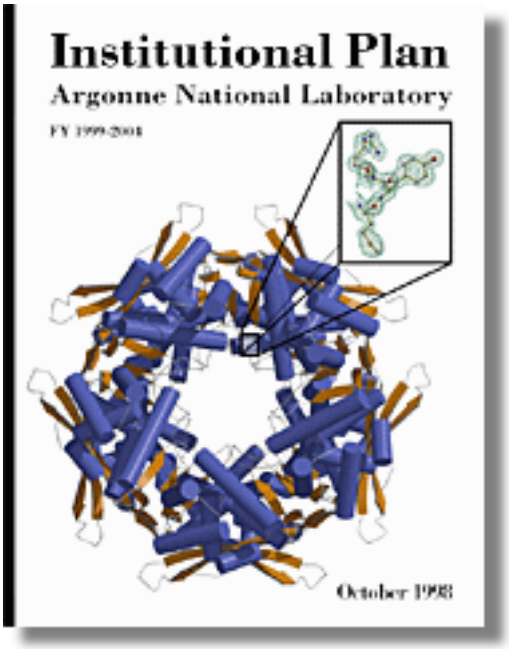
Argonne National Laboratory, October 1998

INSTITUTIONAL PLAN

FY 1999 – 2004



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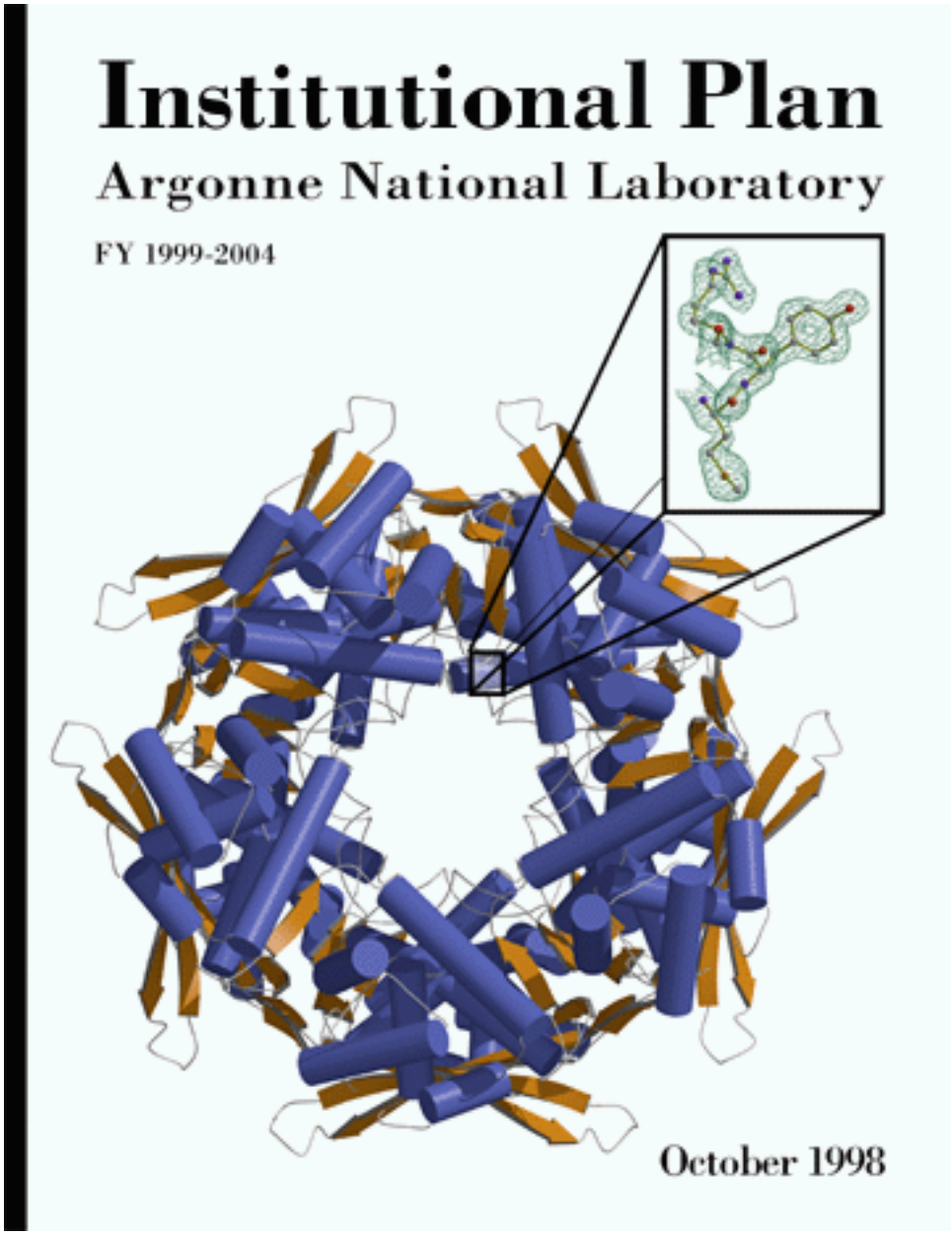

Argonne crystallographers have determined the three-dimensional structure for the 14,000 atoms of the protein cyanase, a bacterial enzyme. The high-intensity X-rays provided by the Advanced Photon Source and the data acquisition capabilities of an innovative CCD (charge-coupled device) detector at the Laboratory's Structural Biology Center now allow such protein structures to be determined far more rapidly than before. The close-up view shows the positions of individual atoms in 3 of the 1,560 amino acids making up the protein's structure (oxygen in red, nitrogen in blue, and carbon in gray), as determined from high-quality electron density maps (indicated in wire frame). The cyanase enzyme functions within certain bacteria to regulate carbon dioxide levels and also to neutralize toxic chemicals. The latter function makes the enzyme potentially important for the development of bioremediation technologies.

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Argonne *Institutional Plan*, October 1998
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This October 1998 *Institutional Plan* was originally prepared in the early spring of 1998. It generally describes the activities and plans of Argonne National Laboratory as of that time. Thus, for example, financial data for FY 1998 are mid-year projections. In addition, a few selected revisions of the *Draft Institutional Plan* of July 1998 are included to reflect comments received and major shifts in plans.

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- I. Laboratory Director's Statement

I. Laboratory Director's Statement

The *Institutional Plan* is the culmination of Argonne's annual planning cycle. This document outlines the Laboratory's plans for the optimal development of its research programs and support operations, in the context of national research and development needs, the missions of the Department of Energy and Argonne National Laboratory, and expected resource constraints. The *Institutional Plan* is the product of internal planning and extensive discussions with DOE managers.

As Argonne's interim director — I began work in my new position on July 1, 1998 — one of my priorities is to strengthen the Laboratory's strategic planning process. Effective planning is especially critical to the Laboratory's future in an era of tight federal R&D budgets. We are also eager to contribute, along with our sister DOE laboratories, to the Department's new strategic planning and roadmapping efforts. Another of my priorities is implementation of Argonne's environment, safety, and health (ES&H) initiatives.

Plan Structure

Chapter II of this *Plan* discusses the Laboratory's missions, its roles within the DOE laboratory system, and its underlying core competencies in science and technology. Chapter III presents the Laboratory's "Science and Technology Strategic Plan," which summarizes key features of the external environment, presents Argonne's vision, and describes how Argonne's strategic goals and objectives support DOE's four business lines. The balance of the chapter comprises strategic plans for 22 areas of science and technology at Argonne, grouped according to the four DOE business lines. The Laboratory's nine major initiatives, presented in Chapter IV, propose important advances in key areas of fundamental science and technology development.

The "Operations and Infrastructure Strategic Plan" in Chapter V includes strategic plans for human resources; environmental protection, safety, and health; site and facilities; and information management. The chapter concludes with a discussion of the business and management practices that the Laboratory is implementing to improve the quality and cost-effectiveness of its operations. Finally, Chapter VI provides resource projections considered a reasonable baseline for planning the Laboratory's future.

Critical Outcomes

Argonne management regards several broad planning objectives as sufficiently important that their achievement constitutes a set of critical outcomes for the Laboratory:

- Conduct science and technology programs that effectively support DOE missions and that are judged outstanding by the research community and by DOE program managers.
- Operate Argonne's major user facilities — the Advanced Photon Source (APS), the Intense Pulsed Neutron Source, and the Argonne Tandem-Linac Accelerator System — in a way that maximizes research productivity and user satisfaction.
- In partnership with industry, successfully develop energy and environmental technologies for transportation, advanced fossil energy conversion, nuclear waste treatment, and other applications.
- Conduct the Laboratory's operations and support functions to provide, at the lowest possible cost, high-quality administrative and support services, along with an effective physical infrastructure.
- Aggressively implement Integrated Safety Management, making ES&H fully a line management responsibility with unambiguous lines of authority; rank with the best in class among all research organizations in safety performance.
- Continuously improve the Laboratory's standing as a trusted neighbor and asset in the local community, Illinois, and the Midwest region.

Recent Accomplishments

I am pleased to report that Argonne has made important advances in its major mission areas over the past year.

At the APS, experiments are now under way on 22 beamlines, and component installation and testing are being completed on an additional 9 beamlines. In the storage ring, vertical emittance has been improved tenfold beyond the original design specification. During the first eight months of FY 1998, the APS achieved an X-ray availability of 92.8% and a mean time between faults of 30.1

hours, performance that would be representative for a mature synchrotron X-ray source.

Preoperational testing of the Structural Biology Center at the APS is generally meeting or exceeding expectations. The tests indicate that this user facility will deliver crystallographic data of very high quality at unprecedented speeds. A complete 1.4-angstrom data set for a lysozyme crystal has already been collected in less than 30 minutes and processed in one hour. At the APS, the Basic Energy Sciences Synchrotron Radiation Center is also reaching full operation, with benefits for broad scientific programs in the materials sciences, chemical sciences, and geosciences.

In March 1998 we signed a cooperative R&D agreement aimed at developing and commercializing novel processes for the production and use of biochips to solve problems in applications such as genomics, pharmaceutical development, disease diagnostics, and university and government research. Argonne's U.S. industrial partners are Motorola and Packard Instrument Company. Also involved through the Laboratory is the Engelhardt Institute of Molecular Biology in Moscow. Packard and Motorola will provide $15 million to the Laboratory over five years to support research; the agreement includes payment of $1.2 million in up-front royalties to Argonne and Engelhardt.

At Argonne's Idaho site, our treatment of spent fuel from the Experimental Breeder Reactor-II is proceeding well. We have successfully completed treatment of some 64 driver fuel assemblies, and we are testing a new electrorefiner with higher throughput. Treatment of reactor blanket material is imminent.

Argonne chemists have discovered "stimuli-responsive" lipid gel materials whose structure mimics that of biological cell membranes. The physical properties of the materials change dramatically but reversibly from gel to fluid in response to external conditions such as temperature and electric or magnetic fields; investigations at the APS and the Intense Pulsed Neutron Source have revealed the structural basis for the changes. These materials may represent the first examples of a new class of "smart gels" that could provide the technological basis for better sensors, chemical valves, molecular machines, and optoelectronic materials.

A new Argonne technology can reduce the cost of producing ethyl lactate — an environmentally benign solvent that has long been approved for use in food products — sufficiently so that in most industrial applications it can displace toxic solvents that threaten to pollute groundwater or damage the earth's ozone layer. The key is a patented membrane system that prevents waste generation during ethyl lactate production. An industrial partner is planning a commercial demonstration plant.

Our materials scientists and engineers have developed an ultrahard coating whose coefficient of friction may be lower than that of any other carbon-based material. The coating promises important benefits for engine parts, oilless bearings, and other major industrial applications. It can be applied quickly in large amounts, and the nontoxic material adheres well to many kinds of substrates.

A measure of our broad success in the physical sciences is a top-ten rating in citations of high-impact papers. Frequently cited Argonne publications are in such areas as chemical theory, high-temperature superconductivity, and experimental high energy physics.

An Integrated Laboratory System

This *Institutional Plan*, more than its predecessors, discusses Argonne's activities and plans in the context of the entire DOE system. Increasingly, the DOE laboratories are cooperating on R&D programs in much the same way that divisions within a multiprogram laboratory work together to bring their special capabilities to bear on a common scientific or technical problem. An appendix describes Argonne's direct R&D collaborations with other DOE laboratories.

Particularly notable among Argonne's interlaboratory collaborations is work with Oak Ridge National Laboratory on design of the Spallation Neutron Source (SNS). Argonne is leading development of the ten initial neutron-scattering instruments for this top-priority national research facility. A staff member at our Intense Pulsed Neutron Source heads the SNS instrument development group, and most of the lead scientists for the individual instruments will work at Argonne for four or five years before relocating their work to Oak Ridge. The neutron user community will be extensively involved in the selection and design of the instruments.

I look forward to leading Argonne into the highly productive and exciting future outlined in this *Institutional Plan*.

Frank Y. Fradin

II. Missions and Roles

Argonne National Laboratory is a large multiprogram laboratory operated by the University of Chicago for the U.S. Department of Energy. The Laboratory's mission is basic research and technology development to meet national goals in scientific leadership, energy technology, environmental quality, and national security. To accomplish its mission for the Department and the nation, Argonne strives continually to advance the frontiers of science and to use its leading-edge capabilities in science and engineering to provide quality solutions for customers and stakeholders. In these efforts the Laboratory often works closely with other DOE laboratories so that the full capabilities of the DOE laboratory system are brought to bear on priority problems in science and technology.

A. Mission Areas

Argonne's major mission areas are the following:

- *Fundamental Science*

  Experimental and theoretical work in the physical, life, and environmental sciences to support the development of energy and environmental technologies and to advance general scientific understanding. Major research thrusts include advanced techniques for X-ray and neutron science, algorithms and tools for massively parallel computers, studies of the human genome, synthesis of advanced materials, detector systems for frontier experiments in particle physics, and studies of nuclear structure far from stability.
- *National Research Facilities*

  Development and operation of national facilities for use by university, industry, and national laboratory groups in research on technology-related and basic-science problems; development of advanced instruments and methods for facilities-centered research. Major national user facilities currently operated by Argonne include the Advanced Photon Source, the Intense Pulsed Neutron Source, and the Argonne Tandem-Linac Accelerator System. The Advanced Photon Source, a $1 billion national investment completed in 1996, is the world's most brilliant source of X-rays for forefront research in technology and science. In a few years it will become one of the most widely used research facilities in the world.
- *Energy Technologies*

  Advanced nuclear technologies supporting civilian nuclear power; technologies for efficient energy utilization in the transportation and industrial sectors, for energy storage, and for fossil energy; supporting research in materials, chemical, and electrochemical technologies. The Laboratory's capabilities in these areas are focused on the safety and efficiency of light-water nuclear reactors; international nuclear safety; energy efficiency, through the Partnership for a New Generation of Vehicles and the Industries of the Future initiatives; advanced batteries and fuel cells; high- and low-temperature superconducting materials and their applications; and advanced fossil fuel conversion technology.
- *Environmental Technologies*

  Technology for nuclear waste management, nuclear decontamination and decommissioning (D&D), industrial waste management, and site restoration. Focuses include conditioning DOE spent fuel for long-term disposal through use of electrometallurgical processing, D&D of obsolete light-water reactors, advanced site characterization techniques, and biological remediation technologies.
- *National Security*

Arms control and nonproliferation technologies. Areas of emphasis are reduced-enrichment fuel for research reactors throughout the world and systems for materials control and accountancy.

- *Technical Evaluation*

  Characterization and evaluation of nationally important projects and technology options in terms of their environmental, cost, or other implications. Major activities in this area include assessments of environmental regulations and policies, site-specific environmental impact and remediation studies, and evaluations of advanced energy technologies.

Argonne contributes to U.S. science and mathematics education through programs for students and teachers. Participation in Laboratory programs by university faculty and students brings their talents to bear on significant research problems and contributes to the education of future scientists and engineers. An important purpose of these programs is to encourage members of underrepresented societal groups to enter careers in science and engineering.

Pervading all Argonne missions is the transfer of technology, particularly through R&D partnerships with industry and universities. These partnerships capitalize on the Laboratory's expertise and facilities. Principal mechanisms include cooperative R&D, use of major facilities, work for non-DOE sponsors, staff exchanges, and licenses. The ARCH Development Corporation licenses technology and, where appropriate, organizes new firms.

An important Laboratory goal is excellence in protecting the environment and the health and safety of its workers and the public. In conducting all its missions, Argonne's policy is that these considerations receive the highest priority in the Laboratory's operations.

B. Roles in an Integrated DOE Laboratory System

In April 1995 DOE established the Laboratory Operations Board to guide the Department's management of its laboratory system. In July 1996 the Board published the Strategic Laboratory Missions Plan — Phase I (URL: www.doe.gov/news/docs/summary.htm), which delineated the roles — "principal," "major contributing," or "specialized participating" — of each multiprogram laboratory in each of the four DOE major mission areas. Argonne's roles are as follows:

DOE Mission Area	**Argonne Role**
Fundamental Science	Principal
Energy Resources	Principal
Environmental Quality	Major Contributing
National Security	Specialized Participating

These role assignments recognize that DOE's multiprogram laboratories operate as part of an integrated system, within which the Department's programs can use the combination of capabilities at one or more laboratories that best meets their needs.

Cooperation among the DOE laboratories, particularly through direct R&D collaborations, is continuing to deepen. This trend toward a more integrated laboratory system is driven by ever improving communications technologies and by increasing experience and innovation with collaborative research at both DOE and the laboratories. A complementary trend is toward closer coordination of planning by DOE program offices, both among themselves and with other federal agencies. The expansion of R&D collaborations among DOE laboratories is sufficiently important that a special appendix to this Institutional Plan is devoted to describing it in more detail from an Argonne perspective. (See "Argonne in an Integrated DOE Laboratory System.")

Argonne in an Integrated DOE Laboratory System

See the Appendix for a description of Argonne's R&D collaborations with other DOE laboratories.

C. Core Competencies Based in Science and Technology

Through more than a half century of achievement in large-scale, multidisciplinary R&D, Argonne has developed a broad set of scientific and technical capabilities and integrated them into distinctive core competencies that enable the Laboratory to perform its missions effectively for DOE and other sponsors.

The Laboratory articulates its core competencies and their underlying technical capabilities for at least three major reasons: (1) to facilitate its internal strategic planning, (2) to communicate the Laboratory's general nature and functions to outsiders, and (3) to help DOE and other potential sponsors understand how to employ the Laboratory most advantageously.

Argonne possesses the following core competencies:

- Integration of a broad science and engineering base into the development and evaluation of nuclear and other advanced energy technologies
- Design, construction, and operation of large accelerator-based user facilities and related technologies
- Conduct of large-scale research programs in materials science, chemical sciences, mechanistic biology, and physics
- Assessment, development, and testing of energy-efficient industrial, transportation, and other end-use technologies
- Application of modeling, simulation, and advanced computing and communications to studies of complex systems and phenomena
- Integration of environmental research, development, assessment, and remediation
- Planning and implementation of R&D partnerships with industry and universities to address problems in primary mission areas
- Education and training of future scientists and engineers by use of frontier research techniques and facilities

The scientific and technological capabilities underlying these eight core competencies are described in Table II.1.

Table II.1 Capabilities Underlying Argonne Core Competencies

SCIENCES

Materials Sciences
Superconductivity
Magnetic Materials
Surface and Interface Studies
Radiation Effects
Neutron and X-ray Diffraction and Scattering
Analytical and Transmission Electron Microscopy
Laser Resonance Spectroscopy
Thin-Film Materials

Chemical Sciences
Photosynthesis
Coal Science
Heavy-Element Separation Science
Electron- and Photon-Stimulated Fast Chemistry
Theoretical Chemical Dynamics
Cluster Chemistry

Biosciences
Computational Biology
Structural, Cellular, and Molecular Biology
Genome Sequencing
Bioprocessing
Ecology

Synchrotron Radiation Techniques
Biostructure Determination
Time-Dependent Materials Characterization
Lithography
Atomic Physics and Surface Science
Advanced X-ray Optical and Detection Techniques

Synchrotron Radiation Sources

Mathematics and Computer Science
Numerical Libraries
Computational Differentiation
Distributed Systems
Codes for Massively Parallel Architectures
Algorithms for Computational Science and Engineering
Modeling, Simulation, and Visualization for Energy and Industrial Technologies

Information Sciences
Information Retrieval
Advanced Communication Technologies
Database Management
Information Architectures
Geographic and Spatial Information Systems
High-Reliability and Secure Systems
Data Visualization
Digital Libraries

Accelerator Physics and Technology
Accelerator Systems and Design
Radio Frequency Superconducting Technology
Advanced Particle and Photon Detectors
Magnetic Field Measurement and Analysis
Radio Frequency and High-Voltage Power Systems

High Energy and Nuclear Physics
Particle Physics
Heavy-Ion Physics

Major Research Facilities
Advanced Photon Source
Intense Pulsed Neutron Source
Argonne Tandem-Linac Accelerator System
High Voltage Electron Microscope Facility
Hot Fuel Examination Facility
Transient Reactor Test Facility
Fuel Conditioning Facility
Alpha-Gamma Hot Cell Facility
Structural Biology Center
High-Performance Computing Facility

TECHNOLOGIES

Advanced Nuclear Technology
Reactor Design and Analysis
Reactor Decommissioning and Decontamination
Reactor Safety Tests and Analysis
Nuclear Fuels and Materials
Nuclear Waste Treatment Technology
Research and Test Reactors

Energy Supply Systems
Fusion Reactor Technologies
Coal Combustion and Gasification
Heat and Mass Transfer

Engineered Materials
Metals and Metallic Alloys
Ceramics and Ceramic Composites

Polymers and Polymer Composites
Coatings and Surfaces
Environmental Effects
Advanced Sensors and Sensor Materials
Superconductors for Power Applications
Surface Modification
Corrosion, Erosion, Friction, and Wear of Engineered Surfaces
Mechanical Behavior and Life Prediction
Liquid Metal Technologies

Industrial Technologies
Instrumentation and Nondestructive Evaluation of Materials and Systems
Pyrochemical and Electrochemical Processing
Energy Storage and Cogeneration
Thermal and Fluid Sciences
Engineering Mechanics and Mechanical Behavior of Structures and Components
Process Efficiency and Waste Recycling
Control Systems
Biotechnology
Ultrahigh-Vacuum Science and Technology

Transportation Systems
Batteries and Fuel Cells for Electric Vehicles
Maglev Systems Design, Analysis, and Testing
Advanced Vehicles
Alternative Fuels
Environmental Planning in Transportation Systems

Systems Analysis, Technology Assessment, and Decision Sciences
Economics, Law, and Policy Analysis
Arms Control and Nonproliferation
Emergency Systems
Probabilistic Risk Analysis
Expert Systems for Artificial Intelligence
Planning for Utility and Other Energy Systems
Engineering Analysis and Cost Estimation
Environmental Policy and Regulatory Analysis

Environmental Science and Technology
Environmental Control Technology
Nuclear Waste Management
Rapid Site Characterization
Land Reclamation
Environmental Pathways Modeling and Measurement
Natural Resource Impacts: Evaluation and Remediation
Atmospheric Sciences and Climate Change Modeling
Inorganic and Isotopic Geochemistry
Analytic Geographic Information Systems
Health Risk Assessment

- **III. Science and Technology Strategic Plan**

III. Science and Technology Strategic Plan

This chapter presents an overview of Argonne's strategic plan. It articulates the Laboratory's vision for the future and describes how Argonne's programs and initiatives support the Laboratory's strategic goals and the missions of the Department of Energy. For 22 Laboratory program areas, it presents summary plans that describe strategies for accomplishing each program's objectives in the context of relevant issues and obstacles to be overcome.

Argonne's planning supports planning by DOE. Overall coordination of the Laboratory's planning with that of the Department relies on several key documents:

- The DOE Strategic Plan of September 1997, the most comprehensive statement of DOE's strategic goals, objectives, and strategies. (URL: www.doe.gov/policy/doeplan.html)
- The Comprehensive National Energy Strategy, DOE's roadmap toward energy security, economic expansion, and greater protection of the environment. R&D features prominently in most of the initiatives affirmed by this April 1998 document. (URL: www.hr.doe.gov/nesp/cnes.htm)
- Facilities for the Future: The Office of Energy Research (Draft) and other roadmaps being developed by DOE program offices.
- The annual Budget Request submitted by DOE to Congress. (URL: www.cfo.doe.gov/budget/99budget/index.htm)
- The annual Performance Agreement between the President and the Secretary of Energy, which establishes for DOE specific commitments and success measures that support the goals and strategies in the DOE Strategic Plan. (URL: www.doe.gov/policy/sol98/index.htm)

Argonne's planning is updated frequently, as required by new developments, including shifts in federal R&D priorities and changes in federal budgets.

IV. Major Initiatives

This chapter describes Argonne's major initiatives. The broader programmatic and strategic context for these initiatives, including their relationships to DOE missions, is provided in Chapter III. The Laboratory's initiatives represent important opportunities to enhance U.S. research capabilities and to advance scientific understanding and engineering achievement across a wide range of disciplines. Pointing to the future, the initiatives presented below are rooted in Argonne's accomplishments and core competencies.

Several of the initiatives discussed in this chapter received funding in FY 1998. They are still treated as initiatives for planning purposes because they are in early stages of development, and their size and programmatic importance justify continued management attention. All funds received during FY 1998 are included in this *Institutional Plan*. However, resources required for initiatives in years beyond FY 1998 are generally not included in those projections. Projected resource requirements for all initiatives include costs associated with protection of the environment and of the health and safety of workers and the public.

