 – Stabilization								
Operating	0.1	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	0.1	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
DP – Weapons Activities								
Operating	563.8	653.0	823.6	770.0	809.4	847.4	867.8	879.9
Capital Equipment	54.9	36.3	51.5	43.2	43.2	43.2	43.2	43.2
Construction	67.7	85.0	102.9	175.8	153.0	99.3	111.0	97.3
Subtotal	686.4	774.3	978.0	989.0	1,005.6	989.9	1,022.0	1,020.4
Direct Personnel (FTEs)	1,826	1,972	2,038	1,942	1,959	1,965	1,937	1,890
GG – Worker and Community Transition Program								
Operating	0.4	0.7	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	0.4	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Totals for Defense Programs								
Operating	564.2	653.7	824.3	770.7	810.1	848.1	868.5	880.6
Capital Equipment	54.9	36.3	51.5	43.2	43.2	43.2	43.2	43.2
Construction	67.7	85.0	102.9	175.8	153.0	99.3	111.0	97.3
Total	686.8	775.0	978.7	989.7	1,006.3	990.6	1,022.7	1,021.0
Direct Personnel (FTEs)	1,826	1,972	2,038	1,942	1,959	1,965	1,937	1,890

Table 28. Energy Efficiency and Renewable Energy ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
EB – Solar Energy								
Operating	6.4	5.5	5.3	5.4	5.4	5.4	5.4	5.4
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	6.4	5.5	5.3	5.4	5.4	5.4	5.4	5.4
Direct Personnel (FTEs)	16	14	13	13	13	13	13	13
EC – Buildings Sector								
Operating	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
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	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Direct Personnel (FTEs)	1	1	1	2	2	2	2	2
ED – Industrial Sector								
Operating	1.8	2.3	2.0	2.4	2.4	2.4	2.4	2.4
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	1.9	2.3	2.0	2.4	2.4	2.4	2.4	2.4
Direct Personnel (FTEs)	6	8	7	8	8	8	8	8
EE – Transportation Sector								
Operating	5.0	5.5	6.5	7.5	7.5	7.5	7.5	7.5
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	5.1	5.5	6.5	7.5	7.5	7.5	7.5	7.5
Direct Personnel (FTEs)	19	17	14	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	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	0.2	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
Totals for Energy Efficiency and Renewable Energy								
Operating	13.4	13.5	14.0	15.6	15.6	15.6	15.6	15.6
Capital Equipment	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	13.8	13.5	14.0	15.6	15.6	15.6	15.6	15.6
Direct Personnel (FTEs)	42	40	35	40	40	40	40	40

Table 29. Environment, Safety, and Health ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
HC – Environmental Safety and Health (Nondefense)								
Operating	0.8	0.7	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	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	4	4	0	0	0	0	0	0
HD– Environmental Safety and Health (Defense)								
Operating	0.2	0.2	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	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Totals for Environment, Safety, and Health								
Operating	1.0	0.9	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
Total	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	4	4	0	0	0	0	0	0

Table 30. Environmental Restoration and Waste Management ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
EW – Environmental Restoration and Waste Management – Defense								
Operating	132.1	149.6	94.7	113.7	115.4	136.9	143.7	149.8
Capital Equipment	4.5	5.8	0.4	0.4	1.0	0.4	0.4	0.4
Construction	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	139.6	156.5	95.1	114.1	116.4	137.3	144.1	150.2
Direct Personnel (FTEs)	296	319	195	222	217	243	244	244
EX – Environmental Restoration and Waste Management – Nondefense								
Operating	2.2	1.0	3.4	9.4	9.9	10.3	7.9	8.1
Capital Equipment	0.1	0.1	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	2.3	1.1	3.4	9.4	9.9	10.3	7.9	8.1
Direct Personnel (FTEs)	1	0	2	5	5	5	4	4
Totals for Environmental Restoration and Waste Management								
Operating	134.3	150.6	98.1	123.1	125.3	147.2	151.6	157.9
Capital Equipment	4.6	5.9	0.4	0.4	1.0	0.4	0.4	0.4
Construction	3.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	141.9	157.6	98.5	123.5	126.3	147.6	152.0	158.3
Direct Personnel (FTEs)	297	319	197	227	222	248	248	248

Table 31. Energy Research ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
AT – Magnetic Fusion								
Operating	3.4	3.7	3.1	3.0	3.0	3.0	3.0	3.0
Capital Equipment	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.2
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	3.7	4.1	3.3	3.2	3.2	3.2	3.2	3.2
Direct Personnel (FTEs)	13	13	10	10	10	10	10	10
KA – High-Energy Physics								
Operating	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.1	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	0.9	0.9	1.0	1.0	1.0	1.0	1.0
Direct Personnel (FTEs)	4	4	4	4	4	4	4	4
KB – Nuclear Physics								
Operating	10.6	10.1	11.0	12.1	12.1	12.1	12.1	12.1
Capital Equipment	0.5	0.6	0.3	0.3	0.3	0.3	0.3	0.3
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	11.1	10.7	11.3	12.4	12.4	12.4	12.4	12.4
Direct Personnel (FTEs)	43	39	40	41	40	39	38	37
KC – Basic Energy Sciences								
Operating	19.6	18.5	19.6	21.5	21.5	21.5	21.5	21.5
Capital Equipment	1.3	5.2	5.8	7.1	7.1	7.1	7.1	7.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	20.9	23.7	25.4	28.6	28.6	28.6	28.6	28.6
Direct Personnel (FTEs)	68	62	63	67	65	63	61	59
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	15.4	13.6	14.2	14.2	14.2	14.2	14.2	14.2
Capital Equipment	0.7	0.8	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	16.1	14.4	15.0	15.0	15.0	15.0	15.0	15.0
Direct Personnel (FTEs)	42	36	36	35	34	33	32	31
KP – Biological and Environmental Research								
Operating	21.0	18.0	19.1	20.5	20.5	20.5	20.5	20.5
Capital Equipment	0.5	1.8	2.8	2.1	2.1	2.1	2.1	2.1
Construction	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	22.9	19.9	21.9	22.6	22.6	22.6	22.6	22.6
Direct Personnel (FTEs)	70	58	59	61	59	57	55	53

Table 31. Energy Research ($M). (Continued)

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
KT – University and Science Education								
Operating	0.2	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	0.2	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
Totals for Energy Research								
Operating	71.0	64.7	67.9	72.3	72.3	72.3	72.3	72.3
Capital Equipment	3.3	8.9	9.9	10.5	10.5	10.5	10.5	10.5
Construction	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	75.7	73.7	77.8	82.8	82.8	82.8	82.8	82.8
Direct Personnel (FTEs)	240	212	212	218	212	206	200	194

Table 32. Fossil Energy ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
AA – Coal								
Operating	0.1	0.5	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	0.1	0.5	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	0.8	0.9	0.6	0.6	0.6	0.6	0.6	0.6
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	0.9	0.6	0.6	0.6	0.6	0.6	0.6
Direct Personnel (FTEs)	3	5	3	3	3	3	3	3
AC – Petroleum								
Operating	2.7	2.2	3.9	3.9	3.9	3.9	3.9	3.9
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	2.7	2.2	3.9	3.9	3.9	3.9	3.9	3.9
Direct Personnel (FTEs)	8	6	10	10	10	10	10	10
AZ – Innovative Clean Coal Technology								
Operating	0.4	1.0	1.5	1.5	1.5	1.5	1.5	1.5
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	0.4	1.0	1.5	1.5	1.5	1.5	1.5	1.5
Direct Personnel (FTEs)	1	1	1	1	1	1	1	1

Table 32. Fossil Energy ($M). (Continued)

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Totals for Fossil Energy								
Operating	4.0	4.6	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
Total	4.0	4.6	6.0	6.0	6.0	6.0	6.0	6.0
Direct Personnel (FTEs)	12	12	14	14	14	14	14	14

Table 33. Human Resources and Administration ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
WM – General Administration – Contractual Services								
Operating	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1
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	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
Totals for HR – Human Resources and Administration								
Operating	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1
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	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0