Argonne carefully considers the implications of the National Environmental Policy Act (NEPA) for its scientific and technical initiatives, as early as it is reasonable to do so. For initiatives where NEPA implications are expected to be significant, the implications are discussed explicitly in this *Institutional Plan*.

The initiatives in this document are presented for consideration by the Department of Energy. Inclusion does not necessarily imply approval, or an intention to implement, by the Department.

Argonne's major initiatives are presented in this chapter in the following order, without implication of priority:

- Exotic Beam Facility
- Center for Computational Science and Technology
- APS Beamlines
- Mechanistic Biology
- Advanced Transportation Technology
- Industries of the Future
- Nuclear Energy Research
- Mixed Waste Treatment and Waste Form Development
- Remote Treatment Facility at Argonne-West

Other Laboratory initiatives more closely related to research within a single program area are listed at the conclusion of the chapter.

A. Exotic Beam Facility

Opening of new frontiers for research in nuclear physics is expected through the acceleration of beams of unstable nuclei. The first experiments conducted at existing accelerators, including the Argonne Tandem-Linac Accelerator System (ATLAS), demonstrated convincingly that unique information becomes accessible. Critical information previously impossible to obtain includes (1) cross sections for astrophysical processes such as nucleosynthesis during and shortly after the Big Bang, energy-generating processes in stars, and heavy-element production via the r-process during supernova explosions; (2) qualitatively new and unexpected nuclear structure effects in nuclei far from stability, at their very limits of existence; and (3) completely new approaches to studies of nuclear decays, reactions, and structure. All of these opportunities have triggered considerable excitement in the scientific community worldwide.

Exploration at these new frontiers will require extension of today's technical capabilities and facilities. This need and its scientific basis have been discussed in various recent workshops and symposia. They are documented in the *Isospin Laboratory (ISL) White Paper* of 1991 and its 1995 update, prepared by the Isospin Laboratory group, a user community involving 400-500 scientists that supports construction of an appropriate facility in North America. Most importantly, the *1996 Long-Range Plan for Nuclear Physics*, prepared by the DOE-National Science Foundation Nuclear Science Advisory Committee (NSAC), gives highest priority to a radioactive beam facility as the major new construction project for the field.

Argonne has developed a facility concept that aims to achieve the physics goals set forth in the *ISL White Paper* and the NSAC *Long-Range Plan*. This Exotic Beam Facility will provide beams of the highest intensity required for research on nuclear structure and on reactions of astrophysical interest. The concept represents a cost-effective way to realize the benchmark facility described in the *ISL White Paper*.

Argonne's basic design concept for the Exotic Beam Facility is based on two accelerators. It uses a flexible approach for the primary production accelerator and capitalizes on the capabilities of the Laboratory's existing state-of-the-art heavy-ion accelerator — ATLAS — as the postaccelerator. The recently completed uranium upgrade of ATLAS makes the accelerator unique in the world in its ability to provide intense, high-quality, continuous-wave (100% duty cycle), heavy-ion beams for all elements up to and including uranium. ATLAS has excellent transverse and longitudinal phase space properties, and it excels in beam transmission and timing characteristics. These capabilities are important for nuclear structure investigations and astrophysics experiments in which the beam quality requirements are especially stringent. In addition, experimental equipment at ATLAS, including recently completed novel instrumentation like the fragment mass analyzer, is well suited to nuclear structure research.

Argonne's Exotic Beam Facility initiative has the added advantage of allowing timely construction. Preliminary estimates of effort, time lines, and cost suggest that this major new facility can be constructed within three years, following approximately two years of detailed facility design. Required resources are specified in Table IV.1. Funding is being sought from the Nuclear Physics (KB-02) program. No major NEPA-related activities or costs are anticipated.

Table IV.1 Exotic Beam Facility
($ in millions BA; personnel in FTE)

	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Costs							
Operating	0.1	0.1	1.1	1.7	2.7	6.4	14.5
Capital Equipment	-	-	0.2	5.0	10.0	20.0	15.0
Construction	-	-	-	25.0	50.0	60.0	15.0
Total	0.1	0.1	1.3	31.7	62.7	86.4	44.5
Direct Personnel	0.5	0.5	4.0	7.0	10.0	25.0	50.0

B. Center for Computational Science and Technology

Argonne proposes an advanced scientific computing initiative that focuses on two elements: (1) operation of a major computing facility providing access to leading-edge computing capabilities and the associated advanced computing infrastructure and (2) R&D to deploy the advanced computing tools and technology required for accelerated scientific simulation.

The proposed program will build on the large-scale computing facilities of Argonne's Center for Computational Science and Technology (CCST). The CCST currently comprises four major components:

- Scalable, large-scale parallel computers, providing the core computing power for underlying computational science problems
- Scalable data servers, providing a high-capacity, high-bandwidth storage subsystem
- A visualization engine, enabling advanced scientific graphics
- A digital media server, enabling multiple, simultaneous multimedia data streams (such as video and audio)

The availability of these resources has opened new frontiers for research (e.g., relativistic study of actinides) and is enabling new approaches to the study of molecular structures.

The next step is to accelerate dramatically the development and application of simulation models. DOE has identified simulation science as one of its principal research objectives for the 21st century. Argonne is working closely with DOE on a major new thrust to enable strategic simulations for the Office of Energy Research in areas previously considered intractable.

The central objective of this Argonne initiative is to move far beyond the idea of Grand Challenge Applications (GCAs), computing efforts that were funded under DOE's High Performance Computing and Communications Initiative. Where GCAs aimed at proof of principle, Argonne's objective now is to empower applications teams to use multiple-teraflops systems for advanced scientific simulation that will serve as a full partner to scientific experimentation.

Achievement of this goal will require dramatic extension of CCST resources and programs. In particular, the current CCST machine configuration will expand to include teraflops-class computational resources with terabytes of memory, virtual-reality environments to enable immersive display of multidimensional data, and wide-area networks providing the high speed and high bandwidth essential for distributed collaborative problem solving.

Argonne scientists will develop vastly improved models that incorporate new optimization methods, better approximations, and greater detail. These improved models, executed on multiteraflops computers, will enable breakthrough simulations in such strategic areas as atomic and molecular modeling, fluid flow, imaging and data analysis, and simulation of complex systems.

Critical to the success of the proposed Argonne initiative will be major advancements in enabling software. The Laboratory will develop and deploy new methods, algorithms, and techniques in several key areas: problem-solving environments (e.g., for dynamic performance analysis), distributed computing technology (e.g., for computational grids), visualization and data management systems (e.g., for real-time analysis and browsing of terabyte-sized data sets), and scalable algorithms (e.g., adaptive gridding and meshing tools).

Such advances will be possible only through the addition of new scientific staff and programmers. Effective teams that must be established will include applications scientists, who will work in the relevant scientific disciplines; computer scientists, who will design and build the necessary computing technologies; and applied mathematicians, who will develop core algorithms for the next generation of applications.

Required resources are described in Table IV.2. The table includes facilities construction funds for an expanded machine room four times larger than the current CCST area and for new office space required by the increased number of scientific and support staff. Funding is being sought from DOE-Energy Research science programs.

Table IV.2 Center for Computational Science and Technology
($ in millions BA; personnel in FTE)[a]

	FY99	FY00	FY01	FY02	FY03	FY04
Costs						
Operating[b]	3.0	12.0	15.0	19.0	24.0	28.0
Capital Equipment[c]	8.0	16.0	18.0	20.0	20.0	20.0
Construction	-	2.0	10.0	12.0	8.0	-

Total	11.0	30.0	43.0	51.0	52.0	48.0
Direct Personnel	15.0	62.0	82.0	104.0	132.0	154.0

[a] Costs specified in the table are incremental to the existing annual base funding of $5 million.
[b] R&D on computational science, enabling technologies, and applications.
[c] Computational resources.

C. APS Beamlines

Future development of APS beamlines presents many opportunities to devise new approaches to materials discovery and characterization. Fourteen sectors at the APS remain available to be developed for future user research programs. DOE and Argonne give high priority to developing this capacity fully and effectively. Six of the 14 sectors have been requested by users for new research initiatives. The requested beamlines include a sector dedicated to X-ray polarization studies; a commercial beamline for advanced analytical service to industrial customers (supported by funds from the state of Illinois); a sector dedicated to use by institutions located in the southern United States; a protein crystallography beamline focusing on the relationship between structure and function; a structural biology beamline; and a broad-based imaging beamline for applications in medicine, archaeology, and materials science. Argonne seeks funding for construction of the undulators and beamline front ends for these six sectors.

Use of the APS will be optimal only when all of the facility's sectors are fully installed and available for user service. Argonne is working with DOE to plan development of the remaining sectors. Specific technical applications for these beamlines have not yet been decided. The strategy for developing the final sectors involves identifying priorities, building strong user community interest, coordinating preparation of construction and operation plans with prospective funders, and planning construction at a rate of one or two sectors per year. The beamlines will be constructed in partnership with users and will be operated by user groups. Prospective techniques and applications identified to date for these beamlines include the following: very-high-energy scattering; sub-nanosecond temporal resolution studies; coherence and interference techniques; three-dimensional imaging; microcomponent fabrication; archaeology and archaeometallurgy; radiation therapy; and microfluorescence, microimaging, and microdiffraction.

Argonne also proposes to build two laboratory-office modules for users of the new strategic beamlines. These modules will be similar to the six modules that currently support 20 sectors.

D. Mechanistic Biology

To determine the structures and functions of DNA and other biological macromolecules, Argonne proposes to advance and integrate its major initiatives in Mechanistic Biology and to promote new cooperative research. The objective of the resulting multidisciplinary initiative is to develop and apply novel computational methods, facilities, technologies, and analytical techniques to secure industrially useful biochemical processes and more effective pharmaceuticals, as well as to improve understanding of disease processes and basic biochemical mechanisms.

Argonne's Mechanistic Biology initiative comprises three major programs: (1) the Structural Biology Center (SBC) and related basic research in protein crystallography, (2) Human Genome Sequencing, and (3) Structural Genomics. These elements and their relationships are described briefly below. Funding for these programs from the DOE Office of Biological and Environmental Research (OBER) is expected to be augmented by other sources, beginning in FY 1998. Table IV.3 summarizes total resource requirements for the three component programs, including non-OBER support.

Table IV.3 Mechanistic Biology[a]
($ in millions BA; personnel in FTE)

	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Costs							
Operating	6.8	7.8	8.1	8.1	8.1	8.1	8.1
Capital Equipment	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Construction	-	-	-	-	-	-	-

Total	7.5	8.4	8.7	8.7	8.7	8.7	8.7
Direct Personnel	31.0	47.0	52.0	52.0	52.0	52.0	52.0

[a] Resource projections include support for the operation of the Structural Biology Center user facility. The estimates include new funding from sources other than DOE-OBER.

Structural Biology Center. Argonne's SBC will significantly enhance U.S. capabilities in structural biology by offering an integrated national user facility at the APS. Organized and operated as a collaborative access team, the SBC is developing, equipping, and operating one sector (two APS beamlines) that will be available to all qualified scientists for the study of structural biology. The brilliant beamlines at the SBC provide crystallographic data with unprecedented speed and efficiency, enabling studies that cannot be carried out at other X-ray facilities.

The state-of-the-art SBC will furnish all X-ray optical equipment, experimental facilities, and computer equipment and software needed by researchers, along with staff qualified to work seamlessly with outside users. Some of the advanced experimental designs and instrumentation being developed for this facility are also expected to be used by other collaborative access teams at the APS. Novel computational crystallography methods will be developed to take advantage of the SBC's unique data collection capabilities. These methods, together with Argonne's large-scale computational facilities, will substantially reduce the time needed to produce molecular models from raw crystallographic data and will facilitate the interpretation of structure-function data derived from other sources.

A parallel Argonne research program in protein crystallography will take advantage of the SBC's capabilities. The results of this structure-function research and genetic sequence information from the Human Genome program promise unique insights into critical biological processes.

Human Genome Sequencing. Argonne has designed a major program in DNA sequencing that emphasizes basic research on the physical and chemical properties of nucleic acids; R&D on technology for high-throughput, low-cost genetic probing and sequencing; and the application of this technology to study gene expression. The Laboratory's approach is sequencing by hybridization on oligonucleotide microchips (SHOM). Research on this approach, which is being performed jointly by scientists from Argonne and the Englehardt Institute of Molecular Biology (of the Russian Academy of Sciences), aims at increasing the efficiency of genome DNA sequencing by orders of magnitude. The SHOM technique promises to advance the state of the art in genome sequencing and to lead to valuable new applications. Short DNA lengths corresponding to specific genes are being sequenced as an intermediate step in genome sequencing.

Argonne continues to establish new collaborations to apply these techniques in genome probing and sequencing. When it is fully developed, Argonne's microchip technology is expected to have substantial commercial value and to find a variety of applications in biology, biotechnology, and medicine — such as diagnostic tests for genetic diseases, gene polymorphism studies, identification of many different microorganisms in a single sample, and rapid comparative sequencing of the genomes of many different individuals and organisms.

Structural Genomics. The objective of the Structural Genomics component of this initiative is to understand and apply the principles of protein folding. Understanding the basic nature of the folds within proteins will allow researchers to predict the three-dimensional structures of yet-uncharacterized proteins by deduction from nucleic acid sequences available in databases produced by the Human Genome program. Knowledge of these structures will be instrumental in defining the biochemical and cellular functions of novel gene products.

E. Advanced Transportation Technology

Argonne proposes to expand its current research, development, and analysis of advanced transportation technologies for DOE and other federal agencies through its newly formed Transportation Technology Research and Development Center. The objective of this initiative is to work cooperatively with U.S. industry to develop and implement cost-effective technologies to improve the fuel efficiency of advanced transportation systems and to reduce their environmental emissions. Future activities focus on eight areas: advanced diesels, energy storage devices, hybrid vehicles, fuel cells, high-performance computing, recycling, railroad and electromagnetic technologies, and intelligent transportation systems.

Advanced Diesels. Diesel engines offer the potential for significant improvements in the fuel economy of automobiles and can be enhanced to provide further energy efficiencies in trucks and locomotives. Controlling emissions of nitrogen oxides and particulate matter remains a key technical hurdle, especially as emissions regulations become tighter. By using permeable membranes to create oxygen-rich and nitrogen-rich streams from ambient air, Argonne plans to extend its recent success in in-cylinder emissions control

to develop advanced air composition techniques and fuel injector systems to reduce emissions of both particulates and nitrogen oxides from diesel engines of all sizes. Current industrial partners include Compact Membrane Systems, the Electro-Motive Division of General Motors, Caterpillar, and Robert Bosch.

Energy Storage Devices. The market for electric vehicles is increasing because of stringent environmental regulations and legislative mandates in California and several other states. In response, General Motors, Ford, and Chrysler formed the U.S. Advanced Battery Consortium (USABC), a partnership with DOE and the Electric Power Research Institute, to develop advanced batteries for electric vehicles. Argonne works with the USABC and also plays a leading role in the organization, planning, and management of a major new multilaboratory R&D initiative (involving Lawrence Berkeley, Brookhaven, and Sandia National Laboratories) to help industry develop commercially viable high-power lithium-ion batteries as energy storage devices for the Partnership for a New Generation of Vehicles. Argonne's R&D will range from materials research on improved anode and cathode materials to the development of novel low-cost packaging concepts for lithium-ion batteries.

Hybrid Vehicles. Hybrid vehicles can be improved to overcome important limitations of electric vehicles — especially range and recharging rate — and thereby to achieve greater acceptability in the market. A hybrid vehicle employing either a small internal combustion engine or a gas turbine with a battery or ultracapacitor could perform as well as a conventional vehicle but be far more energy efficient and environmentally benign. Argonne is using its Advanced Powertrain Test Facility to gather performance and emissions data for hybrid vehicle components and to validate models that simulate the performance of hybrids. The Laboratory is increasing its capabilities for directly measuring the performance characteristics of hybrid vehicle components such as engines, traction motors, and electrical control systems.

Fuel Cells. Fuel cells convert the chemical energy of fuels directly into electrical energy, cleanly and efficiently. Fuel-cell-powered vehicles potentially could nearly double the energy efficiency of conventional vehicles and reduce emissions by 99%. As DOE's lead laboratory for transportation fuel cells, Argonne provides technical management and performs in-house R&D on fuel cell components and fuel-processing technology. The Laboratory has developed proof-of-concept technology for a catalyzed, quick-starting, fast-responding partial-oxidation reformer that converts gasoline to a hydrogen-rich gas for use in polymer electrolyte membrane fuel cells. A follow-on initiative is to (1) scale up the technology for automotive applications, (2) add shift reactors and adsorption units for sulfur and carbon monoxide to optimize the quality of reformate gas, and (3) work with industrial partners to develop prototype hardware designs amenable to low-cost, high-volume manufacturing.

High-Performance Computing. As part of the Supercomputer Automotive Applications Partnership — an R&D consortium under the aegis of the U.S. Council for Automotive Research — Argonne and four other DOE laboratories are collaborating with the three domestic automakers. The Partnership will create software for high-performance computer systems that will cut the time required to design and test new concepts for advanced power plants, aerodynamic shapes, and improved safety features. Argonne will use leading-edge computing systems exploiting massively parallel supercomputers and advanced computational engineering software for fluid dynamics. The focus will be on underhood cooling, which is a critical design consideration for hybrid vehicles.

Recycling. Obsolete motor vehicles contain plastics, chlorofluorocarbons, rubber, glass, and certain heavy metals that are not currently recyclable and must be deposited in landfills. Under a new DOE initiative with the Vehicle Recycling Partnership (involving Ford, General Motors, and Chrysler), Argonne will be developing technologies for processing waste streams resulting from recycling of advanced vehicles with new structural materials and propulsion systems, as well as comparing the cost-effectiveness, energy efficiency, and environmental acceptability of alternative systems for handling the waste streams.

Railroad and Electromagnetic Technologies. New technologies are needed to maintain and improve the existing U.S. railroad system and to meet future demands for increased fuel efficiency, reduced emissions, higher speeds, and greater axle loads. In response to a request by DOE-Energy Research that its laboratories develop partnerships with key U.S. industries, Argonne has joined the Association of American Railroads to help the freight railroad industry address these needs. The Laboratory is also serving as DOE's technical lead in a cooperative government-industry maglev research program mandated by the authorizing legislation for the U.S. Department of Transportation.

Intelligent Transportation Systems. More effective use of technology is urgently needed to make driving on U.S. streets and highways safer and more efficient. In response to this need, Argonne has joined a national effort to improve automotive transportation through intelligent transportation systems relying on advanced electronic and communications technologies, advanced computing, sensors and instrumentation, and information management systems. The Laboratory's work will exploit its experience in developing computer simulations of complex systems, using high-performance computing and display systems, developing sensors and instrumentation, and conducting integrated environmental assessments.

Funding for this research is sought from the Laboratory Technology Research Program (KU) of DOE-Energy Research, from two programs within DOE-Energy Efficiency (Transportation [EE] and Industrial [ED]), and from the Department of Transportation. See Table IV.4.

Table IV.4 Advanced Transportation Technology
($ in millions BA; personnel in FTE)

	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Costs							
Operating	17.8	21.4	25.4	28.4	29.0	29.0	29.0
Capital Equipment	1.4	1.9	2.3	2.3	2.3	2.3	2.3
Construction	-	-	-	-	-	-	-
Total	19.2	23.3	27.7	30.7	31.3	31.3	31.3
Direct Personnel	83.0	92.0	102.0	110.0	110.0	110.0	110.0

F. Industries of the Future

The industrial sector accounts for approximately a third of the energy used in the United States, at a cost of about $100 billion each year. Five of the major process industries — chemicals, forest products, glass/ceramics, metals, and petroleum refining — account for 78% of all industrial energy use, generate 95% of the waste and 95% of the air pollution from manufacturing, and account for about a third of U.S. carbon dioxide emissions. Reflecting the importance of the industrial sector, DOE's Office of Industrial Technologies has structured an Industries of the Future program that is working with major U.S. industries to develop a shared vision of the future and a roadmap of research needs.

In response to this vision and research roadmap, Argonne manages an initiative targeting selected energy-intensive industries that conducts research to improve energy efficiency, to increase resource recovery and reuse, and generally to improve the productivity of the U.S. process industries and make them more competitive relative to producers abroad. Four industries will receive central attention: chemicals, petroleum refining, forest products, and steel and aluminum. This initiative will build on facilities, research programs, and staff that the Laboratory has developed in work for DOE and other federal agencies. It will also take advantage of Argonne's location in the U.S. industrial heartland and the good relations and partnerships with many industrial firms and associations that the Laboratory has established over the past decade.

Chemicals Industry. Over the past four years, the chemicals industry has developed a vision *(Vision 2020)* and associated technology roadmaps through the combined efforts of the Chemical Manufacturers Association, the American Chemical Society, the American Institute of Chemical Engineers, the Council for Chemical Research (CCR), and the Synthetic Organic Chemicals Manufacturing Association. Argonne supports this roadmap development through participation in the CCR process. Particularly relevant for this initiative are the Laboratory's ongoing R&D programs addressing recovery and reuse of polymers, development of chemicals from alternative feedstocks, bioconversion of high-starch wastes to high-value products, catalysis, and plasma chemical processing.

Building on these existing R&D activities, Argonne will develop further scientific and technological capabilities of interest to the chemical industry, including

- Use of the APS in the development of catalysts having greater selectivity and activity;
- Application of advanced computational technologies both to reactions at the molecular level and to interactions among fluids, particles, and reactions at the process level; and
- Development of advanced separations techniques using membranes and ion-selective chemistries invented by Argonne.

This initiative will take advantage of strategic partnerships with other national laboratories and with key industrial chemical firms.

Petroleum Refining Industry. Argonne has played a key role in developing a vision for the petroleum refining industry, particularly by coordinating with the industry and by assisting DOE in early planning and evaluation for collaborative research with industry. The Laboratory coordinated the identification of national laboratory capabilities relevant to research given high priority by the refining industry and published the results on the World Wide Web. Moreover, Argonne helped to organize and lead a "virtual laboratory" for petroleum refining, within which 12 national laboratories are cooperating to identify capabilities and areas of expertise that will be valuable for the industry.

Argonne's initiative particularly targets the key long-range research problem identified by the petroleum industry: the processing and

upgrading of increasingly heavy crude oils. Relevant facilities and expertise being developed at Argonne include

- Advanced computational modeling applied to fluid catalytic cracking to improve overall yield,
- Development of a strategic consortium with refiners to study the fouling of heat exchange surfaces by exploiting unique experimental facilities at Argonne, and
- Development of catalysts for upgrading heavy crudes and residuum.

Forest Products Industry. The American Forest and Paper Association has also prepared a vision for its industry in the year 2020. Agenda 2020 identifies six priority research areas that are critical to reaching the industry's productivity and environmental goals in the next century: sustainable forestry, environmental performance, energy performance, improved capital effectiveness, recycling, and sensors and controls.

Argonne has formed strategic partnerships with equipment suppliers in the paper and pulp industry and with other research organizations to apply unique Laboratory facilities and capabilities in the areas of advanced separations and heat transfer to key technical issues identified by the industry roadmaps. These issues include removal of ionic impurities from process water, advanced heat transfer concepts for paper drying, and new sensors for process control.

Steel and Aluminum Industry. The American Iron and Steel Institute (AISI) is leading the development of a vision and roadmaps for its industry. Argonne is working with AISI on that effort and also on the development of standardized contract language for cooperative programs involving government laboratories and the steel industry. The agreement language is to be broadened in coming months to make it appropriate for nonferrous metals industries such as aluminum. The Aluminum Association has already developed the vision and roadmaps for its industry.

Argonne is targeting key technical hurdles identified in the industry roadmaps where unique Argonne capabilities and facilities can be used to advantage. These opportunities include using the APS and the Intense Pulsed Neutron Source to perform critical materials studies for the development of inert metal anodes for aluminum smelting, forming strategic alliances with other laboratories and with the steel industry to improve refractories, and developing improved separation techniques for recovering valuable materials from electrical-arc furnace dust.

Resources required for this concerted Industries of the Future initiative are summarized in Table IV.5. Funding is being sought from the DOE Office of Industrial Technologies and from the industries involved.

Table IV.5 Industries of the Future
($ in millions BA; personnel in FTE)

	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Costs							
Operating	6.1	7.0	8.0	8.0	8.0	9.0	9.0
Capital Equipment	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Construction	-	-	-	-	-	-	-
Total	6.3	7.2	8.2	8.2	8.2	9.2	9.2
Direct Personnel	29.0	34.0	40.0	40.0	40.0	40.0	40.0

G. Nuclear Energy Research

No new orders for nuclear power plants have been placed in the United States in over two decades. As work on the final plants under construction winds down, U.S. nuclear vendors have reduced staff greatly. The Integral Fast Reactor (IFR) program was terminated in FY 1995, the Advanced Light-Water Reactor program was terminated in FY 1997, and enrollments in nuclear engineering programs at universities across the country have dropped precipitously. The U.S. nuclear technology infrastructure, which once led the world, has been eroded seriously and could be lost almost entirely if present trends continue.

Yet the United States still has 105 operating nuclear power plants producing about 20% of the country's electric power, and worldwide a large and growing market for nuclear technology is projected, especially in China and other Asian countries. The United States needs a strong nuclear technology infrastructure to support the safe and efficient operation of domestic nuclear power plants,

to compete in the growing world market, and to influence international affairs relating to nuclear power.

During its 50-year history, Argonne has played a key role in the development of nuclear reactor technology, from the early pioneering days through the terminated IFR program. Several U.S. laboratories possessed broad nuclear reactor expertise in the past, but Argonne is currently unique in that respect. It is the only remaining laboratory with expertise in all aspects of nuclear technology — reactor physics, safety, fuels and materials, and fuel cycle technologies — complemented by a full set of test facilities.

Argonne is currently working on several international nuclear safety projects, including its management of the International Nuclear Safety Center (INSC) and its participation in the International Nuclear Safety Program. These activities currently focus on Russia, Kazakhstan, and Ukraine, but the INSC concept deserves expansion to other countries. INSC projects include the establishment of an international nuclear safety database; collaborative R&D addressing accident management, code validation, and diagnostic technologies; and evaluation of safety issues for DOE (e.g., regarding the BN-350 reactor in Kazakhstan).

To alleviate the decline in U.S. nuclear technology infrastructure, Argonne proposes a program with the following central goals:

- Maintain a complete core competency in nuclear technology so that the nuclear option is not lost to the United States for the long term
- Support U.S. international competitiveness in nuclear technology while fostering international cooperation as appropriate
- Focus in the near term on priority issues of improving the safety and efficiency of existing reactor operations, as a bridge to longer-term objectives
- Encourage research into innovative reactor concepts that hold promise as future clean energy sources

To achieve these goals Argonne proposes an initial research program, based on the INSC. The following areas will be addressed:

- *Advanced Computing Applications*: Reduce operating costs or improve the reliability and safety of current reactors through techniques including advanced diagnostics, sensor validation, and high-fidelity real-time simulation.
- *Reactor Materials Research*: Extend the lives of aging reactors and their components.
- *Nuclear Safety R&D*: Refine and limit risks from nuclear plants. Establish international collaborations to help develop safety technology.
- *Fuel Minimization*: Extend fuel burnup to reduce both the waste requiring disposal and the fuel costs.
- *Innovative Concepts*: Investigate novel ideas for future nuclear fission technologies.

Argonne has established the structure of its INSC program and has received initial funding, though not enough for sustained activity. The present initiative would expand the technical scope of work under the INSC. Proposed for expansion is work on materials behavior, phenomena limiting plant life, safety experiments (both out-of-pile and in-pile), safety code validation, structural analysis methods, and improved simulation exploiting advanced modeling and application of advanced computing technology. International nuclear safety collaboration and improvement of safety and efficiency of reactor operations are ideal applications of Argonne's established nuclear expertise.

Funding for the Nuclear Energy Research initiative will be sought from the Office of Nuclear Energy, Science and Technology (AF). See Table IV.6.

Table IV.6 Nuclear Energy Research
($ in millions BA; personnel in FTE)

	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Costs							
Operating	10.5	14.5	14.5	14.5	14.5	14.5	14.5
Capital Equipment	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Construction	-	-	-	-	-	-	-
Total	11.0	15.0	15.0	15.0	15.0	15.0	15.0
Direct Personnel	45.0	60.0	60.0	60.0	60.0	60.0	60.0

H. Mixed Waste Treatment and Waste Form Development

The DOE Office of Environmental Management is developing a ten-year plan that focuses on cleaning up most DOE sites within a decade. The new plan includes the application of new technologies researched over the past six years (through support by the DOE-Environmental Management Science and Technology program), which are currently at various points along the development-and-demonstration pipeline. Despite ongoing cleanup efforts and activities planned for the next ten years, many DOE waste streams associated with weapons production are expected to require treatment beyond the next decade. Not slated for complete remediation or permanent disposal by 2006 under the DOE-Environmental Management plan are high-level wastes, spent nuclear fuel, materials associated with plutonium disposition, and other special nuclear materials. In addition, optimized treatment for certain mixed waste streams and immiscible organic groundwater contamination will almost certainly remain unresolved. New science and technology will have to be applied after 2006 to address long-term needs at DOE sites, and the national laboratories have an essential role to play in the development and implementation of that science and technology.

Argonne proposes an advanced environmental technology program that builds on the Laboratory's (1) existing broad capabilities in nuclear technology and environmental science and technology, (2) existing nuclear facilities, (3) extensive understanding of environmental problems at DOE sites, and (4) capabilities for integrating multiple scientific and technical disciplines. Building on these acknowledged competencies, Argonne will develop advanced environmental technologies tailored specifically to the needs of particular DOE facilities and waste streams.

The major thrust areas to be developed within the initiative are (1) technologies for treating mixed waste and (2) waste form development.

Efforts on mixed-waste treatment are logical extensions of Argonne's broad background in reactor technology. The Laboratory specializes in remote handling operations and transuranics; facilities at Argonne-West are uniquely suited to such R&D.

Development of waste forms and innovative new technologies generally involves the integration of applied engineering, basic materials science, and basic chemical science. This work is very important for solving problems associated with high-level waste, mixed waste, and waste stabilization.

Argonne continues to play an important role in environmental technology programs for DOE-Environmental Management and the Army Environmental Center. Although the Department of Defense (DOD) is not likely to fund environmental R&D after 1997, radionuclide-containing wastes produced by DOE will remain a major DOE issue beyond 2006, justifying the development of technologies that are less costly.

Resources required for this initiative are summarized in Table IV.7. Funding will be sought from DOE-Environmental Management (EW); DOE-Nuclear Energy, Science and Technology (AF); and DOD.

Table IV.7 Mixed Waste Treatment and Waste Form Development
($ in millions BA; personnel in FTE)

	FY98	FY99	FY00	FY01	FY02	FY03	FY04
Costs							
Operating	-	10.0	12.0	12.0	15.0	18.0	18.0
Capital Equipment	-	1.0	2.0	2.0	-	-	-
Construction	-	-	-	-	-	-	-
Total	-	11.0	14.0	14.0	15.0	18.0	18.0
Direct Personnel	-	40.0	46.0	46.0	60.0	72.0	72.0

I. Remote Treatment Facility at Argonne-West

Argonne proposes construction of a new Remote Treatment Facility at its Idaho site. The facility's mission is defined in the Idaho Site Treatment Plan: to handle and treat all remotely handled mixed transuranic waste at the Idaho National Engineering and Environmental Laboratory (INEEL).

The Site Treatment Plan is an agreement between the state of Idaho and DOE for cleanup of mixed transuranic waste in Idaho. It has the force of law, as part of the Federal Facilities Act/Consent Order. The Remote Treatment Facility is being designed to segregate, characterize, treat, and repackage remotely handled materials not handled for disposal or interim storage at the Advanced Mixed Waste Treatment Project to be constructed by BNFL, Inc. The Remote Treatment Facility also promises a way of handling and disposing of mixed waste that has long been stored at Argonne-West and a way of safely removing spent nuclear fuel from long-term storage so that it can be treated and disposed of according to the schedules in the 1995 Spent Fuel Settlement Agreement among the state of Idaho, the U.S. Navy, and DOE.

The Remote Treatment Facility will consist of two shielded cells housed in a new 15,000-square-foot building located west of the Hot Fuel Examination Facility (HFEF). The new facility will be connected to HFEF through the equipment transfer tunnel, so that major functions and capabilities of each facility can support the other, thereby avoiding duplication. One of the new cells will be heavily shielded to handle spent nuclear fuel and other highly radioactive packages that will arrive in heavily shielded casks. The other cell will be lightly shielded for the remotely handled mixed transuranic waste that will arrive in boxes and barrels from storage locations around the INEEL site.

The Site Treatment Plan requires that the Remote Treatment Facility be a melt-drain evaporation/calcination (MEDEC) treatment facility for Argonne waste streams containing sodium and a preparation unit for other Argonne waste streams. In remotely handled sodium-bearing waste, it is possible that much of the sodium could be removed from more highly contaminated constituents and packaged in the Remote Treatment Facility for treatment in Argonne's Sodium Processing Facility. Where it is not practical to remove the sodium, *in situ* reaction of the sodium might be performed in the Remote Treatment Facility. In this case, the facility would have heaters to melt the sodium, as well as a nitrogen purge to avoid or control sodium reactions. After sodium is removed and spent nuclear fuel and other highly radioactive materials are segregated, the Remote Treatment Facility will prepare all mixed transuranic waste streams and spent nuclear fuel for long-term disposal. Most of the processing streams for the preparation unit now reside at INEEL's Radioactive Waste Management Complex (RWMC) as remotely handled mixed transuranic waste and remotely handled mixed low-level waste, which are distributed throughout two-thirds of the stored transuranic waste streams that are on pads and in storage buildings at the RWMC. The volume of remotely handled waste destined for the Remote Treatment Facility is small, but the facility is the only practical way of treating those materials — as well as substantial amounts of Argonne's own spent nuclear fuel, much of which has been declared waste.

Waste types and treatments at the Remote Treatment Facility are expected to parallel what BNFL, Inc., is planning for contact-handled waste. If that expectation is realized, then 49% of the waste would be encapsulated (with or without compaction), 26% incinerated, and 25% melted. This approach requires incinerators and melters along with encapsulation units. Large incinerators and melters cannot be used within limited shielded space. Therefore, thermal treatment will have to be provided by small self-contained units allowing control of effluents. Argonne's phosphate-bonded ceramics show some tolerance for encapsulating materials with 15-35% organics, an approach that may reduce the need to incinerate. Technologies developed for the Remote Treatment Facility will be designed to minimize thermal treatments.

Equipment planned for the low-level cell of the Remote Treatment Facility includes the following:

- Segregation tables and storage units that will maintain separation of organic and inorganic materials (It is expected that much of the waste at this stage, when properly segregated and characterized, can be packaged for direct disposal at the Waste Isolation Pilot Plant or at a low-level radioactive waste disposal facility.)
- Cutting and sizing equipment for large pieces of metal and other materials
- Shredders and grinders that can reduce materials to the size of coffee grounds for encapsulation
- A phosphate-bonded ceramic waste station that would stabilize and microencapsulate waste that is 15-35% organics
- Stations to package materials from any of the steps described above
- Inspection and characterization stations (Requirements for these stations will depend heavily on how frequently tests are performed for waste characterization and to satisfy the Resource Conservation and Recovery Act and the Toxic Substances Control Act; requirements will also be determined by the need to integrate capabilities with those of the HFEF and the Analytical Laboratory at Argonne-West.)

Equipment expected to be needed in the high-level cell includes the following:

- Equipment for receiving, preparing, and unloading over-the-road certified shipping casks containing spent nuclear fuel
- Stations for removing fuel elements from their assemblies and for other disassembly processes
- Equipment for transferring fuel elements to the HFEF for further post-irradiation examination and for other testing
- Examination equipment needed to complement or enhance that at the HFEF

Project planning dates for the Remote Treatment Facility are as follows: (1) submit a conceptual design report in March 2001, (2)

complete detailed design in March 2004, and (3) complete construction in March 2006. The resources needed to meet this schedule are described in Table IV.8. Funding is sought from DOE-Nuclear Energy, Science and Technology (AF).

Table IV.8 Remote Treatment Facility at Argonne-West
($ in millions BA; personnel in FTE)

	FY00	FY01	FY02	FY03	FY04	FY05	FY06
Costs							
Operating	5.0	5.0	-	-	-	-	-
Capital Equipment	-	-	-	-	10.0	5.0	5.0
Construction	-	-	-	10.0	20.0	25.0	15.0
Total	5.0	5.0	0.0	10.0	30.0	30.0	20.0
Direct Personnel	28.0	28.0	11.0[a]	43.0	43.0	50.0	30.0

[a] Maintained with carryover funding from FY01 operating funds.

J. Programmatic Initiatives

The programmatic initiatives listed in Table IV.9 are grouped by DOE secretarial office. These initiatives, including their projected resource requirements, are discussed in context with the Laboratory's scientific and technical programs in the research area strategic plans of Chapter III.

Table IV.9 Programmatic Initiatives

Initiative	DOE Program
Energy Research	
ATLAS Detector at the LHC	KA-04
MINOS Long-Baseline Detector	KA-04
IPNS Enhancement	KC-02
Argonne National Atmospheric Observatory	KP
Nuclear Energy, Science and Technology	
High-Efficiency Nuclear Fuel	AF
Testing Advanced Commercial Reactor Fuels at TREAT	AF
Materials Technology for Nuclear Power	AF
Post-Operation Evaluation of EBR-II Materials and Components	AF
Severe Accident Management Technology	AF
Advanced Computing for Engineering Applications	AF
D&D Technology Center	AF
Environmental Management	

Chemical Reactivity and Ignition of Nuclear Materials	EW
Nonproliferation and National Security	
Nuclear Material Safeguard Technologies	GC or GJ, EW

V. Operations and Infrastructure Strategic Plan

This chapter's description of Argonne planning for operations and infrastructure is presented at two levels. The main body of the chapter comprises individual strategic plans for human resources; environment, safety, and health; site and facilities; and information management. The introductory discussion, also organized in strategic plan format, presents globally relevant perspectives on planning for the Laboratory's operations and infrastructure and summarizes salient aspects of the individual plans that follow. The chapter concludes with a discussion of Argonne's performance-based approach to continuous improvement of its business and operations practices.

General Vision and Mission

Operations infrastructure and support activities are crucial to the achievement of Argonne's missions. Operations organizations work as partners of the Laboratory's R&D programs, providing cost-effective, customer-focused infrastructure and services that enable the creation of world-class science, technology, and service products. Maintaining this institutional environment and support structure requires effective and efficient accomplishment of the following major mission elements:

- Provide administrative, business, and technical support to the Laboratory's science and technology programs.
- Develop and manage programs for the recruitment, development, and support of the Laboratory's human resources.
- Develop and manage programs that facilitate and support safety and health in the workplace.
- Provide environmental stewardship of the Laboratory site.
- Manage and operate the Laboratory's physical plant; upgrade general plant facilities or construct new facilities as required.

General Situation Analysis

Nationally, overall DOE funding of research programs has declined for the past several years; Argonne's funding has reflected that general trend. Because operations and infrastructure are supported as a charge to the total program funding received by the Laboratory, there is always a great incentive to reduce these overhead costs and still maintain the effectiveness and quality of operations and services. Every overhead dollar saved creates an additional dollar of direct program funding.

The current incentivized, performance-based contract between DOE and the University of Chicago for the management and operation of Argonne — hereafter referred to as the *Prime Contract* — has ushered in a new era in the relationship between DOE and the Laboratory. The Laboratory has benefited particularly from increased flexibility in management practices. With strong collaboration and support from DOE-Chicago Operations and its Argonne Group, Argonne now has the opportunity to institute a variety of best

business practices. This positive, supportive working relationship is expected to continue.

General Goals and Strategies

The overall goal of the Laboratory's operations infrastructure and support functions is to provide unique, high-value technical services to support science and technology programs, along with effective and efficient administrative, business, and operational services at the lowest possible cost, either from external suppliers or internally. The Laboratory is engaged in a strategy to increase the efficiency of its operations and support units while maintaining their effectiveness and quality.

Attracting, developing, and retaining world-class researchers and support personnel is a primary Laboratory goal. Argonne has launched strategic initiatives to improve performance-based appraisals of employees and compensation and benefits programs, to support the development of human resources, and to maintain a diverse workforce. The Laboratory is developing programs to integrate employee performance evaluation with a performance-based compensation system in which all components of compensation are managed as a coordinated whole. Employee interactions and feedback are being facilitated through new human resources information systems and a broad-based employee opinion survey implemented in FY 1997. Planning for human resources is discussed further in Section V.A.

Argonne has endorsed DOE's Integrated Safety Management (ISM) policy as an effective framework for characterizing the Laboratory's approach to environment, safety, and health (ES&H) management. Ultimate goals are zero injuries and zero adverse environmental impacts. Argonne monitors its progress toward excellence in ES&H performance by using pertinent indicators, along with evaluations and assessments. The ISM program complements these efforts. Two major assessments were recently completed; one concerned potential chemical vulnerabilities, the other potential environmental vulnerabilities. On the basis of these vulnerability assessments, Argonne has developed completion criteria on which to build its ES&H and infrastructure management plan, as well as revised environmental sampling plans that more appropriately reflect potential environmental release pathways. These activities demonstrate the Laboratory's continuing commitment to effective environmental stewardship and safety and health management. Argonne planning for ES&H is discussed further in Section V.B.

Continuing Laboratory goals are the efficient use and maintenance of the physical plant and the replacement of inefficient and substandard facilities. The 1990s have seen construction of the Advanced Photon Source and removal from service of numerous substandard and temporary buildings, as well as significant site enhancement and continuing modernization and life extension for other facilities. Beginning operation in 1997 were new facilities for both water supply and waste treatment. Also opening its doors in 1997 was a new Argonne Information Center that adds a major outreach capability to the existing Visitor Reception Center. A new central supply facility is being proposed to consolidate existing operations and eliminate several obsolete buildings. The Laboratory is implementing strategies to purchase energy supplies at lower cost from increasingly deregulated industries and to adopt additional energy conservation measures. Site planning is discussed further in Section V.C.

Because of the importance of information management and its related infrastructure, Argonne manages both as integral parts of research programs and institutional resources. The Laboratory provides a wide range of central services to support, in both traditional and new electronic modes, the collection, creation, dissemination, and archiving of R&D and administrative information. Strategic planning, funding, and coordinated management for the Laboratory's information infrastructure and systems are addressed collaboratively through policy and planning bodies. To ensure that information infrastructure evolves as needed to support programmatic needs, Argonne leads or collaborates in various national initiatives in networking and telecommunications, particularly through pilot projects that test the applicability of new information technologies to DOE-funded R&D. National and other external networks interface with local Argonne networks, positioning the Laboratory as a major player in national networking initiatives. Planning for information management is discussed further in Section V.D.

Various significant Argonne strategies for strengthening management practices cut across all areas of operations, infrastructure, and services and go beyond them. Improving the quality and effectiveness of administrative, business, and support services continues to be a priority goal. Process reengineering practices are being applied at the functional organization level, as a strategic outgrowth of Laboratory initiatives to increase the quality and effectiveness of operations. Communications and outreach strategies are in place to enhance openness, mutual understanding, and trust among Argonne, DOE, and their stakeholders.

Partnership 2000, a collaboration of senior managers for Argonne and DOE-Chicago Operations, is a strategic initiative to improve business and operations practices through enhanced communication and interaction. The Community Leaders Roundtable is strengthening relations with stakeholders from areas neighboring the Laboratory. DOE's move to a performance-based *Prime Contract* has served as a strategic driver for improving Argonne's performance. Measurement of results is an important tool for performance-based management. Continued reduction of Laboratory overhead costs is being pursued as part of a broad Laboratory strategy to increase the efficiency of operations and services while maintaining effectiveness and quality. Cross-cutting issues relating to management practices are discussed further in Section V.E.

A. Human Resources

Situation

The quality of technical staff is a primary determinant of the performance of an R&D laboratory. Argonne's success depends critically on its ability to employ, develop, and motivate creative scientists and engineers.

Argonne's Human Resources (HR) department works in partnership with the Laboratory's program and operations organizations as its principal customers, to develop an understanding of their needs and to support their strategic objectives. HR policies, procedures, and programs affect the potential employee's decision to join the Laboratory, help shape the working environment for those making a career at Argonne, and contribute to the well-being of employees even after they retire through important benefits such as health insurance and retirement income.

Equal opportunity legislation and affirmative action plans have opened many doors in the United States for women, minorities, individuals with disabilities, and veterans. Increasingly, the changing nature of the workforce and the imperative to increase productivity have encouraged the nation's commitment to diversity. Argonne continues to promote diversity internally and to share its values with external partners.

The regulatory environment plays a major role in shaping the Laboratory's HR policies. HR staff understand the complexity and legal implications of federal and state legislation and provide special training for Laboratory managers when required.

Goals

The general goal of the human resource function is to support exemplary programs that attract, develop, compensate, and retain the highest quality staff, while they capitalize on the Laboratory's rich heritage and cultural diversity. To achieve this end, HR management must be fully integrated with the Laboratory's overall strategy. Some specific goals are as follows:

- Directly link and integrate HR strategies with the strategic needs of division managers.
- Develop a linked, market-driven, performance-based system for compensation and employee appraisal.
- Foster the commitment of managers at all levels to equal opportunity and affirmative action.
- Increase the representation of women and minorities employed by the Laboratory and in the job applicant pool, especially for underutilized job groups identified in the Laboratory's Affirmative Action Plan.
- Give employees opportunities for professional growth.
- Improve the timeliness and effectiveness of HR-related communications, information flows, and work processes.
- Provide services that promote the well-being and productivity of Argonne employees.

Strategies

Maintenance of a competitive compensation structure is considered to be the most important HR function, especially in the competition with private industry for critical talent. All components of compensation C base pay, merit increases, incentive compensation (bonuses), and promotion-related increases C will be managed as a coordinated whole, and each employee's compensation (apart from fringe benefits) will be linked to achieved performance as evaluated under a revised appraisal process that focuses on sustained performance and compensation relative to peers and the external market. The Laboratory will periodically review its performance management system to ensure that it

- Incorporates best practices,
- Identifies exceptional contributions, and
- Identifies high-potential employees.

Argonne's success in recruiting and developing high-quality employees depends on attracting talented people. This success means recruiting the best and brightest, including people from diverse backgrounds. The Laboratory's strategic plan for diversity aims directly at vitalizing diversity as a continuous, pervasive managerial objective. The plan identifies the needs of key stakeholder groups, both internal and external, and develops specific strategies addressing six key areas: research and knowledge transfer, the workforce, subcontracting, technology transfer, science education, and community development.

The key to implementing more effective strategic HR management is enhanced dialogue with the Laboratory's program and operations division managers, particularly regarding opportunities to go beyond purely administrative HR functions. Techniques to be employed include regular formal surveys of managers, greater input from HR liaisons within the individual divisions, and more frequent dialogue with division managers. More participatory management coordination is expected to yield both better HR operations and greater willingness to take advantage of HR services.

Argonne recognizes its responsibility to supplement the formal education of its employees with performance-enhancing training, including subjects such as supervisory skills, team building, and employee relations. Periodic assessments of professional development and other training needs of employees are undertaken. Training is available on the subject of employee relations, especially the many laws affecting the employee-employer relationship. To further support employee performance development, the Laboratory has established a pilot mentoring program under which less experienced employees can benefit from the experience, insights, and expertise already gained by their senior colleagues.

To provide more effective and better-quality information flows at reduced costs, Argonne takes increasing advantage of new electronic alternatives to the extensive flows of information in paper documents traditionally associated with HR functions. A good example is the Laboratory's expanding implementation of the Resumix applicant tracking system, which uses imaging technology and artificial intelligence to match candidates with job openings. When the system is fully implemented, managers throughout the Laboratory will have quicker and more reliable access to information about candidates for job openings, with substantially less administrative effort. The Laboratory's intranet already provides electronic versions of the employee handbook and the HR policy and procedures manual. Being planned is access to descriptions of benefit plans, personal benefit statements, and the historical performance of alternative retirement funds, as well as the capability to respond to on-line surveys, to choose among alternative benefit programs, or simply to change an address.

Argonne's comprehensive health screening and health promotion program emphasizes prevention and the general physical and emotional well-being of employees. It also encourages rehabilitation and maximizes recovery opportunities for those whose work has been interrupted by illness or disability. (The Laboratory has been recognized as one of "America's Healthiest Companies" by the Wellness Council of America.) As an enhancement to its occupational disability process, the Laboratory plans to integrate worker's compensation claims management with HR policies, medical department interventions, ES&H (environment, safety, and health) guidelines, adherence to legal requirements, and activities serving the needs of the Laboratory's research and support divisions. The overall goal is to return the employee to productivity as quickly as possible, to the benefit of both the employee and the Laboratory.

In FY 1998 Argonne's Security Department was added to the HR organization. Future initiatives of the Security Department will focus on automated building access systems and new alarm system equipment and software. The goal is to increase the security and safety of personnel at reduced cost.

B. Environment, Safety, and Health

Situation

Current health and safety statistics indicate that Argonne is a safe place to work and a leader among DOE's research facilities. Achieving and maintaining this record requires explicit attention from all Laboratory employees. An effective program depends on a careful balance among (1) policies and procedures, (2) facilities and equipment, and (3) employee behavior. Inadequacies in any of these elements can lead to accidents.

The current DOE focus on health, safety, and protection of the environment is embodied in its Integrated Safety Management (ISM) policy, which now is part of the *Prime Contract*. The ISM policy highlights seven principles that must be reflected in all aspects of the Laboratory's work:

- Line management is responsible.
- Lines of authority are clear and unambiguous.
- Personnel are qualified.
- Resources for ES&H are adequate.
- Hazards are recognized and analyzed.
- Mitigative features are appropriate.
- Requirements and restrictions are appropriate.

The Laboratory has endorsed the ISM policy as an effective framework for characterizing its approach to safety, health, and protection of the environment. Documenting its implementation at Argonne, including identification of areas needing improvement, is the leading measure by which the Laboratory's performance in ES&H in FY 1998 will be gauged under the *Prime Contract*.

Environmental restoration at Argonne-East includes remediation of areas where contamination has been found or is considered likely on the basis of history. In addition, formerly used reactor sites and selected radiochemistry facilities are being systematically decontaminated and decommissioned. Major remedial actions are detailed in the site's RCRA (Resource Conservation and Recovery Act) Part B permit, which has been approved by the Illinois Environmental Protection Agency (IEPA). Argonne has submitted proposals to DOE to accelerate those restoration activities, subject to the availability of funding.

At Argonne-West, the Federal Facility Agreement and Consent Order for the Idaho National Environmental and Engineering Laboratory (INEEL) establishes a procedural framework and a schedule for developing, prioritizing, implementing, and monitoring environmental management and remediation actions at INEEL in accordance with CERCLA (the Comprehensive Environmental Response, Compensation, and Liability Act), RCRA, and the Hazardous Waste Management Act. A sodium treatment facility is undergoing final operational checks.