Table 34. Fissile Materials Disposition ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
GA – Fissile Materials Disposition								
Operating	20.8	28.4	36.5	36.5	36.5	36.5	36.5	36.5
Capital Equipment	2.9	2.0	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	23.7	30.4	36.5	36.5	36.5	36.5	36.5	36.5
Direct Personnel (FTEs)	64	84	104	100	96	92	88	85
Totals for Fissile Materials Disposition								
Operating	20.8	28.4	36.5	36.5	36.5	36.5	36.5	36.5
Capital Equipment	2.9	2.0	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	23.7	30.4	36.5	36.5	36.5	36.5	36.5	36.5
Direct Personnel (FTEs)	64	84	104	100	96	92	88	85

Table 35. Nuclear Energy ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
AF – Nuclear Energy Research and Development								
Operating	10.9	8.6	10.4	10.4	10.4	10.4	10.4	10.4
Capital Equipment	0.6	4.1	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	11.5	12.7	10.4	10.4	10.4	10.4	10.4	10.4
Direct Personnel (FTEs)	20	15	17	16	15	14	13	13
CD – Uranium Programs								
Operating	2.7	1.3	0.8	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	2.7	1.3	0.8	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	6	3	2	0	0	0	0	0
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)	0	0	0	0	0	0	0	0
ST – Isotope Production and Distribution Program								
Operating	3.8	4.2	3.7	5.2	5.2	5.2	5.2	5.2
Capital Equipment	0.6	0.5	0.5	0.7	0.7	0.7	0.7	0.7
Construction	0.0	0.0	6.0	7.4	0.0	0.0	0.0	0.0
Subtotal	4.4	4.7	10.2	13.3	5.9	5.9	5.9	5.9
Direct Personnel (FTEs)	13	14	12	16	15	14	13	13
Totals for Nuclear Energy								
Operating	17.4	14.1	14.9	15.6	15.6	15.6	15.6	15.6
Capital Equipment	1.2	4.6	0.5	0.7	0.7	0.7	0.7	0.7
Construction	0.0	0.0	6.0	7.4	0.0	0.0	0.0	0.0
Total	18.6	18.7	21.4	23.7	16.3	16.3	16.3	16.3
Direct Personnel (FTEs)	39	32	31	32	30	28	26	26

Table 36. Nonproliferation and National Security ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
GC – Verification and Control Technology								
Operating	58.4	60.0	60.7	63.8	66.9	70.3	73.8	77.5
Capital Equipment	3.0	1.3	1.6	1.6	1.6	1.6	1.6	1.6
Construction	0.0	0.0	0.0	6.0	12.0	24.0	17.7	0.0
Subtotal	61.4	61.3	62.3	71.4	80.5	95.9	93.1	79.1
Direct Personnel (FTEs)	194	179	174	176	178	180	182	184
GD – Nuclear Safeguards and Security								
Operating	7.5	5.8	8.0	10.3	8.7	9.0	9.4	9.7
Capital Equipment	0.6	0.4	0.9	0.6	0.6	0.6	0.6	0.6
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	8.1	6.2	8.9	10.9	9.3	9.6	10.0	10.3
Direct Personnel (FTEs)	26	23	31	38	31	31	31	31
GH – Security Investigations								
Operating	0.0	0.2	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	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	1	1	1	1	1	1	1
GJ – Export Control, Nonproliferation and International								
Operating	29.8	38.4	39.8	37.6	34.3	31.1	32.0	32.8
Capital Equipment	0.8	2.2	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	30.6	40.6	39.8	37.6	34.3	31.1	32.0	32.8
Direct Personnel (FTEs)	71	84	84	76	67	58	57	56
ND – Emergency Management								
Operating	0.1	0.2	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	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel (FTEs)	0	0	0	0	0	0	0	0
NT – Intelligence								
Operating	5.6	6.2	6.0	6.1	6.6	6.9	7.3	7.7
Capital Equipment	0.0	0.2	0.2	0.2	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	6.4	6.2	6.3	6.6	6.9	7.3	7.7
Direct Personnel (FTEs)	26	23	21	21	22	22	22	22
Totals for Nonproliferation and National Security								
Operating	101.4	110.8	114.5	117.8	116.5	117.3	122.5	127.7
Capital Equipment	4.4	4.1	2.7	2.4	2.2	2.2	2.2	2.2
Construction	0.0	0.0	0.0	6.0	12.0	24.0	17.7	0.0
Total	105.8	114.9	117.2	126.2	130.7	143.5	142.4	129.9
Direct Personnel (FTEs)	317	309	310	311	298	291	292	293

Table 37. Policy, Planning, and Program Evaluation ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
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
Totals 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
Total	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 38. Major Program Resources ($M).