Goals

In the area of safety, Argonne continuously pursues the objective of zero injuries. For health and the environment, Argonne pursues zero adverse impacts. Pursuit of these ultimate goals is to be based on effective integration of safety management principles and functions into the Laboratory's work processes and on the active, knowledgeable, and mutually supportive participation of every individual on-site.

Strategies

Argonne monitors its own progress toward excellence in ES&H performance by using pertinent indicators. This important component of Argonne's ES&H program complements evaluations and assessments by DOE and regulatory agencies. Laboratory line management, assisted by central support and oversight organizations, conducts frequent monitoring, surveillance, and evaluation in the workplace to assess the implementation of safety practices and procedures. Argonne generally sets ever higher safety goals that exceed the performance levels achieved by other DOE contractors.

Argonne recently completed two major assessments; one addressed potential chemical vulnerabilities, the other potential environmental vulnerabilities.

Following the explosion of an unused plutonium-finishing tank at the Hanford Reservation, DOE directed all laboratories to conduct a chemical vulnerability assessment. Argonne's comprehensive search for safety and environmental chemical vulnerabilities identified the need for a number of housekeeping improvements but did not find significant unmanaged vulnerabilities. All significant vulnerabilities are identified in, and managed under, terms of the Laboratory's IEPA-approved RCRA Part B permit. This conclusion is based on (1) a complete walkdown of all buildings and structures, (2) a careful review of the chemical management program and records systems, and (3) the Laboratory's recent cleaning of all waste retention tanks.

The chemical vulnerability assessment highlighted a few minor known vulnerabilities. Several tanks of surplus sodium should be disposed of, and a number of radiation sources are awaiting development by DOE of an authorized disposal process. In addition to facilities being managed under the Laboratory's RCRA Part B permit, several other small radiological facilities could beneficially be decontaminated and decommissioned. Except where no authorized process is available (such as for surplus neutron sources), each of these minor vulnerabilities is being addressed in the budget plans that Argonne is submitting to DOE. Pending remediation, the risks involved are being managed actively.

On the basis of these vulnerability assessments, the results from the regular facility condition survey, and regular facility safety reviews, Argonne has prepared a master list of building deficiencies. This list will serve both as the basis for the Laboratory's management plan for ES&H and infrastructure and as a maintenance planning aid.

Highlights of Argonne's environmental vulnerability assessment include the following:

- Argonne has used disciplined practices for waste disposal from the earliest days.
- Minor shallow-groundwater and soil contamination by tritium exists near the CP-5 Reactor.
- At Argonne-West, no on-site disposal (other than that associated with settling ponds) has occurred. Previous spills and releases are fully documented in the Idaho RCRA Part B permit.
- Further data will be required to understand fully the potential for lateral and vertical migration in subsurface water flows at Argonne-East. An FY 1998 study concluded that flow patterns in the bedrock aquifer might have been driven by local pumping practices prior to 1996, when the Laboratory shifted from well water to Lake Michigan water.

Argonne is closely following the development of planning for external regulation of the Laboratory by the Occupational Safety and Health Administration and the Nuclear Regulatory Commission. DOE has indicated that it may ask Argonne-East to participate in a pilot evaluation of external regulation by the two agencies.

Decontamination and decommissioning (D&D) of the CP-5 Reactor at Argonne-East is serving as a test bed for new D&D technologies through demonstrations being performed in concert with industry. D&D of the JANUS reactor in Building 202 began in January 1997.

C. Site and Facilities

Situation

Argonne National Laboratory conducts basic and technology-directed research at two sites owned by DOE. Argonne-East is located on a 1,500-acre site in DuPage County, Illinois, about 25 miles southwest of Chicago. Argonne-West, located on an 800-acre tract within INEEL, about 35 miles west of Idaho Falls, Idaho, is devoted mainly to R&D on nuclear technologies and nuclear environmental management.

Argonne-East contains 4.8 million square feet of floor space, which includes 109,000 square feet of leased external commercial space. The estimated current plant replacement value is approximately $1.7 billion. Argonne-West contains 581,000 square feet of floor space, with an estimated replacement value of $366 million. Space at Argonne-East, which accommodates roughly 6,000 persons (including DOE employees, contractor personnel, and guest/user personnel), is more than 97% occupied.

The principal challenges facing both Argonne sites stem from normal aging of buildings and infrastructure and substantial needs for updating. At Argonne-East, nearly two-thirds of the facilities are more than 30 years old. The aging of these facilities, coupled with increasingly tight funding, has led to growing backlogs of maintenance, repair, and modernization needs. Approximately 40% of occupied Argonne-East facilities need rehabilitation or upgrades. Substandard facilities require replacement. Some of the facilities require partial D&D to make space available for future programs or to comply with environmental regulations. Utility systems at Argonne-East generally have adequate capacity for anticipated requirements, though some upgrades are needed for compliance with standards and increased reliability. At Argonne-West, recent renovations and continuing maintenance of major facilities are enabling pursuit of important DOE nuclear technology programs.

Mission and Goals

Argonne's site and facilities operations support the execution of world-class basic research and technology-directed research by providing reliable, efficient, cost-effective facilities offering work environments that are safe, healthful, and environmentally sound and that generally stimulate creativity and high productivity.

General goals are to improve effective use of existing facilities, to eliminate substandard facilities, and to upgrade strategic facilities and infrastructure.

Strategies

Argonne-East has managed its available building space very aggressively, particularly by employing a space use charge-back system. This incentive motivates efficient use of space and allows removal of larger amounts of substandard space. Demolition of substandard buildings and temporary trailers reduces operating and maintenance expenses, including the cost of purchased energy, and also eliminates unsightly areas. Many cleared sites have already been restored and made available for future Laboratory facilities. The Laboratory is preparing an FY 2001 line item funding request that will eliminate the remaining use of nearby off-site leased space.

Argonne-East has also upgraded or revitalized several strategic buildings, utility systems, and other infrastructure over the years. Included are modifications of existing facilities to accommodate new initiatives, increase ES&H acceptability, increase reliability, save energy, and replace obsolete building systems that require excessive maintenance.

Argonne-East regularly uses a Condition Assessment Survey to evaluate the baseline condition of all facilities. The site has an on-line system for maintenance control and reporting that facilitates better planning of work, tighter control of resources, and more accurate measurement of results.

Argonne recognizes the contributions that an appropriate setting can make to a world-class research facility. Natural-habitat areas of Argonne-East are maintained as buffers and for future expansion. Development in all areas of the East site is subjected to standards for building intensity, coverage, and open space.

At Argonne-West, the demand for hot cell and laboratory facility space is particularly high. A major focus is providing the facilities and infrastructure needed to deal with spent fuel and nuclear waste (for the electrometallurgical fuel treatment program, for example).

Historically, Argonne has received insufficient capital funds to rehabilitate, modernize, and preserve existing facilities. Several DOE programs provide capital funding: general plant project, general purpose equipment, Multiprogram Energy Laboratories — Facilities Support, and Environmental Management. This DOE funding allows the Laboratory to address its most urgent needs to upgrade its physical plant, meet safety and environmental standards, and decontaminate facilities. Particularly needed are additional funds for general purpose equipment and plant rehabilitation, in order to offset the normal effects of aging, to accommodate evolving scientific programs, to satisfy environmental and safety regulations, and to take advantage of new technology and associated new standards.

Efficient integration of facilities and infrastructure management at Argonne-East have been hampered by fragmentation of funding sources. The Laboratory recommends that funding be coordinated through a single point of authority. A unified champion for the Laboratory could act as an ombudsman on the Laboratory's behalf and coordinate needs and applications for funds among various sources.

Argonne manages its assets in consonance with the Life Cycle Asset Management process. More generally, the Laboratory's formal planning processes have the flexibility to accommodate changing missions and directives. Both Argonne sites maintain long-range plans for needed facilities upgrades and for infrastructure rehabilitation. Energy conservation and cost reduction are priorities; a number of strategies are being pursued to further reduce energy consumption and associated costs, including energy savings performance contracting.

Argonne-East is planning replacement facilities to increase the efficiency of its receiving, storage, distribution, and shipping of materials and goods, for both intrasite shipments and those crossing the Laboratory's boundaries, and also to facilitate removal of the last cluster of outmoded Quonset huts and their supporting facilities. Further plans call for replacement and removal of temporary modular office facilities on the site and the rehabilitation or upgrading of other facilities and infrastructure. High priority is attached to continuation of ongoing projects for life safety, environmental remediation, and D&D of closed facilities such as reactors and hot cells.

D. Information Management

Situation

Information management at Argonne emphasizes the effective development, communication, and management of scientific, technical, operational, and administrative information. Because of the importance of information management and its associated infrastructure, the two are managed both as integral parts of research programs and as institutional resources.

Within Argonne's research programs, scientific and technical information is acquired, created, and communicated in a fashion customized to programmatic objectives. Through this decentralized approach, life-cycle management of programmatic information is tightly interwoven with the underlying research in order to meet sponsors' expectations. Laboratory programs are also major users of scientific and technical information generated elsewhere, as well as users of internal administrative and operational data. Effective management of business information is also crucial for support organizations.

Argonne provides a wide range of central services to support the electronic and traditional collection, creation, dissemination, and archiving of R&D and operations information. Service organizations also operate a Laboratory-wide electronic information infrastructure via a spectrum of systems and services for software development and application, telecommunications, and computing. Strategic planning, funding, and coordinated management for the Laboratory's information infrastructure and systems are addressed collaboratively by policy and planning bodies that are supported by review and implementation teams.

To ensure that the infrastructure evolves as required to support programmatic needs, Argonne leads or collaborates in various national initiatives in networking and telecommunications, particularly through pilot projects that test the applicability of new information technologies to DOE-funded R&D. The Laboratory maintains national network connections, such as ESnet (the DOE-Energy Research network) and MREN (a high-speed test network in the Chicago metropolitan area). These external networks interface with local Argonne networks and help to position the Laboratory as a major player in national networking initiatives.

Vision

Argonne will maintain high-performance, cost-effective infrastructure and services in computing and information management. These capabilities will support excellence and efficiency in the Laboratory's R&D programs and operations by providing for efficient use of text, data, video, sound, and graphics in all media. At the two major Argonne sites, information infrastructure and services will be provided by support organizations dedicated to helping all Laboratory organizations find, use, and communicate information effectively. Employees will be proficient in the computer-related skills needed to realize the potential of the Laboratory's information systems.

Goals

The primary goal of Argonne's information management efforts is to maximize the ease and effectiveness with which information is acquired, created, modified, stored, retrieved, and applied, both within the Laboratory and with the Laboratory's partners in government, academia, and the private sector. Supporting strategic goals call for Laboratory operations organizations to

- Maintain an efficient, standards-based infrastructure for communications, computer networking, and information systems;
- Coordinate communications and networking services that support both internal and external information exchange;

- Conduct education programs that upgrade the computer literacy and skills of Laboratory employees;
- Maintain strong core competencies in the emerging and current information technologies that enable timely deployment of systems and services tailored to mission needs; and
- Evaluate emerging information technologies through aggressive use of demonstrations and pilot projects.

Strategies

Argonne's near-term strategies for information management focus on the Laboratory's needs for (1) secure, high-performance telecommunications and networking infrastructure and (2) high-quality Laboratory-wide information systems and services.

The Emerging Telecommunication Act of 1993 requires that, by 2005, all radio frequency allocations and spectrum-dependent radio equipment conform to new narrowband frequency standards. Moving to digital radio trunking systems will meet this mandate but will require the Laboratory to upgrade all of its radio equipment, at a cost of about $2.5 million.

For telephone services beyond FTS2000, Argonne plans to take full advantage of competitive market forces to provide cost-effective voice, data, and video network services that can be reconfigured quickly if any single carrier fails. Carriers will be encouraged to provide all these services via dedicated fiber-optic cable. To ensure compatibility and maximum flexibility in meeting future needs, Laboratory strategies call for deploying an internal telecommunications architecture based on standards widely supported by the commercial telephone service providers for their high-speed interconnections. Included in these plans is the eventual replacement of the Laboratory's central telephone switch by merging its functions with the advanced network switching technologies being deployed to address overall telecommunications needs in an integrated way, a trend already apparent in commercial communications.

Networking facilities at Argonne-East include various high-speed network architectures operating on a fiber-optic cable plant. The current cable plant will allow deployment of standard technologies to support bandwidths into the gigabit-per-second range. Test beds based on appropriate standards, already in place at the Laboratory, ensure Argonne's interoperability with other DOE sites and commercial service providers. In support of DOE's Information Architecture Initiative, Argonne actively participates in DOE standards committees and task groups. In FY 1999 the Laboratory will complete an ongoing program to ensure uninterrupted operation of networking facilities at both Argonne sites at the turn of the century.

Argonne is working with the National Energy Research Supercomputer Center and several other national laboratories and agencies to develop cross-realm authentications for the ESnet wide-area network and the emerging next-generation Internet. Argonne is also participating in a DOE pilot project to demonstrate high-performance network environments linked across dedicated commercial interconnections, in preparation for the advanced fast-packet-switching services that will soon be offered generally via ESnet. These advanced networking initiatives are particularly important as infrastructure for high-performance computing programs at the Laboratory and for providing convenient access to user facilities such as the Advanced Photon Source.

The Laboratory operates a suite of central information systems to manage administrative and operational data in the areas of finance, human resources, procurement, libraries, publications and records tracking, facilities, environmental protection, and employee health and safety. These systems are developed under Argonne's *Administrative Computing Strategic Plan*, which is prepared annually by an oversight committee comprising senior management representatives from programmatic and operations organizations. These Laboratory-wide information systems operate in an integrated client-server environment on UNIX servers and desktop computers, after a multiyear transition from mainframe-based systems that was completed in FY 1998. The Laboratory's continuing strategy is to use commercially available applications software to the greatest extent possible in administrative and operational systems. In FY 1999, the Laboratory will continue to streamline and automate business processes to take full advantage of the capabilities of current information system software. An ongoing process to ensure that these central systems properly process dates in the next century will also be completed in FY 1999. New initiatives will improve Laboratory-wide access to data supporting both R&D and operations functions and will more fully implement electronic commerce in the Laboratory's business activities.

A key near-term strategy for simplifying user access to operational and administrative information is expanded use of World Wide Web interfaces to the Laboratory's business systems. Argonne's ongoing development of electronic document capabilities is emphasizing conversion of Laboratory manuals to Web-compatible digital forms, enhancement of browsing and search tools for scientific and technical information, and acquisition of electronic journals and reference sources constituting a "virtual library." Finally, because Argonne's R&D programs are increasingly publishing their results primarily in digital form, the Laboratory's support organizations will continue to exploit the most effective electronic media available for dissemination of scientific and technical information.

E. Operations, Infrastructure, and Technical Support Management Practices: Goals and Strategies

In its consideration of governance and organization issues affecting DOE and its national laboratories, the Galvin Task Force report states that "in private industry it is virtually axiomatic that a dedicated, empowered quality program will generate better than 20% cost improvements with greater values in significantly improved quality of output of services, engineering, and product." In that spirit and with the establishment of the University's new incentivized, performance-based contract for the management and operation of the Laboratory, Argonne has been aggressively developing and applying management practices to help achieve the highest possible quality in its work, maximize efficiency and productivity, and reduce operating costs. Goals, strategies, and plans are in place to improve business and operations, to expand and strengthen communications and outreach, to measure and manage performance, and to reduce overhead costs and improve productivity.

1. Improving Business and Operational Practices

Achievement of Argonne's vision for operations and infrastructure implies continuous improvement in the Laboratory's operations. The quality and cost-effectiveness of business and operational practices contribute directly to success in performing R&D missions and in providing value to sponsors, customers, and stakeholders. In general, Argonne's goal is best-in-class status in business and operational practices, viewed both from DOE's perspective as the steward of public funds and from the perspective of U.S. industry and other users of the Laboratory's research. More specifically, key goals are to improve functional work processes, to reduce cycle times, and to eliminate tasks that do not add value. Increasingly, critical metrics are used to track, benchmark, and assess performance and to identify opportunities for improvement.

Strategies for improving Argonne's business and operational practices require both a methodology and a means of implementation. The Laboratory's methodology is based on organizational analysis. For a given work process, this methodology involves establishing benchmarks, identifying the baseline of current practice, comparing Argonne's practices with those of other organizations to help establish goals for improvement, and analyzing the current process in depth to identify specific improvements that are possible within the constraints of statutory requirements and available resources.

Across all of Argonne's operations, work processes are being assessed, and improvements are being implemented. Benchmarking has enabled streamlining and efficiencies for building maintenance, vehicle maintenance, the mailroom, utility systems, and grounds maintenance. Outsourcing has improved quality and cost-effectiveness for water supply, elevator maintenance, and architecture and engineering services. Further outsourcing is under review. A new computerized procurement system — the Procurement and Requisition Integrated System — is being implemented to automate subcontracting and replace more labor-intensive systems, to simplify procurement processes, to coordinate data from multiple sources, and to support related business functions.

2. Communications and Outreach

In order to conduct its R&D operations efficiently and effectively, Argonne must have the confidence and support of its customers and stakeholders, its neighbors, and its employees. Accordingly, the Laboratory takes special care to maintain close, positive relationships with these people and to foster a climate of mutual trust. This effort involves constant attention to two-way communications that are accurate, clear, timely, and credible. An active and growing outreach program seeks to inform Argonne's constituents about the Laboratory's work and to involve them constructively in its activities.

Argonne's external communications involve news media relations; a highly regarded World Wide Web site; distribution of publications; hosting of community affairs activities, site tours, open houses, and other special events; speeches by Laboratory staff to external audiences; and a vast array of Laboratory-sponsored conferences and seminars. Internal communications use employee newsletters, a growing intranet, sitewide electronic mail broadcasts, colloquia featuring renowned speakers, and a telephone "INFO-line," as well as a variety of special employee events. An annual highlight is the "State of the Laboratory" address by Argonne's director.

Argonne has worked closely with DOE-Chicago Operations and its Argonne Group to establish a series of monthly meetings with representatives of communities neighboring Argonne-East. This highly successful Community Leaders Roundtable keeps Argonne's neighbors informed about the Laboratory's activities and expected impacts on the surrounding area and provides an informal vehicle for feedback.

Comprehensive employee surveys conducted in 1996 and 1997 have guided planning to enhance Argonne's internal communications. Already under way is an expanded Laboratory intranet including employee manuals and even an interactive suggestion box. Current initiatives to enhance external communications and outreach include promoting the new Argonne Information Center, which houses exhibits depicting Argonne's history of accomplishment, current R&D programs, and environmental management activities. The Center will become the centerpiece for an expanded visitor program that will bring thousands of students, teachers, and other neighbors to Argonne each year.

Argonne is helping corporations and other organizations conducting research at the Advanced Photon Source to publicize their research initiatives and findings. The Laboratory is also increasing the number of its news releases and other outreach efforts to the general science news media. At the same time, traditional techniques such as representation at press briefings and professional meetings are being pursued more intensively.

Throughout the past half century, Argonne has benefited from unusually strong community support, positive news media relations, and strong management commitment to communications and outreach. Current strategies in communications and outreach, outlined above, are designed to build on those successes.

3. Measuring Performance

The current *Prime Contract*, effective through September 1999, requires systematic measurement of the Laboratory's performance. After completion of the second year under this contract on September 30, 1997, Argonne sees strong evidence that performance evaluation motivates and facilitates continuous improvement in support operations much more effectively than compliance-based approaches. The Laboratory's measured performance, in both research programs and support operations, determines the performance fee that the University receives, as well as a bonus pool for employees. The performance-based contract for Argonne is a coordinated part of DOE's comprehensive Strategic Management System, which uses performance as the common link that meshes interrelated budgeting and program evaluation processes.

a. Scientific and Technical Programs

Argonne's science and technology programs received an overall performance rating of "outstanding" (the highest possible) in FY 1997, the second year of the current performance-based *Prime Contract*. This rating was developed by DOE's Argonne Group, on the basis of appraisals of the Laboratory's work by the several DOE program offices that are major sponsors. The several individual program ratings were weighted by funding level to determine the overall rating in science and technology.

The rating from each DOE program office was based on separate ratings for science performance and for technology performance, relative to criteria specified in the *Prime Contract*. The goals and success indicators used to evaluate science differ appropriately from those used to evaluate technology.

Despite the formality of the DOE evaluation process, the very nature of scientific inquiry — its complexity, duration, and examination of the unknown — limits the relevance of narrowly quantitative criteria for evaluating the quality of scientific research. Review by scientific peers has long been understood to be the most reliable basis for guiding and evaluating research. In addition to the DOE reviews, visiting committees (under the auspices of the Board of Governors for Argonne appointed by the University of Chicago) review each of the Laboratory's major science and technology programs on a cycle of 12 to 24 months. Committee members are drawn from the external scientific, engineering, and business communities. The reviews are valuable guides for individual research programs and for Laboratory management.

b. Support Operations

Argonne's support operations encompass administrative, business, and technical support for science and technology programs; management and operation of the physical plant, along with construction of new facilities; and management of environmental compliance, safety, and health programs. Altogether, 15 functional areas are distinguished within support operations, ranging from affirmative action and diversity to "work for others" (i.e., work for non-DOE sponsors). Distinctive goals, success indicators, and performance measurements developed for each area are included in the *Prime Contract*.

At the end of the second year under the current *Prime Contract*, the University of Chicago delivered to DOE a narrative and quantitative self-assessment of Laboratory support operations based on results for 59 contractual performance measures. These results provided the major basis for DOE's annual appraisal of support operations, which yielded an overall rating of "excellent." DOE's rating agreed with Argonne's self-assessment in all areas but one.

4. Overhead Cost Reduction and Improved Productivity

For more than a decade, Argonne has maintained a disciplined, methodical system for reviewing and controlling overhead costs. The Laboratory's overhead management process has contributed significantly to achievement of a relatively flat overhead rate over the past several years, a time when DOE initiatives exerted great cost pressure. This systematic, detailed, bottom-up process involves scientific and operations managers in establishing a budget for each nondirect functional area. Through this process, the Laboratory has been able to reduce its overhead cost ratio from 22.4% in FY 1994 to 19.2% in FY 1998. A contract performance measure established in FY 1997 directly rates the Laboratory's success in achieving this objective.

Under the *Prime Contract*, Argonne is responsible for developing and implementing its own personnel policies and procedures. The Total Compensation Cost Containment Pilot Program gives the Laboratory the flexibility needed to control cost growth through containment of staffing levels, pay, and benefits while at the same time improving its performance. A significant feature of the program is reduced DOE involvement in Laboratory staffing and compensation management, such as elimination of approval requirements.

Argonne's accomplishments in containing overhead costs and in maintaining an efficient balance between scientific and support personnel reflect sustained efforts over the past decade. Table V.1 summarizes Argonne's current status and future objectives in terms of DOE's three high-level productivity metrics. The third metric described, average operating cost per research FTE, can be used to project the Laboratory's cumulative indirect cost savings of $99 million over the six years from FY 1994 through FY 2000, which contribute toward meeting the Secretary's $1.4 billion "Galvin savings" goal for the DOE laboratories.

Table V.1 shows the significant progress that Argonne has already achieved in increasing its productivity, along with goals for further improvement over the next three years through current initiatives in overhead cost reduction and efficiency improvement. In the context of expected declines in constant-dollar expenditures at the Laboratory, Argonne's productivity improvement strategy aims to stabilize the Laboratory's scientific workforce and, as much as possible, to accommodate expected reductions through increasing efficiency and effectiveness in overhead and technical support services. An overall reduction of about 8% in administration, business, operations, and technical support was achieved in FY 1998. The target for the next two years is to hold support costs constant, which promises to slightly improve a research-to-support ratio that is already highly favorable. The Laboratory's favorable average cost per researcher, already among the lowest for a DOE multiprogram laboratory, is targeted to remain steady over the next three years, maintaining a level in FY 2000 that is more than 5% lower than that in the baseline year of FY 1994, measuring in constant dollars.

Table V.1 Productivity Metrics

	Actual Values					Objectives	
	FY94	FY95	FY96	FY97	FY98	FY99	FY00
Research-to-Support (Labor Dollar) Ratio[a]	2.10	2.20	2.20	2.20	2.30	2.30	2.30
Technical Labor on Research (%)[b]	86.0	84.6	85.0	86.0	87.0	85.0	85.0
Average Operating Cost per Research FTE[c]	137.5	134.1	131.8	130.3	130.4	131.0	131.0

[a]Research labor dollars divided by support labor dollars.

[b]Technical labor dollars divided by research labor dollars, multiplied by 100.

[c]Thousands of FY 1994 dollars per year per FTE.

VI. Resource Projections

The resource projections in this chapter are considered a reasonable baseline for planning the desired future of the Laboratory and for addressing important contingencies, particularly those associated with increasingly stringent federal budgets. The projections do not necessarily represent the outcome that the Laboratory considers most likely.

The projections show levels of activity at Laboratory, program, and subprogram levels. The resources required for Argonne's initiatives for years beyond FY 1998 generally are not included in these resource projections. Funds received in FY 1997 and FY 1998 for initiatives are included in the funding levels shown for those years. Only funded and budgeted construction projects are included in the tables, except in Tables VI.1 and VI.20, which also specify funding for proposed construction projects.

The figures for FY 1997 represent historical dollar values. The FY 1998 figures are midyear projections in current dollars. Projections to FY 1999 incorporate annual cost escalation of 4.0% for effort and 3.4% for materials and services. Escalation rates for FY 2000 are, respectively, 5.3% and 3.4%. Operating costs beyond FY 2000 are expressed in FY 2000 dollars.