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Total DOE Reimbursables	61.5	62.0	65.0	65.0	65.0	65.0	65.0	65.0
Direct Personnel (FTEs)	206	193	202	202	202	202	202	202
DOE Totals								
Operating	990.9	1,106.0	1,243.9	1,225.4	1,265.7	1,326.4	1,356.4	1,380.0
Capital Equipment	71.5	61.8	65.0	57.2	57.6	57.0	57.0	57.0
Construction	72.3	86.2	108.9	189.2	165.0	123.3	128.7	97.3
DOE Total	1,134.7	1,254.0	1,417.8	1,417.8	1,488.3	1,506.7	1,542.1	1,534.3
Direct Personnel (FTEs)	3,084	3,181	3,145	3,088	3,075	3,088	3,049	2,994
Work for Others								
NRC	3.1	2.5	1.1	1.1	1.1	1.1	1.1	1.1
DoD	54.3	45.4	37.8	40.0	40.0	40.0	40.0	40.0
HHS/NIH	10.4	10.5	10.5	9.8	9.8	9.8	9.8	9.8
NASA	5.9	6.5	9.5	4.7	4.7	4.7	4.7	4.7
EPA	0.5	1.1	0.5	0.8	0.8	0.8	0.8	0.8
Other Federal Agencies	22.8	27.2	25.1	21.3	21.3	21.3	21.3	21.3
Private Industry	15.7	16.0	12.0	18.0	23.0	28.0	35.0	35.0
All Other Non-Federal	1.8	2.9	2.0	2.0	2.0	2.0	2.0	2.0
Total Work for Others	114.5	112.1	98.5	97.7	102.7	107.7	114.7	114.7
Direct Personnel (FTEs)	414	392	341	332	347	362	383	383
Laboratory-wide Totals								
Operating	1,105.4	1,218.1	1,342.4	1,323.1	1,368.4	1,434.1	1,471.1	1,494.7
Capital Equipment	71.5	61.8	65.0	57.2	57.6	57.0	57.0	57.0
Construction	72.3	86.2	108.9	189.2	165.0	123.3	128.7	97.3
Laboratory-wide Totals	1,249.2	1,366.1	1,516.3	1,569.5	1,591.0	1,614.4	1,656.8	1,649.0
Total Direct Personnel (FTEs)	3,462	3,573	3,486	3,420	3,422	3,450	3,432	3,377
Capital Equipment (FTEs)	14	10	13	11	11	11	11	11
Construction (FTEs)	109	130	164	285	249	186	194	147
Total FTEs	3,585	3,713	3,663	3,716	3,682	3,647	3,637	3,535

Table 39. Subcontracting and Procurement ($M).[1]

Resources by Subprogram	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Universities	9.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
All Others	704.0	600.0	575.0	575.0	575.0	575.0	575.0	575.0
Transfers to Other DOE Facilities	10.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Total External Subcontracts and Procurements	723.0	610.0	594.0	594.0	594.0	594.0	594.0	594.0

[1]Total dollars obligated within each fiscal year.

Table 40. Small and Disadvantaged Business Procurement ($M).[1]

	Actual Cost FY97	Projected Cost FY98	BA FY99	BA FY00	BA FY01	BA FY02	BA FY03	BA FY04
Total Procurement from Small and Disadvantaged Businesses	294.0	268.0	262.0	262.0	262.0	262.0	262.0	262.0
Percent of Annual Procurement	44%	44%	44%	44%	44%	44%	44%	44%

[1]Total dollars obligated within each fiscal year.