The year-to-year escalation rates for construction costs, from FY 1999 to FY 2004, are provided by DOE.

The resource projections are presented in 20 tables:

- Tables VI.1 and VI.2 summarize Laboratory total funding and personnel levels, respectively.
- Tables VI.3-VI.19 give operating, capital equipment, and construction funding along with personnel levels for each subprogram within specified DOE secretarial offices and for work supported by non-DOE agencies. Tables VI.3-VI.16 describe work funded by DOE, Table VI.17 lists work funded by DOE contractors, and Tables VI.18 and VI.19 pertain to

work funded by all other organizations.

- Table VI.20 summarizes the information in Tables VI.3-VI.19, giving total Laboratory funding for each DOE secretarial office.

Table VI.1 Laboratory Funding Summary ($ in millions BA)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
DOE Effort	376.8	363.0	397.7	425.3	419.0	424.5	420.0	423.4
Work for Others (WFO) Program	61.0	69.6	73.9	72.9	71.2	71.0	71.0	71.0
Additional Work for Non-DOE Organizations	9.3	19.7	4.0	3.5	3.5	3.5	3.5	3.5
Total Operating	447.1	452.3	475.6	501.7	493.7	499.0	494.5	497.9
Capital Equipment	14.6	13.6	17.6	20.5	20.3	20.3	20.8	20.8
Construction	8.0	3.1	3.5	0.0	0.0	0.0	0.0	0.0
Inventory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Purpose Equipment	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
General Plant Projects	6.6	5.1	4.8	8.0	8.9	9.3	9.8	10.2
Multiprogram Energy	4.8	10.8	7.2	4.6	1.1	0.0	0.0	0.0
Laboratories — Facilities								
Support Program								
Total Laboratory Funding	483.1	486.9	510.9	537.0	526.2	530.8	527.3	531.1
Proposed Projects:								
Program Construction	0.0	0.0	0.0	12.4	9.4	6.8	15.8	35.8
Multiprogram Energy	0.0	0.0	0.0	4.4	35.1	34.3	26.5	28.0
Laboratories — Facilities								
Support Program								
Total Projected Funding	483.1	486.9	510.9	553.8	570.7	571.9	569.6	594.9

Table VI.2 Laboratory Personnel Summary (in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Direct Personnel								
DOE Effort	2084.0	1947.9	1949.8	1982.2	1931.7	1919.4	1912.4	1919.4
Work for Others (WFO) Program	332.7	320.2	312.1	307.2	294.2	291.7	291.7	292.2
Additional Work for Non-DOE Organizations	15.7	13.9	14.0	14.0	14.0	14.0	14.0	14.0

Total Operating	2432.4	2282.0	2275.9	2303.4	2239.9	2225.1	2218.1	2225.6
Other Direct[a]	543.7	524.5	522.9	529.3	514.6	511.2	509.6	511.3
Total Direct Personnel	2976.1	2806.5	2798.8	2832.7	2754.5	2736.3	2727.7	2736.9
Indirect Personnel	1468.7	1423.3	1418.8	1436.2	1396.4	1387.1	1382.7	1387.4
Total Personnel	4444.8	4229.8	4217.6	4268.9	4150.9	4123.4	4110.4	4124.3

[a]Other direct personnel for FY97 and FY98 include an estimated 400 technical service FTEs that are not included in the detailed program tables. Projections for later years are adjusted similarly.

Table VI.3 Energy Research: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Fusion Energy Sciences (AT)								
Operating	2.5	2.8	3.1	3.4	3.4	3.4	3.4	3.4
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
Total	2.5	2.8	3.1	3.4	3.4	3.4	3.4	3.4
Direct Personnel	10.8	12.0	12.0	14.0	14.0	14.0	14.0	14.0
Facility Operations (KA-02)								
Operating	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	1.0	1.6	2.0	2.7	2.7	2.7	2.7	2.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.1	1.6	2.0	2.7	2.7	2.7	2.7	2.7
Direct Personnel	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Research and Technology (KA-04)								
Operating	7.7	7.4	7.9	9.2	9.2	9.2	9.2	9.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7.7	7.4	7.9	9.2	9.2	9.2	9.2	9.2
Direct Personnel	46.6	46.6	46.8	53.9	53.9	53.9	53.9	53.9
Total High Energy Physics (KA)								

Operating	7.8	7.4	7.9	9.2	9.2	9.2	9.2	9.2
Capital Equipment	1.0	1.6	2.0	2.7	2.7	2.7	2.7	2.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	8.8	9.0	9.9	11.9	11.9	11.9	11.9	11.9
Direct Personnel	46.7	46.6	46.8	53.9	53.9	53.9	53.9	53.9
Medium Energy Physics (KB-01)								
Operating	3.1	3.1	3.1	4.0	4.0	4.0	4.0	4.0
Capital Equipment	0.2	0.2	0.2	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
Total	3.3	3.3	3.3	4.3	4.3	4.3	4.3	4.3
Direct Personnel	20.6	17.4	17.4	22.4	22.4	22.4	22.4	22.4
Heavy-Ion Physics (KB-02)								
Operating	10.0	10.5	10.6	12.8	12.8	12.8	12.8	12.8
Capital Equipment	1.2	1.2	1.3	1.9	1.9	1.9	1.9	1.9
Construction	0.5	0.4	0.4	0.0	0.0	0.0	0.0	0.0
Total	11.7	12.1	12.3	14.7	14.7	14.7	14.7	14.7
Direct Personnel	63.3	66.8	66.3	71.5	71.5	71.5	71.5	71.5

Table VI.3 Energy Research: Resources by Subprogram (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Nuclear Theory (KB-03)								
Operating	0.9	0.9	0.9	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.9	0.9	0.9	1.2	1.2	1.2	1.2	1.2
Direct Personnel	7.1	7.0	7.0	8.3	8.3	8.3	8.3	8.3
Low Energy Physics (KB-04)								
Operating	0.3	0.3	0.4	1.1	1.1	1.1	1.1	1.1
Capital Equipment	0.0	0.0	0.0	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

Total	0.3	0.3	0.4	1.3	1.3	1.3	1.3	1.3
Direct Personnel	1.2	1.6	2.4	6.3	6.3	6.3	6.3	6.3
Total Nuclear Physics (KB)								
Operating	14.3	14.8	15.0	19.1	19.1	19.1	19.1	19.1
Capital Equipment	1.4	1.4	1.5	2.4	2.4	2.4	2.4	2.4
Construction	0.5	0.4	0.4	0.0	0.0	0.0	0.0	0.0
Total	16.2	16.6	16.9	21.5	21.5	21.5	21.5	21.5
Direct Personnel	92.2	92.8	93.1	108.5	108.5	108.5	108.5	108.5
Materials Sciences (KC-02)								
Operating	27.6	27.9	29.3	30.8	30.8	30.8	30.8	30.8
Capital Equipment	1.3	2.1	2.9	3.1	3.1	3.1	3.1	3.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	28.9	30.0	32.2	33.9	33.9	33.9	33.9	33.9
Direct Personnel	145.2	170.0	177.0	180.0	180.0	180.0	180.0	180.0
Advanced Photon Source (KC-02)								
Operating	75.9	76.8	81.6	94.0	94.0	94.0	94.0	94.0
Capital Equipment	2.5	2.6	2.6	5.5	5.5	5.5	5.5	5.5
Construction	3.0	2.9	3.1	0.0	0.0	0.0	0.0	0.0
Total	81.4	82.3	87.3	99.5	99.5	99.5	99.5	99.5
Direct Personnel	361.8	413.2	437.0	443.9	446.4	446.4	446.4	446.4
Total Materials Sciences (KC-02)								
Operating	103.5	104.7	110.9	124.8	124.8	124.8	124.8	124.8
Capital Equipment	3.8	4.7	5.5	8.6	8.6	8.6	8.6	8.6
Construction	3.0	2.9	3.1	0.0	0.0	0.0	0.0	0.0
Total	110.3	112.3	119.5	133.4	133.4	133.4	133.4	133.4
Direct Personnel	507.0	583.2	614.0	623.9	626.4	626.4	626.4	626.4
Chemical Sciences (KC-03)								
Operating	16.2	17.0	17.6	18.6	18.6	18.6	18.6	18.6
Capital Equipment	4.8	2.2	2.3	2.3	2.3	2.3	2.3	2.3

General Purpose Equipment	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	4.8	4.8	4.8	8.0	8.4	8.8	9.3	9.7
Total	27.8	26.0	26.9	31.1	31.5	31.9	32.4	32.8
Direct Personnel	79.7	82.0	85.5	90.0	90.0	90.0	90.0	90.0
Engineering and Geosciences (KC-04)								
Operating	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Capital Equipment	0.6	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
Total	1.2	1.1	0.8	0.8	0.8	0.8	0.8	0.8
Direct Personnel	2.5	4.8	4.3	4.3	4.0	4.0	4.0	4.0
Total Basic Energy Sciences (KC-02, KC-03, KC-04)								
Operating	120.3	122.4	129.1	144.0	144.0	144.0	144.0	144.0
Capital Equipment	9.2	7.3	8.0	11.1	11.1	11.1	11.1	11.1
General Purpose Equipment	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Construction	3.0	2.9	3.1	0.0	0.0	0.0	0.0	0.0
General Plant Projects	4.8	4.8	4.8	8.0	8.4	8.8	9.3	9.7
Total	139.3	139.4	147.2	165.3	165.7	166.1	166.6	167.0
Direct Personnel	589.2	670.0	703.8	718.2	720.4	720.4	720.4	720.4
Mathematical, Information, and Computational Sciences (KJ-01)								
Operating	12.3	12.8	12.8	18.0	19.0	25.0	30.0	33.0
Capital Equipment	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	12.8	13.3	13.3	18.5	19.5	25.5	31.0	34.0
Direct Personnel	34.3	40.0	40.0	50.0	50.0	60.0	65.0	70.0
Laboratory Technology Research (KJ-02)								
Operating	3.2	2.2	3.3	4.0	4.0	4.0	4.0	4.0
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	3.2	2.2	3.3	4.0	4.0	4.0	4.0	4.0

Direct Personnel	3.1	17.0	15.7	16.0	16.0	16.0	16.0	16.0
Advanced Energy Projects (KJ-03)								
Operating	1.5	1.1	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
Total	1.5	1.1	0.6	0.6	0.6	0.6	0.6	0.6
Direct Personnel	5.7	5.9	3.3	3.3	3.3	3.3	3.3	3.3
Total Computational and Technology Research (KJ)								
Operating	17.0	16.1	16.7	22.6	23.6	29.6	34.6	37.6
Capital Equipment	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	17.5	16.6	17.2	23.1	24.1	30.1	35.6	38.6
Direct Personnel	43.1	62.9	59.0	69.3	69.3	79.3	84.3	89.3
Life Sciences (KP-11)								
Operating	7.5	6.7	6.1	6.3	6.6	6.6	6.6	6.6
Capital Equipment	0.1	0.5	0.8	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
Total	7.6	7.2	6.9	6.9	7.2	7.2	7.2	7.2
Direct Personnel	41.0	42.3	38.6	39.1	39.1	39.1	39.1	39.1
Environmental Processes (KP-12)								
Operating	3.1	2.5	3.1	3.2	3.2	3.2	3.2	3.2
Capital Equipment	-0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.0	2.5	3.2	3.3	3.3	3.3	3.3	3.3
Direct Personnel	14.1	14.4	15.0	15.1	15.1	15.1	15.1	15.1
Environmental Remediation (KP-13)								
Operating	0.0	0.2	0.2	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
Total	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Direct Personnel	0.0	1.0	1.1	0.5	0.5	0.5	0.5	0.5
Total Biological and Environmental Research (KP)								
Operating	10.6	9.4	9.4	9.6	9.9	9.9	9.9	9.9
Capital Equipment	0.0	0.5	0.9	0.7	0.7	0.7	0.7	0.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	10.6	9.9	10.3	10.3	10.6	10.6	10.6	10.6
Direct Personnel	55.1	57.7	54.7	54.7	54.7	54.7	54.7	54.7
Total University and Science Education (KT)								
Operating	0.0	0.0	1.3	2.6	2.6	2.6	2.6	2.6
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
Total	0.0	0.0	1.3	2.6	2.6	2.6	2.6	2.6
Direct Personnel	5.7	0.0	3.6	7.2	7.2	7.2	7.2	7.2
Total Energy Research								
Operating	172.5	172.9	182.5	210.5	211.8	217.8	222.8	225.8
Capital Equipment	12.1	11.3	12.9	17.4	17.4	17.4	17.9	17.9
General Purpose Equipment	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Construction	3.5	3.3	3.5	0.0	0.0	0.0	0.0	0.0
General Plant Projects	4.8	4.8	4.8	8.0	8.4	8.8	9.3	9.7
Subtotal	194.9	194.3	205.9	238.1	239.8	246.2	252.2	255.6
Direct Personnel	842.8	942.0	973.0	1025.8	1028.0	1038.0	1043.0	1048.0
Inventory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Multiprogram Energy Laboratories —	4.8	10.8	7.2	4.6	1.1	0.0	0.0	0.0
Facilities Support Program								
Total Energy Research	199.7	205.1	213.1	242.7	240.9	246.2	252.2	255.6

Table VI.4 Nuclear Energy, Science and Technology: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Nuclear Energy Research and Development (AF)								
Operating	87.5	88.0	102.7	101.4	100.1	100.1	100.1	100.1
Capital Equipment	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Construction (Modifications to Reactors)	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	1.5	0.0	0.0	0.0	0.5	0.5	0.5	0.5
Total	92.7	89.0	103.7	102.4	101.6	101.6	101.6	101.6
Direct Personnel	417.5	454.3	486.1	468.5	449.6	432.3	432.3	432.3
Uranium Programs Activities (CD-10)								
Operating	1.8	1.8	0.9	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
Total	1.8	1.8	0.9	0.6	0.6	0.6	0.6	0.6
Direct Personnel	14.6	9.4	5.6	3.8	3.8	3.8	3.8	3.8
Total Nuclear Energy, Science and Technology								
Operating	89.3	89.8	103.6	102.0	100.7	100.7	100.7	100.7
Capital Equipment	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Construction	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	1.5	0.0	0.0	0.0	0.5	0.5	0.5	0.5
Total	94.5	90.8	104.6	103.0	102.2	102.2	102.2	102.2
Direct Personnel	432.1	463.7	491.7	472.3	453.4	436.1	436.1	436.1

Table VI.5 Energy Efficiency and Renewable Energy: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Solar and Renewable Resource Technologies (EB)								
Operating	2.8	3.9	4.5	5.5	5.5	5.5	5.5	5.5
Capital Equipment	0.0	0.1	0.4	0.7	0.7	0.7	0.7	0.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Total	2.8	4.0	4.9	6.2	6.2	6.2	6.2	6.2
Direct Personnel	10.7	19.5	20.5	22.0	22.0	22.0	22.0	22.0
Building Technology, State and Community Sector (EC)								
Operating	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4
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
Total	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Direct Personnel	1.6	3.2	2.4	2.1	2.0	2.0	2.0	2.0
Industries of the Future (Specific) (ED-18)								
Operating	4.8	4.3	3.1	1.4	1.4	1.4	1.4	1.4
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
Total	4.8	4.4	3.1	1.4	1.4	1.4	1.4	1.4
Direct Personnel	16.4	22.0	16.5	8.0	8.0	8.0	8.0	8.0
Industries of the Future (Crosscutting) (ED-19)								
Operating	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4
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
Total	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Direct Personnel	0.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Other Industry Sector (Other ED)								
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	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Total Industry Sector (ED)								

Operating	5.0	4.7	3.5	1.8	1.8	1.8	1.8	1.8
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
Total	5.0	4.8	3.5	1.8	1.8	1.8	1.8	1.8
Direct Personnel	17.5	24.2	18.5	10.0	10.0	10.0	10.0	10.0

Table VI.5 Energy Efficiency and Renewable Energy: Resources by Subprogram (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Technology Deployment (EE-01)								
Operating	1.1	0.6	0.4	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
Total	1.1	0.6	0.4	0.6	0.6	0.6	0.6	0.6
Direct Personnel	4.7	3.6	1.8	2.1	2.1	2.1	2.1	2.1
Advanced Automotive Technologies (EE-02)								
Operating	7.4	9.7	10.7	14.8	14.8	14.8	14.8	14.8
Capital Equipment	0.4	0.2	2.1	0.7	0.7	0.7	0.7	0.7
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7.8	9.9	12.8	15.5	15.5	15.5	15.5	15.5
Direct Personnel	25.1	49.7	44.6	60.5	60.5	60.5	60.5	60.5
Advanced Heavy-Vehicle Technologies (EE-03)								
Operating	0.2	1.1	1.7	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	0.2	1.1	1.7	2.7	2.7	2.7	2.7	2.7
Direct Personnel	1.0	5.1	7.1	11.2	11.2	11.2	11.2	11.2
Transportation Materials Technologies (EE-04)								
Operating	1.1	1.2	1.7	2.1	2.1	2.1	2.1	2.1
Capital Equipment	0.0	0.2	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
Total	1.1	1.4	1.9	2.3	2.3	2.3	2.3	2.3
Direct Personnel	4.2	6.6	7.1	9.4	9.4	9.4	9.4	9.4
Implementation and Program Management (EE-09)								
Operating	1.1	1.0	0.8	1.1	1.1	1.1	1.1	1.1
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
Total	1.1	1.0	0.8	1.1	1.1	1.1	1.1	1.1
Direct Personnel	4.4	4.1	3.0	3.6	3.6	3.6	3.6	3.6
Total Transportation Sector (EE)								
Operating	10.9	13.6	15.3	21.3	21.3	21.3	21.3	21.3
Capital Equipment	0.4	0.4	2.3	0.9	0.9	0.9	0.9	0.9
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	11.3	14.0	17.6	22.2	22.2	22.2	22.2	22.2
Direct Personnel	39.4	69.1	63.6	86.8	86.8	86.8	86.8	86.8
Policy and Management (EH)								
Operating	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4
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
Total	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4
Direct Personnel	0.8	1.6	1.0	1.5	1.5	1.5	1.5	1.5
Total Energy Efficiency and Renewable Energy								
Operating	19.6	23.0	24.0	29.4	29.4	29.4	29.4	29.4
Capital Equipment	0.4	0.6	2.7	1.6	1.6	1.6	1.6	1.6
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	20.0	23.6	26.7	31.0	31.0	31.0	31.0	31.0
Direct Personnel	70.0	117.6	106.0	122.4	122.3	122.3	122.3	122.3

Table VI.6 Fossil Energy: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Coal (AA)								
Operating	1.6	1.4	1.7	1.9	1.9	1.9	1.9	1.9
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
Total	1.6	1.4	1.7	1.9	1.9	1.9	1.9	1.9
Direct Personnel	10.6	9.5	10.2	10.0	10.0	10.0	10.0	10.0
Gas (AB)								
Operating	1.6	1.9	2.2	2.2	2.2	2.2	2.2	2.2
Capital Equipment	0.0	0.1	0.4	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	1.6	2.0	2.6	2.2	2.2	2.2	2.2	2.2
Direct Personnel	6.2	12.3	10.0	9.9	9.9	9.9	9.9	9.9
Petroleum (AC)								
Operating	1.0	0.6	1.0	1.1	1.1	1.1	1.1	1.1
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
Total	1.0	0.6	1.0	1.1	1.1	1.1	1.1	1.1
Direct Personnel	1.6	6.3	4.5	4.5	4.5	4.5	4.5	4.5
Fuels Conversion, Natural Gas and Electricity (AU)								
Operating	0.0	0.1	0.3	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
Total	0.0	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Direct Personnel	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Fossil Energy Environmental Restoration (AW)								
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
Total	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Innovative Clean Coal Technology (AZ)								
Operating	-0.3	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	-0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table VI.6 Fossil Energy: Resources by Subprogram (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Total Fossil Energy								
Operating	3.9	4.2	5.2	5.5	5.5	5.5	5.5	5.5
Capital Equipment	0.0	0.1	0.4	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	3.9	4.3	5.6	5.5	5.5	5.5	5.5	5.5
Direct Personnel	19.3	29.6	25.7	25.4	25.4	25.4	25.4	25.4

Table VI.7 Environmental Management: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Environmental Restoration and Waste Management — Defense (EW)								
Operating	21.0	15.4	16.0	14.4	12.3	11.8	5.9	6.2
Capital Equipment	0.1	0.0	0.2	0.1	0.1	0.1	0.1	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	21.1	15.4	16.2	14.5	12.4	11.9	6.0	6.3
Direct Personnel	81.4	79.5	67.0	49.0	37.0	35.0	29.0	31.0

Environmental Restoration and Waste Management — Non-Defense (EX)								
Operating	28.3	18.3	20.2	17.3	16.2	16.1	12.5	12.6
Capital Equipment	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	1.8	-0.2	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total	30.6	18.5	20.3	17.4	16.3	16.2	12.6	12.7
Direct Personnel	99.1	98.0	78.0	76.0	70.0	69.0	63.0	63.0
Total Environmental Management								
Operating	49.3	33.7	36.2	31.7	28.5	27.9	18.4	18.8
Capital Equipment	0.3	0.1	0.3	0.2	0.2	0.2	0.2	0.2
Construction	1.8	-0.2	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total	51.7	33.9	36.5	31.9	28.7	28.1	18.6	19.0
Direct Personnel	180.5	177.5	145.0	125.0	107.0	104.0	92.0	94.0

Table VI.8 Defense Programs ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Defense Programs (DP)								
Operating	0.9	3.3	4.6	4.3	1.1	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.9	3.3	4.6	4.3	1.1	1.0	1.0	1.0
Direct Personnel	4.7	12.5	14.9	20.8	5.5	3.7	3.7	3.7

Table VI.9 Nonproliferation and National Security: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Nonproliferation and Verification R&D (GC)								
Operating	1.9	1.9	2.2	2.2	2.2	2.3	2.3	2.3

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
Total	2.0	1.9	2.2	2.2	2.2	2.3	2.3	2.3
Direct Personnel	7.7	11.9	11.2	10.8	10.6	10.6	10.6	10.6
Nuclear Safeguards and Security (GD)								
Operating	0.2	0.2	0.5	0.5	0.5	0.5	0.5	0.5
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
Total	0.2	0.2	0.5	0.5	0.5	0.5	0.5	0.5
Direct Personnel	0.4	2.1	2.5	2.3	2.3	2.1	2.1	2.1
Arms Control and Nonproliferation (GJ)								
Operating	9.9	11.2	13.5	12.6	12.7	12.8	12.8	12.8
Capital Equipment	0.3	0.3	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
Total	10.2	11.5	13.7	12.8	12.7	12.8	12.8	12.8
Direct Personnel	36.3	46.3	43.4	41.9	41.8	42.3	42.3	42.3
Emergency Management (ND)								
Operating	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	1.0	0.4	0.9	1.2	1.1	1.1	1.1	1.1
Nonproliferation and National Security Program Direction (NN)								
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	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0

Intelligence (NT)								
Operating	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
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
Total	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Direct Personnel	2.0	1.4	1.7	1.7	1.7	1.7	1.7	1.7

Table VI.9 Nonproliferation and National Security: Resources by Subprogram (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Total Nonproliferation and National Security								
Operating	12.4	13.7	16.7	15.9	16.0	16.2	16.2	16.2
Capital Equipment	0.4	0.3	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
Total	12.8	14.0	16.9	16.1	16.0	16.2	16.2	16.2
Direct Personnel	47.4	62.5	59.8	57.9	57.5	57.8	57.8	57.8

Table VI.10 Environment, Safety, and Health: Resources by Subprogram ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Environment, Safety, and Health — Non-Defense (HC)								
Operating	1.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Direct Personnel	7.5	9.1	6.5	6.5	6.5	6.5	6.5	6.5
Environment, Safety, and Health — Defense (HD)								
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
Total	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Direct Personnel	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Environment, Safety, and Health								
Operating	1.8	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.8	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Direct Personnel	7.6	9.1	6.5	6.5	6.5	6.5	6.5	6.5

Table VI.11 Civilian Radioactive Waste Management ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Waste Management System (DB)								
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	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table VI.12 Policy, Planning, and Program Evaluation ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Policy, Planning, and Program Evaluation (NA and PE)								
Operating	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	2.1	1.0	1.4	0.8	0.8	0.8	0.8	0.8

Table VI.13 Economic Impact and Diversity ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004

Minority Economic Impact Program (WA-50)								
Operating	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	0.7	1.0	0.9	0.9	0.9	0.9	0.9	0.9

Table VI.14 Fissile Materials Disposition ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Fissile Materials Disposition (GA)								
Operating	1.5	1.6	1.9	1.9	1.9	1.9	1.9	1.9
Capital Equipment	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.9	1.8	2.0	2.0	2.0	2.0	2.0	2.0
Direct Personnel	5.8	8.6	10.5	10.0	10.0	9.5	9.5	9.5

Table VI.15 Federal Energy Regulatory Commission ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Federal Energy Regulatory Commission (VR)								
Operating	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	0.1	0.3	0.8	0.8	0.8	0.8	0.8	0.8

Table VI.16 Energy Information Administration ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
National Energy Information System-NEIS (TA)								

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	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table VI.17 Work for Other DOE Contractors ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Operating	36.2	30.1	31.2	32.3	32.3	32.3	32.3	32.3
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
Total	36.2	30.1	31.2	32.3	32.3	32.3	32.3	32.3
Direct Personnel	152.6	122.5	113.6	113.6	113.6	113.6	113.6	113.6
Funds Transferred to Other DOE Contractors	-11.1	-11.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0