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D. CITED DOCUMENTS AND WEB SITES

1. Cited Documents

Appendix F of the DOE/UC Contract (W-7406-ENG-36)

Defense Nuclear Facility Safety Board Recommendation 94-1

DOE Stockpile Stewardship Plan

DOE Record of Decision on the Stockpile Stewardship and Management Programmatic Environmental Impact Statement

DOE's Strategic Plan of September 1997 (http://www.doe.gov/policy/doeplan.htm)

FY98 Capital Assets Management Process

FY 2000 Annual Controller's Budget Book

Los Alamos-Sandia-Savannah River Tritium Engineering Master Plan

Los Alamos Site-Wide Environmental Impact Statement

Science Education at Los Alamos National Laboratory (LALP-97-148)

Secretary of Energy's 1998 Agreement with the President of the United States (http://www.doe.gov/policy/sol98/index.htm)

Site Development Plan-Technical Site Information

Site Treatment Plan

2. Cited Web Sites

http://education.lanl.gov (link to information on science education at Los Alamos)

http://education.lanl.gov/EPO/REPORTS/EPO.catalog.pdf (link to *Science Education at Los Alamos National Laboratory*)

http://fusionenergy.lanl.gov (link to information on fusion energy research at Los Alamos)

http://lib-www.lanl.gov/pubs/Education.htm (link to Science Education Program Annual Report)

http://lib-www.lanl.gov/cgi-bin/cwelcome_c.cgi (link to the Los Alamos Research Library)

http://www.doe.gov/policy/doeplan.htm (link to DOE's Strategic Plan of September 1997)

http://www.doe.gov/policy/sol98/index.htm (link to Secretary of Energy's 1998 Agreement with the President of the United States

http://www-emtd.lanl.gov (link to information on Environmental Management technologies that facilitate the solution of environmental problems)

http://www.lanl.gov/projects/ia/year2000 (link to the Information Architecture project's Year 2000 effort)

E. ACRONYMS

ACL	Advanced Computing Laboratory
ACPI	Accelerated Climate Prediction Initiative
ACTD	advanced-concept-technology demonstration
ADAPT	Advanced Design and Production Technology
AHF	Advanced Hydrotest Facility
AIDS	autoimmune deficiency syndrome
ALDNW	Associate Laboratory Director for Nuclear Weapons
APT	Accelerator Production of Tritium
ARG	Accident Response Group
ARIES	Advanced Recovery and Integrated Extraction System
ASCI	Accelerated Strategic Computing Initiative
ASTD	Accelerated Site Technology Deployment
BA	Budget Authority
BAO	Business Administration and Outreach
BCW	biological and chemical warfare
BRASS	Basic Rapid Alarm Security System
BUS	Business Operations
C4I	command and control, communications, computers, and intelligence
CARLA	computer-assisted retrieval at Los Alamos
CDAC	Career Development Advisory Committee
CDP	conceptual design plan
CHAMMP	Computer Hardware, Advanced Mathematics, and Model Physics
CHGS	Center for Human Genome Studies
CIC	Computing, Information, and Communications
CIO	Community Involvement and Outreach Office
CISA	Center for International Security Affairs
CIT-PO	Civilian and Industrial Technology Program Office
CLC	Campus–Laboratory Collaborations
CLWR	commercial light-water reactor
CMIP	Capability Maintenance and Improvement Project
COM	Community Outreach Manager
CPM LIR	Construction Project Management Laboratory Implementation Requirements
CPU	central processing unit
CQI	Continuous Quality Improvement
CRADA	cooperative research and development agreement
CRI	Cray Research, Inc.
CTBT	Comprehensive Test Ban Treaty
CWIC	Central Weapons/Production Information Center
CY	calendar year
DARHT	Dual-Axis Radiographic Hydrotest
DARPA	Defense Advanced Research Projects Agency
DNA	deoxyribonucleic acid
DNFSB	Defense Nuclear Facility Safety Board
DoD	Department of Defense
DOE	Department of Energy
DOE/AL	DOE Albuquerque Operations Office
DOE-NN	DOE Office of Nonproliferation and National Security
DOT	Department of Transportation
DP	DOE Defense Programs