Table VI.18 Work for Others (WFO) Program ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
NUCLEAR REGULATORY COMMISSION								
Nuclear Regulatory Commission								
Operating	6.4	4.3	4.0	3.7	3.4	3.4	3.4	3.4
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
Total	6.4	4.3	4.0	3.7	3.4	3.4	3.4	3.4
Direct Personnel	26.0	19.1	17.9	15.8	14.0	14.0	14.0	14.0
DEPARTMENT OF DEFENSE								
Office of Secretary of Defense								
Operating	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	1.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1
U.S. Air Force								
Operating	2.0	3.3	2.6	2.6	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	2.0	3.3	2.6	2.6	2.7	2.7	2.7	2.7
Direct Personnel	12.4	16.0	13.0	13.0	13.0	13.0	13.0	13.5
The Joint Staff								
Operating	1.4	3.1	3.0	2.5	2.5	2.5	2.5	2.5
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
Total	1.4	3.1	3.0	2.5	2.5	2.5	2.5	2.5
Direct Personnel	6.2	8.0	5.0	5.0	5.0	5.0	5.0	5.0
U.S. Army								
Operating	12.9	10.5	13.0	12.0	12.0	12.0	12.0	12.0
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	12.9	10.5	13.0	12.0	12.0	12.0	12.0	12.0
Direct Personnel	71.6	52.0	65.0	63.0	63.0	63.0	63.0	63.0
Defense Special Weapons Agency								
Operating	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel	8.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0

Table VI.18 Work for Others (WFO) Program (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004

Defense Advanced Research Projects Agency								
Operating	4.0	3.0	2.5	2.5	2.4	2.1	2.1	2.1
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
Total	4.0	3.0	2.5	2.5	2.4	2.1	2.1	2.1
Direct Personnel	15.3	13.5	11.5	11.5	10.5	8.0	8.0	8.0
Strategic Defense Initiative								
Operating	0.6	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
Total	0.6	1.0	1.5	1.5	1.5	1.5	1.5	1.5
Direct Personnel	1.2	3.0	4.0	4.0	4.0	4.0	4.0	4.0
U.S. Marines								
Operating	0.0	0.1	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
Total	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
U.S. Navy								
Operating	1.0	1.1	0.5	0.5	0.5	0.5	0.5	0.5
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
Total	1.0	1.1	0.5	0.5	0.5	0.5	0.5	0.5
Direct Personnel	3.0	2.5	1.5	1.0	1.0	1.0	1.0	1.0
Other Defense								
Operating	0.0	0.7	1.2	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.7	1.2	1.2	1.2	1.2	1.2	1.2

Direct Personnel	0.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0
Total Department of Defense								
Operating	24.1	23.1	24.6	23.1	23.1	22.8	22.8	22.8
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	24.1	23.1	24.6	23.1	23.1	22.8	22.8	22.8
Direct Personnel	120.3	97.6	105.1	102.6	101.6	99.1	99.1	99.6

Table VI.18 Work for Others (WFO) Program (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
OTHER FEDERAL AGENCIES								
Environmental Protection Agency								
Operating	1.2	1.3	1.4	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.2	1.3	1.4	1.2	1.2	1.2	1.2	1.2
Direct Personnel	5.1	7.0	5.3	4.8	4.8	4.8	4.8	4.8
Federal Emergency Management Agency								
Operating	4.7	4.8	4.9	4.9	4.9	4.9	4.9	4.9
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
Total	4.7	4.8	4.9	4.9	4.9	4.9	4.9	4.9
Direct Personnel	21.2	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Department of State (International Atomic Energy Agency)								
Operating	2.0	1.9	1.5	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
Total	2.0	1.9	1.5	2.0	2.0	2.0	2.0	2.0

Direct Personnel	8.2	11.2	8.2	9.0	9.0	9.0	9.0	9.0
Department of Health and Human Services								
Operating	0.1	0.9	0.8	0.8	0.8	0.8	0.8	0.8
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.1	0.9	0.8	0.8	0.8	0.8	0.8	0.8
Direct Personnel	0.4	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Department of Transportation								
Operating	0.3	0.1	0.4	1.0	1.0	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	0.1	0.4	1.0	1.0	1.0	1.0	1.0
Direct Personnel	1.2	1.0	1.5	4.5	4.5	4.5	4.5	4.5

Table VI.18 Work for Others (WFO) Program (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Department of Agriculture								
Operating	5.1	7.4	7.6	7.6	7.6	7.6	7.6	7.6
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
Total	5.1	7.4	7.6	7.6	7.6	7.6	7.6	7.6
Direct Personnel	22.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0
National Science Foundation								
Operating	0.1	1.6	1.3	1.1	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
Total	0.1	1.6	1.3	1.1	0.1	0.1	0.1	0.1
Direct Personnel	1.0	11.7	9.7	8.5	0.5	0.5	0.5	0.5
National Aeronautics and Space Administration								

Operating	0.3	0.6	0.9	1.4	1.4	1.4	1.4	1.4
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
Total	0.3	0.6	0.9	1.4	1.4	1.4	1.4	1.4
Direct Personnel	2.3	2.0	3.0	5.0	5.0	5.0	5.0	5.0
Department of Commerce								
Operating	0.1	0.1	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
Total	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Direct Personnel	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Department of the Interior								
Operating	0.5	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	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Agencies								
Operating	0.6	4.3	3.3	3.4	3.1	3.2	3.2	3.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.6	4.3	3.3	3.4	3.1	3.2	3.2	3.2
Direct Personnel	3.2	20.8	15.8	16.0	15.2	15.2	15.2	15.2

Table VI.18 Work for Others (WFO) Program (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Total Other Federal Agencies								
Operating	15.0	23.0	22.2	23.5	22.2	22.3	22.3	22.3
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
Total	15.0	23.0	22.2	23.5	22.2	22.3	22.3	22.3

Direct Personnel	68.0	108.9	98.7	103.0	94.2	94.2	94.2	94.2
NONFEDERAL ORGANIZATIONS								
Electric Power Research Institute								
Operating	0.0	0.3	0.6	0.4	0.4	0.4	0.4	0.4
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
Total	0.0	0.3	0.6	0.4	0.4	0.4	0.4	0.4
Direct Personnel	0.0	1.5	2.2	2.0	2.0	2.0	2.0	2.0
Private Firms								
Operating	8.7	12.2	15.4	15.4	15.4	15.4	15.4	15.4
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
Total	8.7	12.2	15.4	15.4	15.4	15.4	15.4	15.4
Direct Personnel	45.7	75.0	72.4	69.3	67.9	67.9	67.9	67.9
Universities and State and Local Governments								
Operating	4.4	5.3	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	4.4	5.3	6.0	6.0	6.0	6.0	6.0	6.0
Direct Personnel	23.1	15.0	15.0	14.0	14.0	14.0	14.0	14.0
International Organizations and Foreign Countries								
Operating	2.4	1.4	1.1	0.8	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
Total	2.4	1.4	1.1	0.8	0.7	0.7	0.7	0.7
Direct Personnel	12.6	3.1	0.8	0.5	0.5	0.5	0.5	0.5
Total Nonfederal Organizations								

Operating	15.5	19.2	23.1	22.6	22.5	22.5	22.5	22.5
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
Total	15.5	19.2	23.1	22.6	22.5	22.5	22.5	22.5
Direct Personnel	81.4	94.6	90.4	85.8	84.4	84.4	84.4	84.4

Table VI.18 Work for Others (WFO) Program (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
TOTAL WORK FOR OTHERS (WFO) PROGRAM								
Operating	61.0	69.6	73.9	72.9	71.2	71.0	71.0	71.0
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	61.0	69.6	73.9	72.9	71.2	71.0	71.0	71.0
Direct Personnel	295.7	320.2	312.1	307.2	294.2	291.7	291.7	292.2

Table VI.19 Additional Work for Non-DOE Organizations[a] ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
CRADA Partners								
Operating	3.2	17.9	3.0	3.1	3.1	3.1	3.1	3.1
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
Total	3.2	17.9	3.0	3.1	3.1	3.1	3.1	3.1
Direct Personnel	15.2	13.8	14.0	14.0	14.0	14.0	14.0	14.0
Services to APS Users								
Operating	6.1	1.8	1.0	0.4	0.4	0.4	0.4	0.4
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
Total	6.1	1.8	1.0	0.4	0.4	0.4	0.4	0.4
Direct Personnel	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total Additional Work for Non-DOE Organizations								

Operating	9.3	19.7	4.0	3.5	3.5	3.5	3.5	3.5
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
Total	9.3	19.7	4.0	3.5	3.5	3.5	3.5	3.5
Direct Personnel	15.7	13.9	14.0	14.0	14.0	14.0	14.0	14.0

[a]Certain work performed by Argonne for non-DOE sponsors is not administered under the Laboratory's Work for Others (WFO) program and so is considered separately in this table. Included here are (1) funds received from cooperative R&D agreement (CRADA) partners and (2) funds received from collaborative access teams (CATs) at the Advanced Photon Source (APS) for services performed.

Table VI.20 Funding by Assistant Secretarial Office ($ in millions BA, personnel in FTE)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
DOE WORK								
Table VI.3 — Energy Research								
Operating	172.5	172.9	182.5	210.5	211.8	217.8	222.8	225.8
Capital Equipment	12.1	11.3	12.9	17.4	17.4	17.4	17.9	17.9
General Purpose Equipment	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Construction	3.5	3.3	3.5	0.0	0.0	0.0	0.0	0.0
General Plant Projects	4.8	4.8	4.8	8.0	8.4	8.8	9.3	9.7
Subtotal	194.9	194.3	205.9	238.1	239.8	246.2	252.2	255.6
Inventory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Multiprogram Energy Laboratories —	4.8	10.8	7.2	4.6	1.1	0.0	0.0	0.0
Facilities Support Program								
Total Energy Research	199.7	205.1	213.1	242.7	240.9	246.2	252.2	255.6
Direct Personnel	842.8	942.0	973.0	1025.8	1028.0	1038.0	1043.0	1048.0
Table VI.4 — Nuclear Energy, Science and Technology								
Operating	89.3	89.8	103.6	102.0	100.7	100.7	100.7	100.7
Capital Equipment	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Construction	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	1.5	0.0	0.0	0.0	0.5	0.5	0.5	0.5
Total	94.5	90.8	104.6	103.0	102.2	102.2	102.2	102.2
Direct Personnel	432.1	463.7	491.7	472.3	453.4	436.1	436.1	436.1

Table VI.5 — Energy Efficiency and Renewable Energy								
Operating	19.6	23.0	24.0	29.4	29.4	29.4	29.4	29.4
Capital Equipment	0.4	0.6	2.7	1.6	1.6	1.6	1.6	1.6
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	20.0	23.6	26.7	31.0	31.0	31.0	31.0	31.0
Direct Personnel	70.0	117.6	106.0	122.4	122.3	122.3	122.3	122.3
Table VI.6 — Fossil Energy								
Operating	3.9	4.2	5.2	5.5	5.5	5.5	5.5	5.5
Capital Equipment	0.0	0.1	0.4	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	3.9	4.3	5.6	5.5	5.5	5.5	5.5	5.5
Direct Personnel	19.3	29.6	25.7	25.4	25.4	25.4	25.4	25.4
Table VI.7 — Environmental Management								
Operating	49.3	33.7	36.2	31.7	28.5	27.9	18.4	18.8
Capital Equipment	0.3	0.1	0.3	0.2	0.2	0.2	0.2	0.2
Construction	1.8	-0.2	0.0	0.0	0.0	0.0	0.0	0.0
General Plant Projects	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total	51.7	33.9	36.5	31.9	28.7	28.1	18.6	19.0
Direct Personnel	180.5	177.5	145.0	125.0	107.0	104.0	92.0	94.0

Table VI.20 Funding by Assistant Secretarial Office (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Table VI.8 — Defense Programs								
Operating	0.9	3.3	4.6	4.3	1.1	1.0	1.0	1.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.9	3.3	4.6	4.3	1.1	1.0	1.0	1.0
Direct Personnel	4.7	12.5	14.9	20.8	5.5	3.7	3.7	3.7
Table VI.9 — Nonproliferation and National Security								

Operating	12.4	13.7	16.7	15.9	16.0	16.2	16.2	16.2
Capital Equipment	0.4	0.3	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
Total	12.8	14.0	16.9	16.1	16.0	16.2	16.2	16.2
Direct Personnel	47.4	62.5	59.8	57.9	57.5	57.8	57.8	57.8
Table VI.10 — Environment, Safety, and Health								
Operating	1.8	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.8	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Direct Personnel	7.6	9.1	6.5	6.5	6.5	6.5	6.5	6.5
Table VI.11 — Civilian Radioactive Waste Management								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Table VI.12 — Policy, Planning, and Program Evaluation								
Operating	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	2.1	1.0	1.4	0.8	0.8	0.8	0.8	0.8
Table VI.13 — Economic Impact and Diversity								
Operating	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Direct Personnel	0.7	1.0	0.9	0.9	0.9	0.9	0.9	0.9

Table VI.20 Funding by Assistant Secretarial Office (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Table VI.14 — Fissile Materials Disposition								
Operating	1.5	1.6	1.9	1.9	1.9	1.9	1.9	1.9
Capital Equipment	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.9	1.8	2.0	2.0	2.0	2.0	2.0	2.0
Direct Personnel	5.8	8.6	10.5	10.0	10.0	9.5	9.5	9.5
Table VI.15 — Federal Energy Regulatory Commission								
Operating	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Direct Personnel	0.1	0.3	0.8	0.8	0.8	0.8	0.8	0.8
Table VI.16 — Energy Information Administration								
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capital Equipment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Personnel	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Table VI.17 — Work for Other DOE Contractors								
Operating	36.2	30.1	31.2	32.3	32.3	32.3	32.3	32.3
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
Total	36.2	30.1	31.2	32.3	32.3	32.3	32.3	32.3
Direct Personnel	152.6	122.5	113.6	113.6	113.6	113.6	113.6	113.6
Funds Transferred to Other DOE Contractors	-11.1	-11.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0

TOTAL WORK FOR DOE PROGRAMS								
Operating	376.8	363.0	397.7	425.3	419.0	424.5	420.0	423.4
Capital Equipment	14.6	13.6	17.6	20.5	20.3	20.3	20.8	20.8
General Purpose Equipment	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Construction	8.0	3.1	3.5	0.0	0.0	0.0	0.0	0.0
General Plant Projects	6.6	5.1	4.8	8.0	8.9	9.3	9.8	10.2
Subtotal	408.0	386.8	425.8	456.0	450.4	456.3	452.8	456.6
Inventory	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Multiprogram Energy Laboratories — Facilities Support Program	4.8	10.8	7.2	4.6	1.1	0.0	0.0	0.0
Total	412.8	397.6	433.0	460.6	451.5	456.3	452.8	456.6

Table VI.20 Funding by Assistant Secretarial Office (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Table VI.18 —Work for Others (WFO) Program								
Operating	61.0	69.6	73.9	72.9	71.2	71.0	71.0	71.0
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	61.0	69.6	73.9	72.9	71.2	71.0	71.0	71.0
Direct Personnel	295.7	320.2	312.1	307.2	294.2	291.7	291.7	292.2
Table VI.19 —Additional Work for Non-DOE Organizations								
Operating	9.3	19.7	4.0	3.5	3.5	3.5	3.5	3.5
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
Total	9.3	19.7	4.0	3.5	3.5	3.5	3.5	3.5
Direct Personnel	15.7	13.9	14.0	14.0	14.0	14.0	14.0	14.0
TOTAL OPERATING FUNDING	447.1	452.3	475.6	501.7	493.7	499.0	494.5	497.9

TOTAL CAPITAL EQUIPMENT	14.6	13.6	17.6	20.5	20.3	20.3	20.8	20.8
TOTAL CONSTRUCTION	8.0	3.1	3.5	0.0	0.0	0.0	0.0	0.0

Table VI.20 Funding by Assistant Secretarial Office (Cont.)

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
TOTAL INVENTORY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL GENERAL PURPOSE EQUIPMENT	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
TOTAL GENERAL PLANT PROJECTS	6.6	5.1	4.8	8.0	8.9	9.3	9.8	10.2
TOTAL MULTIPROGRAM ENERGY LABORATORIES — FACILITIES SUPPORT PROGRAM	4.8	10.8	7.2	4.6	1.1	0.0	0.0	0.0
GRAND TOTAL LABORATORY FUNDING	483.1	486.9	510.9	537.0	526.2	530.8	527.3	531.1
TOTAL PROPOSED PROJECTS								
TOTAL PROGRAM CONSTRUCTION	0.0	0.0	0.0	12.4	9.4	6.8	15.8	35.8
TOTAL MULTIPROGRAM ENERGY LABORATORIES — FACILITIES SUPPORT PROGRAM	0.0	0.0	0.0	4.4	35.1	34.3	26.5	28.0
GRAND TOTAL PROJECTED FUNDING	483.1	486.9	510.9	553.8	570.7	571.9	569.6	594.9

- Appendix: Argonne in an Integrated DOE Laboratory System

Appendix: Argonne in an Integrated DOE Laboratory System

Cooperation among Argonne and the other DOE laboratories, particularly through direct R&D collaborations, continues to deepen. This integration of the DOE laboratory system is driven by several factors. The most pervasive is the emergence of new technologies that facilitate the long-distance communication needed for close coordination and now even allow some experiments to be controlled from anywhere in the United States. In response to new opportunities and accumulating experience, DOE managers increasingly are innovating with collaborative structures for the laboratories' performance of their programs. At the same time, experience and confidence with a widening range of collaborative approaches are accumulating at the laboratories. Seizing opportunities for increased interlaboratory collaboration and integration has been strongly endorsed by DOE advisory groups such as the Galvin Task Force and the external members of the Laboratory Operations Board.

A DOE R&D program can achieve effective integration across the national laboratories in different ways. The preferred approach depends largely on the nature of the science or technology development being undertaken and the distribution across the laboratory system of complementary R&D programs and other relevant capabilities. In simpler cases, a DOE program manager can achieve appropriate integration by first making nonduplicative project assignments that take advantage of the particular strengths of various laboratories and by then fostering sufficient communication among the laboratories so that their efforts remain coordinated. In other cases, greatly increased research productivity accrues when two or more laboratories work directly together on closely intermeshed projects or even on the same project. It is on these direct R&D collaborations among DOE laboratories that this discussion focuses. Laboratories that collaborate directly often enjoy considerable discretion to mutually choose research directions and complementary projects, within broad bounds set by the sponsoring DOE program office.

Table A.1 (presented at the end of this appendix) describes some of Argonne's more notable direct collaborations with other DOE laboratories. Brief summary descriptions in the table focus on how effective collaboration is achieved. Not included are detailed discussions of the value of the research and of which laboratory does which tasks. The table also does not describe the many routine ways that DOE laboratories cooperate, as when one laboratory simply provides technical services to another on the basis of its special capabilities. Omitted as well are major Argonne R&D collaborations that involve only partners outside the DOE laboratory system, though many of the included collaborations do, as noted, extend outside the system to universities and industrial firms.

Particularly notable among the collaborations described in Table A.1 is the Spallation Neutron Source (SNS) to be built at Oak Ridge National Laboratory, the highest priority of DOE's Office of Basic Energy Sciences among new research facility construction projects. Construction of the SNS by pooling the capabilities of five national laboratories represents the largest collaboration of this kind that the Department has ever undertaken. Total project cost for the facility is $1.33 billion.

Table A.1 is misleading if it suggests that interlaboratory collaboration is a remarkable exception. In a number of program areas at Argonne, interlaboratory collaboration tends to be the rule.

Interlaboratory collaboration is a way of life for Argonne's nuclear physics program. Table A.1 includes two notable current collaborations in heavy-ion nuclear physics and accelerator development: (1) operation of the Gammasphere detector and (2) research aimed at developing an advanced accelerator for radioactive nuclei. Another notable heavy-ion collaboration is the PHOBOS experiment at Brookhaven's Relativisitic Heavy Ion Collider (RHIC). In medium energy nuclear physics, Argonne provides leadership in collaborative research at the Hall C experimental area of the Thomas Jefferson National Accelerator Facility, for which Argonne earlier constructed the 400-ton Short-Orbit Spectrometer. Argonne also collaborates extensively in Fermi National Accelerator Laboratory (Fermilab) experiments using high-energy lepton and hadron probes to measure quark distributions in nuclei. All of these experimental collaborations involve many university researchers. A major international collaboration in which Argonne represents the DOE laboratory system is construction of the RICH Detector for the HERMES experiment at Germany's Deutsche Elektronen Synchrotron (DESY).

In high energy physics, large collaborations have become a necessity over the last three decades. Driving this trend have been the increasing size, complexity, and cost of detectors and other projects, along with an associated decline in the number of facilities. Table A.1 includes the four detector collaborations in which Argonne currently is working directly with other DOE laboratories: (1) the ATLAS detector at Europe's CERN; (2) the STAR detector at Brookhaven National Laboratory; (3) the MINOS detector, operated in conjunction with Fermilab; and (4) the long-standing Collider Detector at Fermilab (CDF). The CDF is notable for pioneering operational modes for very large international detector collaborations in high energy physics that originally had perhaps 300 members but today have as many as 1,700 (so that, for example, papers to be published are approved by all collaboration members and list all members as authors). As the current situation illustrates, Argonne's detector collaborations naturally include the host accelerator laboratory, which is often but not always a DOE laboratory. Argonne generally works closely with a group of universities to build a major detector component, while other laboratories lead the development of complementary components. Along with university partners, Argonne currently represents the DOE laboratory system in the large international ZEUS detector collaboration at DESY and in the Soudan 2 underground experiment located in Minnesota.

Argonne's computer scientists collaborate with many colleagues in other scientific and technical disciplines who face major computational challenges. Table A.1 features three such direct collaborations with other DOE laboratories, including (1) a DOE Grand Challenge project addressing the relativistic quantum chemistry of the actinide elements, (2) a "Clipper'' project to develop advanced network capabilities for distributed applications, and (3) an Advanced Visualization Technology Center for the large data sets that will be produced by the next generation of supercomputers. (See Energy Research for the first two, Defense Programs for the third.) Other Argonne collaborations within the DOE laboratory system include work with Oak Ridge National Laboratory on coupled atmosphere-ocean models, work with Pacific Northwest National Laboratory on automatic differentiation technology, and work with Los Alamos National Laboratory on advanced message-passing concepts. Argonne also participates in the Advanced Computing Technology Initiative, which is developing parallel numerical software tools that are being used by researchers at Los Alamos, Lawrence Livermore, and Lawrence Berkeley National Laboratories.

DOE is leading the way toward new computational and communications technology that will facilitate even greater collaboration and integration across its laboratory system. At the heart of this effort is the DOE2000 program, which aims to develop new computational tools and libraries that will change fundamentally the way scientists work together, particularly from distant sites, and the way they address the major challenges of scientific computation. One major component of DOE2000, Advanced Computational Testing and Simulation, is included in Table A.1 because its projects are being conducted as collaborations involving subsets of six DOE multiprogram laboratories. Even more directly aimed at advancing future interlaboratory collaboration, within DOE and beyond, is the National Collaboratories component of DOE2000, which is developing new technologies that will make possible laboratories without walls — laboratories that unite expertise, instruments, and computers and ultimately enable scientists to carry out cooperative research without regard for geography. A third DOE2000 component, Collaborative Pilot Projects, is implementing two test applications of technologies that can be assembled today. One, the Materials MicroCharacterization Collaboratory, is centered at Argonne and is included in Table A.1.

It is important to recognize that R&D collaborations among DOE laboratories are often just the beginning of much broader collaborations with other federal agencies, universities, private companies, and organizations in other countries. A dramatic case in point is DOE's Atmospheric Radiation Measurement (ARM) Program, which includes collaborators supported by the National Oceanic and Atmospheric Administration, the National Aeronautics and Space

Administration, and the National Science Foundation, as well as by government agencies in Canada, Australia, the United Kingdom, and Russia. (In Table A.1, see the next-to-final entry for the Office of Energy Research.) ARM scientific investigations are conducted primarily by self-organized teams that submit proposals for peer review and work at a large field research site in the southern Great Plains (Oklahoma-Kansas). Two further large sites are being developed in the tropical western Pacific Ocean (between Indonesia and Christmas Island) and on the North Slope of Alaska. Of 61 science teams participating in the ARM Program, 55 are led by principal investigators from outside the DOE laboratory system. However, the DOE laboratories provide most of the research support: deploying and operating instruments, collecting and archiving data, and sending data to science team members.

Some DOE offices are pervasively organized to exploit the benefits of collaborative R&D. A leading example is the Office of Industrial Technologies, which is structured into industry teams under its "Industries of the Future" strategy. (In Table A.1, see the entries for Energy Efficiency and Renewable Energy.) For seven industries — chemicals, forest products, steel, aluminum, metal casting, glass, and agriculture —widely diverse collaborations among cost-sharing private companies and DOE laboratories are created to respond to important needs that industrial firms have targeted but lack the specialized capabilities and individual incentives to pursue. The DOE laboratories engage through the Laboratory Coordinating Council and various subsidiary working groups to respond flexibly and creatively to industry needs, often working together on larger projects with industry where complementarity among the laboratories' capabilities can be exploited.

Direct collaboration among the multiprogram laboratories is the norm for work supported by the Nuclear Transfer and Supplier Policy Division within DOE's Office of Nonproliferation and National Security, illustrated in Table A.1 by the program Cooperation on Nuclear Export Controls in Russia and the Newly Independent States. In fact, virtually all of Argonne's work for this sponsor is conducted through close collaborations among multiprogram laboratories, and the work generally originates from project proposals developed jointly by the laboratories. Other current programs of this kind include Support to Multilateral Nonproliferation Regimes, Nuclear Export License Review, Technology Security, and Nonproliferation Workshops. Another major joint activity is development and maintenance of the Proliferation Network System, a database that serves to coordinate proliferation analyses among participating laboratories and the DOE sponsor.