DRC	division review committee
DSWA	Defense Special Weapons Agency
EE/RE	Office of Energy Efficiency and Renewable Energy
EM	Environmental Management
EPA	Environmental Protection Agency
ER	Environmental Restoration
ES&H	Environment, Safety, and Health
ESD	Electronic Software Distribution
FE	Facilities Engineering
FE	Office of Fossil Energy
FHWA	Federal Highway Administration
FM	Facility Management
FMD	Fissile Materials Disposition
FORTÉ	Fast on-Orbit Recording of Transient Events
FSU	former Soviet Union
FTE	full-time equivalents
FY	fiscal year
HE	high explosives
HERCULES	High-Explosives Reaction Chemistry by Ultrafast Laser Spectroscopies
HIPPI	high-performance parallel interface
HIV	Human Immunodeficiency Virus
HPCC	High-Performance Computing and Communications
HPSS	High-Performance Storage System
HR	Human Resources
HSWA	Hazardous and Solid Waste Amendment
HTS	high-temperature superconductors
IA	Information Architecture
IAEA	International Atomic Energy Agency
ICF	Inertial Confinement Fusion
ICN	Integrated Computing Network
ID	Initial Delivery
I/O	input/output
IP	Individual Projects
IRM	Information and Records Management
ISM	Integrated Safety Management
IT	International Technology
ITER	International Thermonuclear Experimental Reactor
JBREWS	Joint Biological Remote Early Warning System
JCI	Joint Catalysis Institute
JCS	Joint Chiefs of Staff
JGI	Joint Genome Institute
LAAO	DOE Los Alamos Area Office
LANL	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LDRD	Laboratory-Directed Research and Development
LIDAR	light detection and ranging
LLW	low-level waste
LSND	Liquid Scintillator Neutrino Detector
MASS	Material Accountability and Safeguards System
MFE	magnetic fusion energy
MVGP	mission, vision, and guiding principles

MOX	mixed oxide
MPC&A	materials protection, control, and accounting
MTF	Magnetized Target Fusion
NAC	Nonproliferation and Arms Control
NASA	National Aeronautics and Space Administration
NBC	nuclear, biological, and chemical
NE	Office of Nuclear Energy, Science, and Technology
NEPA	National Environmental Policy Act
NEST	Nuclear Emergency Search Team
NHMFL	National High Magnetic Field Laboratory
NIF	National Ignition Facility
NIH	National Institutes of Health
NIS	Nonproliferation and International Security
NISC	Nonproliferation and International Security Center
NMED	New Mexico Environmental Department
NMSF	Nuclear Materials Storage Facility
NMSM	Nuclear Materials and Stockpile Management
NNMT	Nonnuclear Munitions Technology Program
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NTS	Nevada Test Site
NWT	Nuclear Weapons Technology
OBER	Office of Biological and Environmental Research
OBES	Office of Basic Energy Sciences
OCC	Outreach Coordination Council
OER	Office of Energy Research
OFES	Office of Fusion Energy Sciences
ORTA	Office of Research and Technology Applications
OS	operating system
PAWS	Parallel Application WorkSpace
PD	Program Development
PHERMEX	Pulsed High-Energy Radiographic Machine Emitting X-Rays
POCM	performance objective, criteria, and measure
POOMA	Parallel Object-Oriented Methods and Applications
PSE	Problem Solving Environment
R&D	research and development
REDI	Remote Electronic Desktop Integration Project
RF	radio frequency
RFETS	Rocky Flats Environmental Technology Site
RHIC	Relativistic Heavy Ion Collider
RHU	radioisotope heat unit
RI	Records Inventory
RLTWP	Radioactive Liquid Waste Treatment Plant
RPM	resource planning module
RS	Refresh System
RTG	radioisotope thermoelectric generator
S&T	science and technology
SDP	Site Development Plan
SERS	Science and Engineering Research Semester
SMP	symmetric multiprocessor

SMS	Software Management Systems
SPSS	short-pulse spallation source
SSI	Strategic Simulation Initiative
START	Strategic Arms Reduction Talks
STB	Science and Technology Base Program
STC	Superconductivity Technology Center
TA	Technical Area
TCE	trichloroethylene
TDEA	Technology Development, Evaluation, and Application Program
TITANS	Theoretical Institute for Thermonuclear and Nuclear Studies
TOPS	Teacher Opportunities to Promote Science
TR	Technology Refresh
TRANSIMS	Transportation Analysis System
TRU	transuranic
TWISP	Transuranic Waste Inspectable Storage Project
UAV	unmanned aerial vehicle
UC	University of California
UCLAO	University of California Laboratory Administration Office
UCOP	UC Office of the President
WETF	Weapons Engineering Tritium Facility
WFO	Work for Others
WIPP	Waste Isolation Pilot Plant
WM	Waste Management
WR	War Reserve

V. INDEX

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