In addition to R&D collaborations, Argonne works with other DOE laboratories to improve business and operations performance across a system of laboratories operated by universities, private corporations, and nonprofit organizations. A leading forum for this purpose is the National Laboratories Improvement Council (NLIC), which includes management representatives from all major DOE laboratories, plus key representatives from DOE. For six years the NLIC has helped to organize, plan, and support improvement initiatives in business and operations areas and has fostered sharing of best business practices and lessons learned. Current initiatives aim at closer integration of the laboratories into DOE strategic planning, consistent incorporation of performance-based management principles into the contracts between DOE and laboratory operators, and more effective communication of the laboratories' accomplishments and their value.

Table A.1 Argonne's Direct Collaborations with Other DOE Laboratories and Beyond

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
ENERGY RESEARCH				

Spallation Neutron Source (SNS) construction project, supported by the Office of Basic Energy Sciences. Design and construct a new accelerator-based facility providing the world's most intense pulsed neutron beams for scientific and industrial R&D. The total project cost of this facility, which will be located at Oak Ridge National Laboratory, is $1.33 billion.	Brookhaven, Lawrence Berkeley, Oak Ridge, Los Alamos. The neutron user community, including universities and industrial firms, plays a key advisory role.	$23 million	As a group, advise DOE on program directions through the Basic Energy Sciences Advisory Committee. Jointly recommend particular project elements to DOE. Meet approximately every six weeks for in-depth technical coordination on the entire facility construction project.	A new collaborative approach to designing and constructing a major DOE research facility, intended to be a model for future facilities. Each collaborating laboratory is responsible for integrating a major component — ion source, linac, accumulator ring, target, or instrumentation -- into the final facility. In addition to taking advantage of each laboratory's distinctive strengths during construction, the new approach will facilitate the eventual shift at the Oak Ridge site to an operations staff with appropriate skills.
Tailored Microstructures in Hard Magnets, a technical project within the DOE Center of Excellence for the Synthesis and Processing of Advanced Materials, which was established by the Office of Basic Energy Sciences, Division of Materials Sciences, in partnership with the DOE laboratories. Improve materials for permanent magnets through improved understanding of the relationship between microstructure and magnetic properties.	Brookhaven, Lawrence Berkeley, Oak Ridge, Idaho Engineering and Environmental, Los Alamos. Ames Laboratory. Industrial manufacturers of permanent magnets.	Approximately $3 million	Coordinate to establish appropriate research areas. Mutually select technical approaches that best exploit and integrate the distinctive capabilities of the laboratory partners. Communicate all useful information quickly. Exchange experimental samples for characterization by techniques available at partner laboratories.	The DOE Center of Excellence for the Synthesis and Processing of Advanced Materials was designed specifically as a distributed organization dedicated to promoting a limited number of coordinated, cooperative multilaboratory research partnerships related to the synthesis and processing of advanced materials for energy technologies. After a finite life of five years within the Center, a project is expected to have an established research agenda and associated collaborations and to become a normal DOE program that does not require such intense nurturing. Replacement projects will then be brought into the Center. DOE laboratory coordinators for the Center's various projects have major input into long-run directions for the Center, along with an industry steering group that also helps to review ongoing projects.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
Materials MicroCharacterization Collaboratory, a pilot project of the DOE2000 program. Jointly supported by three DOE offices: Basic Energy Sciences; Mathematical, Information, and Computational Sciences; and Energy Efficiency and Renewable Energy. An interactive "virtual" laboratory on the Internet for consulting with colleagues and applying at a distance the characterization tools used for materials research.	Lawrence Berkeley, Oak Ridge. University of Illinois at Urbana-Champaign. National Institute of Standards and Technology of the Department of Commerce. Many industrial partners.	$3.0 million	Advise DOE on long-run program directions through a steering committee. Select mutually complementary projects to be undertaken. Coordinate standards and protocols for all R&D partners. Conduct weekly videoconferences on technical issues and program management.	The partners will be developing, testing, procuring, and defining hardware and software for remote collaboration, focusing on microscopy and microanalysis.

Development of high-gradient superconducting accelerating structure technology for high energy physics and fourth-generation light sources, a collaboration stemming from a larger technology development collaboration centered at Germany's DESY. Supported by the Office of Energy Research. The two DOE laboratories in Illinois plan to share the infrastructure required to adapt the DESY technology to their respective specialized interests and ultimately to serve other applications across the DOE system.	Fermilab. (Roughly 40 institutions worldwide participate in the large DESY-centered collaboration, including Argonne, Fermilab, and two U.S. universities.)	Argonne's participation supported by Laboratory-directed resources at this early stage	Advise DOE jointly on general issues and individually on applications (Fermilab for high energy physics, Argonne for fourth-generation light sources). Meet weekly for scientific and engineering discussions and monthly for longer-term planning of the substantial new infrastructure needed.	The long-run objective is to develop for the entire DOE laboratory system a coordinated capability in superconducting accelerator technology that will rely on collaboration with other DOE laboratories as its standard mode of operation.
Computational Chemistry for Nuclear Waste Characterization and Processing: Relativistic Quantum Chemistry of Actinides. Primarily supported by the Chemical Sciences Division and the Mathematical, Information, and Computational Sciences Division. Develop the capability to model -- by applying the methods of relativistic quantum chemistry on massively parallel computers — compounds containing heavy elements such as uranium and plutonium, comparable to the capability currently available for light-element compounds. The resulting new understanding is needed for environmental remediation at former DOE nuclear weapons sites.	Pacific Northwest. Also Lawrence Berkeley's National Energy Research Scientific Computing Center. Ohio State University, Syracuse University. Eloret Corp.	$300,000 (for Argonne only)	Coordinate to select mutually complementary projects and jointly performed projects within the general scope of the predecessor DOE Grand Challenge project. Employ weekly teleconferences and more frequent electronic and telephone communications to coordinate day-to-day work. Together advise DOE on long-run program directions.	Like many DOE Grand Challenge applications, multiple massively parallel computers are used at different sites, an easier task in this case because the computers at Argonne and Pacific Northwest have the same architecture. Collaboration tools such as white boards, network video and audio conferencing, and screen sharing are being explored. A set of such tools will be evaluated and installed at all sites, and feedback will be provided to the tool developers. This experience and the associated feedback promise to help future collaborations.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
U.S. participation in development of the *ATLAS detector for the Large Hadron Collider (LHC)* to be built at the CERN laboratory in Switzerland. U.S. participation is funded by DOE's High Energy Physics Division and by the National Science Foundation (NSF). By observing particle collisions at energies seven times greater than previously possible, investigate major physics questions such as the mechanism for electroweak symmetry breaking.	Brookhaven, Lawrence Berkeley. Approximately 25 universities.	$8 million	With university partners, advise DOE as a group through the ATLAS Executive Committee. Coordinate to choose mutually complementary technical approaches, subject to DOE approval.	This collaboration is notable for including large numbers of institutional and close individual collaborators (even for high energy physics), provision of sizable funding through both DOE and NSF, and an absolute constraint imposed by Congress on total U.S. funding for ATLAS and a second LHC detector. DOE and NSF coordinate funding and management through an innovative joint oversight group to which the DOE laboratories have input through the two detector collaborations. Two levels of contingency funds cushion the absolute U.S. funding cap.
STAR detector at Brookhaven's RHIC (Relativistic Heavy Ion Collider) accelerator. Supported by DOE's High Energy Physics Division. Study very energetic collisions of heavy ions and the predicted creation of a new state of matter, the quark gluon plasma; also study collisions of polarized protons.	Brookhaven, Lawrence Berkeley. Four universities.	$6 million	With university partners, advise DOE as a group through Brookhaven's Program Advisory Committee and select mutually complementary technical approaches, subject to DOE approval. Coordinate closely on day-to-day research activities, often through an R&D task team with members from multiple DOE laboratories and from universities.	Large in size among nuclear physics collaborations (which tend to have fewer participants than those in high energy physics), the STAR collaboration illustrates the effective functioning of well-established detector collaboration procedures.

The *MINOS detector* for long-baseline neutrino oscillations, supported by DOE's High Energy Physics Division. Located in a mine in Minnesota, the detector will receive neutrinos emitted from Fermilab in Illinois after they have traveled 730 kilometers underground.	Fermilab. Several universities.	$5.4 million	Select mutually complementary technical approaches, subject to DOE approval. Coordinate closely on day-to-day research activities, often through an R&D task team with members from the two DOE laboratories and from universities.	Of modest size for high energy physics, this collaboration illustrates the effective functioning of procedures that have been refined over many years as the numbers of participants in detector collaborations have increased.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
Collider Detector at Fermilab (CDF), supported by DOE's High Energy Physics Division. The original high-transverse-momentum detector at the Tevatron collider is used to study particle production and dynamics at the world's highest collider energy, including the production of top and bottom quarks and possibly electroweak symmetry breaking.	Fermilab, Lawrence Berkeley. Several U.S. universities and research groups from Italy and Japan.	Approximately $15 million	Collaborate in CDF upgrading under overall Fermilab leadership. Share in or undertake individually a broad range of tasks, including design, tooling, and task management, with many participating physicists spending a substantial fraction of their time at Fermilab.	This project pioneered many of the now-accepted operational modes for international detector collaborations involving hundreds of high energy physicists. Distinct project construction and operations organizations, responsible for meeting budgets and schedules, are in creative tension with a collaboration organization focused on physics requirements, detector performance, and analysis and publication of results. Atop the physics collaboration is a governing council of institutional representatives that organizes four or five analysis groups for different areas of physics, within which researchers coordinate (e.g., share analysis techniques and prevent overconcentration on popular topics) and review one another's work. The council decides global questions such as collaboration membership and optimization of running conditions for one investigation rather than another.
Operation of *Gammasphere*, supported by DOE's Nuclear Physics Division. The world's most powerful gamma-ray detector for studying the structure of atomic nuclei, Gammasphere was recently moved to Argonne's ATLAS accelerator from Lawrence Berkeley National Laboratory.	Lawrence Berkeley and other national laboratories.	$800,000	Within a collaboration of 21 institutions, designed, constructed, and tested the $23 million Gammasphere. Operate the detector (first at Lawrence Berkeley, now at Argonne) to take advantage of unique complementary accelerator facilities available at each site. Coordinate closely on the very complicated dismantling, moving, and reassembly. Contribute collaborators to many outside experimental teams using Gammasphere. Advise DOE on future directions through the DOE-NSF Nuclear Science Advisory Committee, joint program advisory committees, and other avenues.	The harmonious, efficient relocation of Gammasphere illustrates one way that national laboratories work together effectively as part of a larger system.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations

Research aimed at developing *an ISOL (isotope separation on-line) accelerator facility* to provide intense beams of short-lived, unstable (radioactive) nuclei for research in nuclear physics and related fields. To be supported by DOE's Nuclear Physics Division.	Lawrence Berkeley (development of detectors and an advanced ECR [electron cyclotron resonance] ion source). Thomas Jefferson National Accelerator Facility (development of superconducting resonators).	Funding largely laboratory-directed at this early stage	Coordinate concepts for various components of the new accelerator facility. Advise DOE jointly on future directions through the DOE-NSF Nuclear Science Advisory Committee, various program advisory committees, and other avenues.	These collaborations are largely informal and laboratory-directed at this early stage, indicating the initiative that the DOE laboratories take in exploiting the complementarity of their capabilities.
Advanced Computational Testing and Simulation (ACTS) component of the DOE2000 program, supported by the Mathematical, Information, and Computational Sciences Division. Design new mechanisms, interfaces, and modules that enable flexible interoperability of tool kits, codes, and advanced computing resources for mission-critical DOE problems.	Various ACTS projects involve Lawrence Berkeley, Oak Ridge, Lawrence Livermore, Los Alamos, and Sandia. University of Southern California. Aerospace Corp.	$950,000 (for Argonne only)	As a group, advise DOE on long-run program directions.	Various elements of ACTS projects — such as developing interfaces between computational tool kits originating at different laboratories, exploring component-based approaches to large-scale optimization, using numerical kernels to enable code reuse, and creating functionality to support experiments in networked computing — clearly will facilitate future collaboration across DOE sites.
Clipper environment for high-speed distributed computing, supported by the Mathematical, Information, and Computational Sciences Division. In preparation for the next-generation Internet, develop the network components and services needed for applications in a distributed environment that require high-speed data flows and supercomputing; demonstrate these innovations in a test bed involving three DOE laboratories.	Lawrence Berkeley. Stanford Linear Accelerator Center.	$200,000 (for Argonne only)	Advise DOE jointly on program directions; mutually select complementary projects, subject to DOE approval. Communicate design information via shared Web pages as well as normal electronic mail; meet formally every two months.	Collaborating DOE laboratories will be the first beneficiaries of resulting advances in distributed computing. Development of prototype applications is facilitated by much faster connections between the three laboratories, for example, via the National Transparent Optical Network and ESnet.
Application of High-Performance Computing to Automotive Design and Manufacturing, a CRADA supported by the Offices of Energy Research and Defense Programs and formed under the auspices of the U.S. Council for Automotive Research (USCAR). Develop much better physical models and computational methods for fluid dynamics (applicable to fuel and air flow) and structural mechanics (focusing on the crashworthiness of composite materials).	Oak Ridge, Lawrence Livermore, Los Alamos, Sandia. General Motors, Ford, Chrysler.	Over FY 1994-FY 1997, approximately $11 million (for DOE laboratories only)	Regularly contribute to research planning among all participating organizations as part of meetings of the operating committee of the Supercomputer Automotive Applications Partnership. Participate in regular program coordination meetings and detailed reviews of technical progress. Among DOE laboratory researchers, typically coordinate monthly on technical issues.	The computational fluid dynamics code CHAD and composite materials models in the structural mechanics code DYNA are now being tested and applied by both industrial and national laboratory partners. The success of this CRADA led to a successor involving many of the same research partners, the Automotive Underhood Thermal Management Analysis Using 3-D Coupled Thermal-Hydrodynamic Computer Models.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
Fusion Energy Sciences. A program to acquire the knowledge base needed for an economically and environmentally attractive fusion energy source.	Oak Ridge, Pacific Northwest, Sandia. Princeton Plasma Physics Laboratory. University of Wisconsin, University of California at Los Angeles, University of California at San Diego. General Atomics, Boeing.	Approximately $230 million	Advise DOE on long-run program directions via steering committees. Selectively propose projects jointly to DOE. Coordinate with one another and with university and industrial partners through telephone conferences every week or two and through a major annual meeting.	A "virtual technology laboratory" within the fusion community facilitates the coordination and review of programs. Video conferencing to replace formal meetings is being developed.

Atmospheric Radiation Measurement (ARM) Program, supported by DOE's Environmental Sciences Division. In order to better understand global and regional climate change, teams of scientists gather field measurements at several diverse sites around the world and develop models of the processes that control solar and thermal infrared radiative transfer in the atmosphere.	Brookhaven, Lawrence Berkeley, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. National Renewable Energy Laboratory. Also 19 other government agencies, 4 private companies, 5 international organizations, 17 universities.	$40 million	Participate in science team research, including collaborations with researchers from many organizations. Beyond science team projects selected by formal peer review, advise DOE jointly on program directions through the ARM Management Team. Collaborate daily with other scientists on various functional teams and in various site management offices. Coordinate the participation of other R&D partners, especially in connection with field observations and the analysis of collaborative experiments.	A remarkably diverse collaboration, in terms of geographic dispersion, as well as numbers and types of organizations. Pursuing methods of data management and information exchange via the Internet that will facilitate future interlaboratory integration.
Atmospheric Chemistry Program, supported by the Environmental Sciences Division. Advance information about the atmospheric environment, especially regional and continental chemistry and the fate of tropospheric trace chemicals related to energy production; conduct laboratory studies, theoretical investigations, numerical modeling, and collaborative field campaigns.	Lawrence Berkeley, Pacific Northwest, Lawrence Livermore. Two other federal agencies, eight universities, two private companies.	$6.5 million	Participate in various projects selected by peer review and closely coordinate their execution, especially through one to four collaborative field experimental campaigns conducted each year. Advise DOE jointly or individually. Meet within special-interest groups of program participants two or three times each year.	Joint field work features use of the Battelle G-1 research aircraft. The program's Web site, in addition to research project descriptions, will provide data sets and codes for numerical atmospheric models.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
ENERGY EFFICIENCY AND RENEWABLE ENERGY				
"Industries of the Future" structuring of the Office of Industrial Technologies. A strategy for coordinating and facilitating R&D for energy-intensive materials and process industries, often through partnerships involving DOE laboratories.	All eight other DOE multiprogram national laboratories. National Renewable Energy Laboratory, Ames Laboratory, Federal Energy Technology Center, Savannah River Site, Y-12 Plant, Albany Research Center. Industry trade associations, professional societies, universities, other government agencies, and many industrial firms.	$136 million	Through the Laboratory Coordinating Council, meet and confer with industry and other potential partners, as well as with the DOE program office. Contribute to the industry-led, DOE-fostered process of creating R&D visions and roadmaps for seven major industry groups. Create broad R&D partnerships featuring industry cost sharing and often involving multiple DOE laboratories.	The Laboratory Coordinating Council is an important organizational innovation for developing exceptionally broad R&D partnerships between industry and the DOE laboratories, and beyond.
Applied CarboChemicals CRADA within the Alternative Feedstocks Program of the Office of Industrial Technologies. Development of cost-competitive chemical feedstocks from renewable resources such as corn.	Oak Ridge, Pacific Northwest. National Renewable Energy Laboratory. The company Applied CarboChemicals, a CRADA partner.	Roughly $625,000 (for the DOE laboratories only)	Make joint recommendations to DOE on long-run program directions and particular projects to be undertaken. Coordinate the participation of CRADA partner Applied CarboChemicals. Maintain frequent communication and coordination on technical issues among all partners.	Among the first multilaboratory projects in applied development of a new technology, considered a model for later projects. Developed the first multilaboratory CRADA and licensing agreements, which have facilitated later similar efforts.
ENVIRONMENTAL MANAGEMENT				

Twelve projects for the *Environmental Management Science Program* (EMSP), which is jointly sponsored by the Office of Environmental Management and the Office of Energy Research. Basic research aimed at much better technical solutions to DOE's environmental cleanup problems.	Pacific Northwest. Savannah River Site. U.S. Navy's Naval Surface Warfare Center. Ten universities.	$3.8 million for the 12 projects involving Argonne	Provide broad advice to EMSP (and other Environmental Management programs) through the Strategic Laboratory Council, which includes one representative from each DOE laboratory and facilitates information exchange across institutions, as well as assisting EMSP in other ways, such as organizing joint conferences and workshops. Among R&D partner bench scientists, coordinate once or twice a month.	EMSP is a premier case of integration across sponsoring offices at DOE. Extensive collaboration among EMSP R&D partners is a core strategy, is explicitly encouraged by the program's proposal process, and is increasingly being implemented. An information network exploiting the Internet and other tools helps EMSP researchers communicate and collaborate beyond the program, with technology developers, managers of sites with environmental problems, regulators, and others. National workshops are held with potential DOE users of EMSP technologies.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
Environmental Management programs (other than EMSP, described above). Environmental restoration, waste management, and associated technology development (including R&D, demonstration, testing, and evaluation projects) for DOE sites.	The multiprogram national laboratories (other than Brookhaven). Ames Laboratory, Environmental Measurements Laboratory, Rocky Flats Environmental Technology Site, Savannah River Site. Many industrial firms and universities.	Approximately $40 million for Argonne alone, including R&D, technical support activities, and actual cleanup	Often advise DOE jointly on appropriate technical approaches, though the majority of R&D projects are selected by a straightforward process of proposals from individual laboratories. Through the Strategic Laboratory Council (as described above for EMSP), advise DOE on long-run R&D directions, program reviews and improvements, and strategic planning, including roadmaps. Among R&D partner bench scientists, coordinate weekly to monthly.	Technology demonstration projects are often very large in scale and accomplish major programmatic objectives in themselves. The demonstrations give an unusually wide range of technology providers and other collaborators the opportunity to prove themselves.
TechCon program, Office of Environmental Restoration. Encourage and facilitate application of private-sector and other new technologies to environmental management at specific DOE sites by using the latest information, communication, and decision support tools (such as dedicated Web sites).	Pacific Northwest. (Sandia coordinates the Innovative Treatment Remediation Demonstration [ITRD] program, which increasingly cooperates with TechCon.)	$750,000 ($1.5 million for ITRD)	Collaborate with DOE and private-contractor project managers at particular sites, often jointly, to identify opportunities to apply superior remediation technologies. Facilitate the interactions among all parties, particularly private-sector suppliers of environmental technologies needed to take advantage of these opportunities. Define related R&D needs.	Implements particularly wide-ranging interactions to facilitate application of the best environmental technology available anywhere, be it from a national laboratory or an international source.
Plutonium Focus Area, supported by the Nuclear Material Stabilization Office. Identify and recommend solutions (including additional R&D) for technical and operational problems associated with the stabilization, long-term storage, and monitoring of nonweapons-grade plutonium surpluses and wastes.	Idaho Engineering and Environmental, Los Alamos, Sandia. Oak Ridge Y-12 Plant, Rocky Flats Environmental Technology Site, Savannah River Site. Lockheed Martin Idaho Technologies Co. (LMITCO), Oxford Instruments.	Approximately $4 million for LMITCO and Argonne	Coordinate the participation of private companies involved in product testing and validation. Selectively advise DOE jointly on long-run program directions. Idaho-based partners meet weekly for technical coordination.	DOE-Environmental Management designed the "focus area" approach to provide a common framework for cooperation across DOE sites to attack common problems. In the past, for example, plutonium monitoring and surveillance systems (including ES&H and safeguards and security aspects) were implemented independently by each site.
DEFENSE PROGRAMS				

Nuclear Criticality Predictability Program, supported by Defense Programs, Environmental Management, and other DOE offices. Establish within DOE an improved and integrated capability to predict criticality in nuclear fission systems through new experiments, benchmarking against available U.S. and international data, refinement of three alternative Monte Carlo computer models used within DOE, and processing of nuclear data into standard working forms.	Oak Ridge, Idaho Engineering and Environmental, Los Alamos. Two universities.	Approximately $8 million	As a group, advise DOE on long-run program directions. Work together on tasks such as evaluation of nuclear data, coordinating informally at the bench scientist level approximately every two months. Coordinate quarterly and annually to choose mutually complementary projects, subject to DOE approval.	Resulting information and software will be distributed in standardized form by the DOE-wide code center and will be easily used by engineers throughout DOE and beyond. For example, the refined nuclear criticality computer codes will be easily incorporated into the various laboratories' existing software systems.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
Advanced Visualization Technology Center for Visualization SuperCorridors, supported by the Office of Defense Programs (DOE-DP) through the Accelerated Strategic Computing Initiative (ASCI). Develop breakthrough technologies that will enable the visualization, storage, and manipulation of the large data sets for computational science and engineering produced by supercomputers performing trillions of operations per second.	Los Alamos and, in the future, other DOE-DP laboratories. University of Utah.	$1 million (for Argonne only)	The DOE-DP laboratories and ASCI alliance partners will apply test applications for software tools developed by Argonne and the University of Utah, which will manage the program day to day. All partners advise DOE jointly through a program advisory committee that includes all three DOE-DP laboratories, DOE program managers, and others.	Testing of applications requires close collaboration among all partners. Evolving procedures include weekly conference calls (involving entire research teams every other week) and very frequent electronic communication.
Russian/American Fuel Cell Consortium (RAFCO), supported by four DOE offices: Defense Programs, Nonproliferation and National Security, Energy Efficiency and Renewable Energy, and Fossil Energy. Coordinate joint U.S.-Russian R&D on fuel cell technology and promote nuclear nonproliferation by providing research opportunities for former Russian weapons scientists.	Los Alamos, Sandia. International Fuel Cells, Inc., M-C Power Corp. All-Russian Institute of Technical Physics, All-Russian Institute of Experimental Physics.	$3 million from Energy Efficiency and Renewable Energy in FY 1998	Through participation in the RAFCO Joint Committee and the RAFCO Subcommittee on Technology, advise DOE on program technical directions and select mutually complementary projects to be undertaken cooperatively by Russian and American researchers (subject to approval by the sponsoring DOE program office). For projects involving cost-shared participation by U.S. industrial firms, also play a coordinating role, generally on technical issues and program management. Coordinate at the bench scientist level at least monthly.	Individual projects involve direct collaboration between Russian researchers and one or more DOE laboratories. RAFCO is notable for extensive joint laboratory contributions to administrative bodies faced with the considerable challenges of organizing cooperation between researchers in the two former Cold War adversaries. Policies and procedures being developed will facilitate future collaborations between U.S. national laboratories and their Russian counterparts.
NONPROLIFERATION AND NATIONAL SECURITY				
International Nuclear Safety Program (not including the research-oriented International Nuclear Safety Center, discussed below). Now supported by the Office of Nonproliferation and National Security. In cooperation with other Western industrialized countries and international agencies, conduct joint projects with eight former Soviet bloc countries hosting Soviet-designed nuclear reactors, to help correct major reactor safety deficiencies and establish a self-sustaining nuclear safety infrastructure.	Brookhaven, Pacific Northwest, Oak Ridge, Idaho Engineering and Environmental. Many U.S. engineering services and other companies.	$35 million	Coordinate and, within particular projects, participate either individually or as teams. Daily communication is typical among participating laboratories.	Special initiatives focus on reducing risks at the Chornobyl power plant, one unit of which (out of the original four) is still generating electricity. Participation in projects must go beyond other DOE-sponsored research organizations to include the host country (Russia, Ukraine, Armenia, Bulgaria, Czech Republic, Hungary, Lithuania, Slovakia, or Kazakhstan). DOE laboratory collaborators make extensive use of technologies such as videoconferencing and the paperless office.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations
International Nuclear Safety Center (INSC), now supported by the Office of Nonproliferation and National Security. For nuclear power engineering worldwide, promote the open exchange of safety information, cooperate in the development of safer technologies, and help collect and disseminate relevant information (particularly through a remotely accessible electronic database covering engineering information and results from safety analyses for U.S.- and Soviet-designed power plants and other nuclear facilities around the world).	Pacific Northwest, Idaho Engineering and Environmental. The Russian INSC, and through it more than ten Russian nuclear research institutes.	$2.1 million	Among U.S. researchers, coordinate monthly.	The U.S. INSC database and its Russian counterpart include the results of joint projects and are immediately accessible worldwide via the Internet. These on-line resources are very valuable in collaborations between the two countries.
Subway preparedness component of the Chemical-Biological Nonproliferation Program, supported by the Office of Research and Development. Develop advanced technologies and technical services to help cities detect and counter the use of chemical or biological weapons in subways by terrorists.	Lawrence Livermore, Los Alamos, Sandia, Idaho Engineering and Environmental. As this new program develops, partners will include engineering firms and emergency response organizations at all levels of government.	$930,000 for the national laboratories	Advise DOE jointly on program directions, both informally and through a formal advisory group. Coordinate to choose mutually complementary projects, subject to approval by the DOE sponsor. Conduct joint R&D on topics such as simulating the impacts of chemical and biological releases.	Effective development and implementation of new technologies to address this complicated problem — such as detectors and computer models for predicting the transport and fate of chemical or biological agents — typically will require integration of expertise from multiple DOE laboratories and industry, plus close cooperation with city governments. Local transit authorities will cooperate in the program as appropriate and will support their own preparedness operations.
Initiatives for Proliferation Prevention, supported by the Office of Arms Control and Nonproliferation. Identify and develop commercial nonmilitary work for scientists and engineers involved in weapons programs (nuclear, chemical, and biological) in the former Soviet Union (FSU), particularly by involvement of U.S. companies in cooperative R&D through DOE laboratories and ultimately in commercial deployment of FSU technologies.	All eight other DOE multiprogram laboratories. National Renewable Energy Laboratory, Kansas City Plant.	$30 million	Through the Interlaboratory Advisory Board, advise DOE on long-run program directions, recommend desirable projects to DOE, and oversee the participation of U.S. businesses. Coordinate formally on technical issues every two months, less formally about weekly. Use a Lotus Notes database on the World Wide Web to facilitate interlaboratory communication and informal program auditing by DOE.	Before involvement of U.S. companies, an R&D collaboration between a DOE laboratory and one or more FSU institutes is an opportunity to begin the education of FSU participants in intellectual property rights, entrepreneurship, and commercialization. To facilitate the collaborations, DOE has simplified project review processes and fostered implementation of uniform administrative procedures.

Table A.1 (Cont.)

DOE Program	Argonne's R&D Partners — National Laboratories; Others	Total DOE Program Funding (FY 1998)	Joint Roles of DOE Laboratories	Collaboration Highlights and Innovations

U.S./FSU Program of Cooperation on Nuclear Material Protection, Control, and Accounting (MPC&A), supported by the Office of Arms Control and Nonproliferation through the Russia/NIS Nuclear Material Security Task Force. In cooperation with the FSU countries, including the newly independent states (NIS), help strengthen security at sites in countries containing weapons-usable nuclear materials and assist in developing the countries' MPC&A systems.	Brookhaven, Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. Central Training Academy, New Brunswick Laboratory, Pantex, Savannah River Site.	$237 million	Through the MPC&A Advisory Panel, provide technical recommendations to DOE on program plans and on project scopes, staffings, and budgets. Participate on multilaboratory teams undertaking particular projects, typically coordinating on technical issues at least weekly with team members at other laboratories. Coordinate the participation of other organizations, including FSU research institutes and private companies.	A typical large MPC&A project involves a very diverse set of tasks, to which several DOE laboratories logically contribute on the basis of their established special capabilities. Final implementation is in Russia or the NIS.
BN-350 Fuel Disposition, a project supported by the Office of Arms Control and Nonproliferation. To reduce proliferation concerns, develop safe, secure long-term storage for spent nuclear fuel assemblies now located at the BN-350 breeder reactor in Aktau, Kazakhstan. Cooperate with the reactor facility, a major research institute, and the Kazakhstan analog to the Nuclear Regulatory Commission.	Pacific Northwest, Los Alamos, Sandia. Nuclear Assurance Corp.	$10.9 million	Advise DOE jointly, as a group, regarding issues affecting harmonization of the tasks led by each laboratory. By electronic mail and telephone, coordinate daily on technical issues with partners at the other laboratories and in Kazakhstan.	The methods of communication used between technical experts in Kazakhstan and the United States are routine but effective, in part because similar backgrounds and interests foster a productive rapport.
Cooperation on Nuclear Export Controls in Russia and the NIS, supported by the Nuclear Transfer and Supplier Policy Division. Help the FSU countries implement effective systems for controlling the export of materials, equipment, and technology that could be used to build nuclear weapons.	Oak Ridge, Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia. Savannah River Site.	$3.1 million	As a group, make recommendations to DOE on long-run program directions and particular projects to be undertaken. Within each multilaboratory project team, coordinate each week with the other laboratories on technical issues. Coordinate the participation of NIS technical institutes.	The program is implemented largely through cooperative agreements directly between DOE laboratories and nine NIS technical institutes. These arrangements have greatly facilitated identification and training of the NIS technical experts needed by the government agencies administering nuclear export controls.

Supplement 1: Work for Sponsors Other than DOE

Part of Argonne's work is supported by sponsors other than DOE. Major sponsors include the Nuclear Regulatory Commission, Department of Defense, Environmental Protection Agency, Federal Emergency Management Agency, Department of State, Department of Transportation, Department of Agriculture, National Science Foundation, National Aeronautics and Space Administration, Electric Power Research Institute, and private firms. (See Chapter VI for program funding.)

Argonne's work for non-DOE sponsors supports accomplishment of its missions (see Chapter II) and development of its initiatives (see Chapter IV). From a national perspective, this "work for others" (WFO) allows Argonne's unique facilities and capabilities to be applied to U.S. R&D priorities.

The Laboratory's WFO strengthens resources available for DOE missions and programs and promotes development of specific energy and environmental technologies. It enhances Argonne's research capabilities, helps support the infrastructure at the Laboratory, and ultimately increases opportunities to transfer Argonne technologies to productive applications in the private sector. The Laboratory does not undertake work for non-DOE sponsors if that work can be performed satisfactorily by private organizations.

A. Nuclear Regulatory Commission

Argonne conducts research for the Nuclear Regulatory Commission (NRC) under a legislatively mandated memorandum of understanding between DOE and the NRC. Most of Argonne's work for the NRC is supported by the Office of Nuclear Regulatory Research. The largest efforts address materials issues, steam generator tubing degradation, high-burnup fuel, and severe-accident behavior. In addition, Argonne provides technical assistance to the Office of Nuclear Reactor Regulation and to various other NRC offices in many different areas. Both the research and the technical assistance take advantage of Argonne's special capabilities in nuclear reactor technology, technical evaluation, and systems analysis. Argonne's work for the NRC helps to ensure that U.S. nuclear power plants will continue to produce electricity without carbon emissions.

1. Office of Nuclear Regulatory Research

Argonne's materials research focuses on the degradation of structural materials in light-water reactors caused by reactor environments, including the effects of water chemistry and neutron irradiation. These studies include measurements of (1) growth rates of stress corrosion cracks and (2) the fatigue life of stainless and ferritic steels used in the reactor core, piping, and pressure vessel. Results from these studies are used by the NRC to ensure the structural integrity of plants as they age. The testing includes specimens from operating commercial reactors. Additional irradiations of stainless steels are performed in Norway's Halden test reactor to provide further systematic data on relationships between material composition and susceptibility to cracking after irradiation.

A comprehensive study of degradation in the steam generator tubing of nuclear power plants is under way. Critical areas being addressed include (1) evaluation of techniques used for in-service inspection of steam generator tubes and recommendations for improving the reliability and accuracy of those inspections, (2) validation and improvement of correlations for evaluating structural integrity and leakage of degraded steam generator tubes, and (3) validation and improvement of correlations and models for predicting degradation in aging tubes during operations. The studies focus on mill-annealed Alloy 600 tubing, but tests will also be performed on replacement materials such as thermally treated Alloy 600 and Alloy 690.

Argonne is investigating the behavior of high-burnup nuclear fuels for the NRC. To reduce operating costs and minimize the accumulation of spent fuel, nuclear utilities are striving to increase the burnup of their nuclear fuels, thus extracting more electricity from a given amount of fuel and reducing (1) the volume of the spent fuel requiring subsequent handling, (2) the number of refueling outages, and (3) plant downtime. Currently, utilities seek to achieve burnup roughly 50% higher than in the 1970s, when most of the NRC's criteria and codes for fuel behavior were established. However, at high burnups, fuel pellets and cladding are potentially less resistant to damage under some conditions. These considerations may necessitate modification of fuel rod damage criteria used in NRC regulations and of materials properties assumed in safety analyses. Furthermore, new alloys and fabrication procedures designed to counter burnup effects may also affect regulatory criteria and safety analyses. To help address these issues, Argonne is determining the behavior of high-burnup fuel under accident conditions where coolant is lost and is establishing a database for the mechanical properties of high-burnup cladding, which is needed for licensing safety analyses.

The NRC continues to use Argonne's broad expertise in severe-accident phenomena. An experimental study of the energetics of steam explosions resulting from interactions between water and molten core materials focuses on the possible extent of chemical augmentation of the energetics by metallic constituents in the core melt, particularly zirconium. Results will contribute to evaluation of the structural integrity of reactor vessels and reactor containments in severe accidents.

The Laboratory uses simulation models for electric utilities to estimate the cost of replacement energy and other costs when reactors are shut down. Cost estimates developed for both temporary and permanent shutdowns are updated periodically. These estimates aid regulatory policy-making, particularly regarding shutdowns required to resolve safety or regulatory issues.

2. Office of Nuclear Reactor Regulation

In addition to experimental research work performed for the Office of Nuclear Regulatory Research, Argonne helps the Office of Nuclear Reactor Regulation in a variety of areas related to the performance of materials, components, structures, and systems in nuclear power plants. This work contributes to the development and updating of a standard review plan for operating reactors that is used by NRC staff to assess the suitability of extending a plant's original 40-year license for an additional 20 years.

Argonne provides comprehensive reviews of reports prepared by reactor owner groups (for pressurized-water reactors or boiling-water reactors) and utilities on the management of aging components, structures, and systems in nuclear power plants. These reviews focus on issues related to the degradation of aging materials, issues that are relevant to the decision to renew a nuclear plant license.

The Laboratory also provides support for NRC's rule making and other regulatory functions by performing regulatory analyses of proposed and final rules and proposed changes to regulatory guides and by analyzing public comments on rule making.

B. Department of Defense

Argonne conducts research for several organizations within the Department of Defense (DOD).

1. Office of Secretary of Defense

As simulations of military operations become more accurate, the need for detailed data on terrain to support these simulations has grown dramatically. To provide the required input for the Program Analysis and Evaluation Office, Argonne is developing a sophisticated application for generation of synthetic terrain.

The Laboratory is developing components for the Joint Warfare System (JWARS), a comprehensive modeling and simulation system for analysis, planning, and acquisition. JWARS utilizes existing state-of-the-art models but adds new capabilities, including environmental effects and more comprehensive use of spatial data. An intelligent geographic information manager developed at Argonne will provide unique visualization capabilities by dynamically linking modeled data to various graphic analysis subsystems within JWARS.

2. Office of Strategic Computing and Simulation

Argonne participates in the Center on Astrophysical Thermonuclear Flashes, one of five Academic Strategic Alliances Program centers of the Accelerated Strategic Computing Initiative (ASCI). Argonne provides essential software for ensuring code portability and high performance.

In another ASCI project, Argonne is collaborating with university researchers and DOE-Defense Program laboratories in the development of technology for the visualization, storage, and manipulation of large-scale data sets produced from teraflops-speed supercomputers.

3. U.S. Air Force

The U.S. Air Force sponsors several programs at Argonne. The Laboratory's experience and expertise in conducting environmental assessments of sites with unique environmental features or unique potential impacts are being used for several major proposed Air Force activities.

Argonne is studying biodiversity at a number of Air Force installations across the country, focusing on the abundance of federal- and state-listed species and on the existence of exceptional natural communities. The information collected is incorporated into geographic information systems.

Argonne also studies a number of environmental systems to identify for the Air Force the most cost-effective technical approaches to environmental management. For the Air Force Materiel Command, the Laboratory is developing innovative approaches to computer-assisted management of large numbers of air pollutant emission sources in complex industrial areas. The models being developed will contribute to risk management planning related to the storage and use of hazardous materials. New approaches for environmental management will shift the emphasis from compliance to pollution prevention. In addition, the Laboratory is assisting the Pacific Air Force and Space Command in its implementation of novel, cost-effective methods of managing cultural and natural resources at military installations in the United States and abroad.

For the Air Force Weather Agency, Argonne is developing a theater weather forecasting and analysis capability aimed particularly at theater battle management. The focus is on the overall system architecture and the parallel implementation of selected software elements, which will support collaborative development of the system. This Global Theater Weather Analysis and Prediction System is now installed at the Air Force Weather Agency, Offutt Air Force Base, Nebraska. The basic forecasting model is a version of a mesoscale model originally developed by the National Center for Atmospheric Research (NCAR) and Pennsylvania State University. Argonne's parallel version of the model is widely used and is now provided by NCAR to the public domain. Argonne plans further development of the parallel forecasting model and development of a state-of-the-art analysis model.

Argonne is providing technical support for the Air Force's Hypervelocity Rocket Sled Upgrade Program. This work includes technical reviews, advice, and analyses regarding support and guidance systems that use superconducting magnets and cryogenic systems.

4. The Joint Staff

Argonne supports the J-8 Directorate of the Joint Staff. This work entails developing better planning and simulation models and evaluating new or improved information management technologies. An important aspect of the work involves developing innovative uses of rapidly advancing graphics technologies to manipulate and analyze large databases. These Laboratory efforts take advantage of more than 15 years of experience in designing large engineering and scientific databases; developing new methods of representing data; and building and using knowledge bases, image exploitation, and data visualization. The work for J-8 also benefits from the availability of relevant advanced processors at Argonne's High-Performance Computing Research Facility, the Laboratory's extensive and diverse experience in applied decision analysis, and its experience in studying knowledge representation and applying expert systems.

Working with J-8, Argonne has greatly expanded its efforts to develop a modeling system for simulating and displaying environmental effects at Earth's surface. The resulting software system, the Dynamic Environmental Effects Model, supports both static and dynamic investigations of geographic areas. It will have wide applicability, both within and outside J-8 and DOD. To provide the "synthetic environment" needed by the military for training and analysis, the model must manage and coordinate information based on natural (atmospheric and oceanic) processes and human disturbances (effects of vehicles and weapons). The model uses software objects intensively and is a sophisticated and comprehensive implementation of modern object-oriented theory. Initial development, pioneered by J-8 and Argonne, has already elicited interest and funding from the armed services and other DOD agencies.

Argonne is improving the efficiency of computer models for J-8 in a variety of ways, including their adaptation to advanced processors, and is recommending improved computer system configurations that incorporate advanced multiple-processor computers, high-performance workstations, advanced networking, and greater data storage capacity. In addition, the Laboratory is providing R&D on distributed computing, distributed database management systems, and parallel processing using object-oriented techniques.

Also for J-8, Argonne is pioneering the use of advanced information retrieval techniques in planning and decision support systems. Such systems integrate text management and data management technologies into a single platform for analyzing requirements for new acquisitions. In addition, the Laboratory is applying object-oriented techniques to mission planning. Associating image data with objects greatly enhances the quality of assessments. Argonne is using these tools to support the Joint Community in infrastructure assurance analyses and technical R&D evaluations.

Since 1987 the Joint Staff has sponsored a multifaceted logistics and mobility modeling program at Argonne. The program has two primary goals: (1) to provide decision makers with information management capabilities for planning missions such as military operations, disaster relief, and peacekeeping and (2) to develop advanced computer system prototypes for planning and tracking the movement of personnel, equipment, and supplies throughout the world. The program has grown to include 13 interrelated projects. One representative model simulates detailed logistic movements that begin with arrivals at ports (by sea or air) and includes movements across land (by road, rail, inland water, or air) through various intermediate destinations to a final set of destinations. Movements of people, supplies, and equipment are included. Other Argonne models address the same kinds of movements at different levels of detail. A more aggregated model determines the maximum amount of material that can be pushed through an infrastructure network in a given time period. On the other hand, a highly disaggregated model simulates each process that occurs at a seaport (unloading, handling, and waiting) at a much greater level of detail. Infrastructure components are also modeled. As part of the overall effort, deployment operations at Army installations are being simulated.

For the U.S. Atlantic Command, Argonne is assisting in the development of a system running on a laptop personal computer that can assess vulnerability to terrorist attacks and the costs and benefits of various mitigative measures. The Laboratory will develop the architecture for this suite of software tools and will integrate both existing and new models. In addition, Argonne will incorporate its unique object-based spatial data management system for viewing, annotating, and analyzing spatial data. The resulting system will be inexpensive, very easy to use, and quickly customizable to any DOD site. The system will ultimately be available for use by civilian agencies.

Argonne is intensely involved in the design and implementation of high-performance networks incorporating the latest switching technologies, to support both classified and unclassified network implementations with a high degree of flexibility. Designs provide for multimedia connectivity worldwide via the Internet and the Defense Simulation Internet. Current efforts in this area are being extended to the J-8 Directorate, the Joint Staff, and the U.S.-Republic of Korea Combined Forces Command. Long-range plans provide for phased implementation of higher-performance technologies as they evolve.

5. U.S. Army

For the Army Logistics Integration Agency, Argonne is part of a team developing the Distributed Intelligent Architecture for Logistics (DIAL), which will integrate logistics models into a distributed computing environment by using an architecture capable of expansion. A suite of independent software agents will manage communications and trigger tasks or events among distributed applications. The Laboratory has already developed a functional model and is now implementing the design. A new class of agent, called "the supervisor," is under development; a demonstration prototype will be field tested soon. Designs for other types of software agents are being explored.

Argonne assists the Army's implementation (in conjunction with the Federal Emergency Management Agency) of the Chemical Stockpile Emergency Preparedness Program. The Laboratory supports program development, policy analysis and development of associated guidance, emergency preparedness planning, institutional analysis, development of hazard-specific risk communications and emergency public education mechanisms, and testing and assessment of response capabilities. Argonne also assists in technical management. This work involves hazard analysis, modeling of chemical agent dispersion, development of cost estimation and measurement methodologies, and integration for emergency planning.

For the Construction Engineering Research Laboratory of the Army Corps of Engineers, Argonne is conducting research at a series of demonstration sites to develop techniques for environmental rehabilitation of U.S. Army training bases in the continental United States and Europe. The focus is on developing site-specific recommendations for training sites (at Hohenfels and Grafenwöhr, Germany) that will serve as models for other installations, thereby facilitating integration of training needs with environmental management. Argonne also is creating a knowledge-based air emissions reduction model to improve compliance decision making.

To predict fog-oil dispersion, Argonne is studying the mechanics of the process and developing a computer model.

For the Waterways Experiment Station of the Army Corps of Engineers, Argonne has provided advanced visualization software to support field sampling; the Laboratory is currently a partner in the Groundwater Modeling System Program.

Argonne also helps the Army Corps of Engineers implement projects under the Superfund and Defense Environmental Restoration Programs through the Baltimore District. The Laboratory is developing specialized approaches to remedial investigations and feasibility studies, particularly for sites with radiological contamination, and is designing and overseeing implementation of remediation technologies for various sites.

Argonne assists several districts of the Army Corps of Engineers in the efficient execution of the Formerly Utilized Sites Remedial Action Program (FUSRAP), which was transferred from DOE to the Corps in FY 1998. The Laboratory brings specialized technical capabilities to this cleanup program, including the Adaptive Sampling and Analysis Program (ASAP), the RESidual RADioactivity (RESRAD) code for dose assessment and determination of cleanup criteria, and advanced tools for management of environmental data.

Argonne is conducting an integrated program of environmental and engineering research and technical support for the Army Corps of Engineers (Mobile District) and the Army's Training and Doctrine Command, examining issues such as land restoration, solid waste management, and cleanup of hazardous waste sites.

For the Army Chemical and Biological Defense Command, Argonne assists in the development and analysis of restrictions regarding the land disposal of chemical agents and their by-products in the environment. Studies are coordinated with multiple environmental agencies within the Army and the state of Utah. The Laboratory also supports the Command's Alternate Technology Program in the area of environmental compliance for demilitarization of assembled munitions by exploring alternatives to incineration of material from the U.S. chemical agent stockpile. In addition, Argonne is employing models and analyses to address environmental management issues at the Command's Rocky Mountain Arsenal and Pueblo Depot Activity.

For the U.S. Army Reserve, Argonne supports studies of asbestos usage and analyses of lead contamination on firing ranges at reserve armories and training sites.

Argonne has undertaken studies of the environmental risks posed by active and former test ranges for the Army Test and Evaluation Command. Argonne is now conducting specific environmental restoration and compliance assessment studies at several installations of the Command (Dugway Proving Ground, Yuma Proving Ground, and Aberdeen Proving Ground).

Argonne provides technical assistance for environmental restoration activities at the Aberdeen Proving Ground, which has a legacy of chemical contamination. The Laboratory is seeking solutions to such problems through a restoration study at the "J Field" site. Work addresses management of environmental information, wetlands issues, and the natural attenuation of groundwater contamination.

Argonne supports the U.S. Army Environmental Center through R&D on environmental restoration at various Army installations,

including several sites that have been placed on the National Priorities List. Specific activities include development of state-of-the-art environmental data management systems to expedite remedial decision making and use of groundwater and soil gas models to evaluate alternative methods of restoring aquifers. The Laboratory is also supporting compliance and regulatory analyses for the Center, including critical issues related to the Range Rule, which addresses public health and safety risks from used munitions. Another project for the Army Environmental Center is demonstrating the use of slurry bioreactors for detoxifying soils contaminated with explosives.

For the U.S. Army Defense Ammunition Center (USADAC), a part of the Industrial Operations Command (IOC), the Laboratory is developing a data system for hazardous waste characterization to support environmental compliance related to the destruction of munitions and explosives at Army installations and to the reuse and recycling of components. In related efforts, Argonne is developing a demilitarization planning and management system that incorporates the USADAC system and other information to improve the Army's ability to plan for cost-effective and environmentally sound demilitarization. In addition, the Laboratory performs specialized environmental modeling and analyses to address restoration problems at IOC installations.

6. Defense Special Weapons Agency

As part of its arms control program, Argonne develops verification procedures for the Defense Special Weapons Agency. Currently the Laboratory is studying the overall, long-term information and organizational requirements for treaty verification and compliance as further treaties are implemented. These efforts include analysis of functional requirements; technical evaluation, independent verification, and validation of new automated systems; prototyping for automated training techniques; and assistance in implementation planning. The Laboratory is also performing studies and technical evaluations in support of the Open Skies Treaty.

The Defense Special Weapons Agency's Arms Control Technology Program Office is developing technologies that will aid in the implementation of various arms control treaties. Effective verification of chemical arms control agreements, such as the Chemical Weapons Convention, requires protection of the health and safety of United Nations inspection teams. To make verification inspections safer, Argonne is developing a novel field-portable monitor for the selective determination of volatile organoarsenical agents at trace levels in ambient air.

The Laboratory also assists the Technology Applications Directorate with emergency preparedness reviews at civilian and military facilities.

7. Defense Advanced Research Projects Agency

For the Defense Advanced Research Projects Agency, Argonne is developing efficient algorithms and software for the symmetric and unsymmetric eigenvalue problem. In another project, the Laboratory is using technology developed for DOE's Human Genome Project to develop oligonucleotide microchip detectors that will detect and identify microbes, genes that code for protein toxins, and specific protein and chemical toxins. As part of a third effort, called the Globus project, Argonne researchers are developing software for geographically distributed computations.

Because of the success of its Logistics and Mobility Modeling Program, Argonne has been selected as lead agency for simulations in the Advanced Logistics Program. The simulation area — a distinctive Argonne competency that includes advanced simulation, visualization tools, and algorithms for parallel computation; automated reasoning; and object-oriented databases — contributes significantly to the Advanced Logistics Program. Of particular interest are several high-fidelity simulations of transportation and logistics processes that Argonne has developed over the last decade. Argonne plans to integrate these simulations into a new type of hybrid modeling system that combines simulation and scheduling technology with real-time data feeds on the locations and status of various items. The result will be a unique view of the past, the present, and projected states of readiness in the logistics support infrastructure.

C. Other Federal Agencies

1. Environmental Protection Agency

Argonne researchers work with the U.S. Environmental Protection Agency (EPA) to develop risk models for health effects attributable to human exposure to criteria pollutants. Recently completed were models relating ozone exposures to the formation of lesions in the human lung, decreased lung function, and symptoms such as coughing and chest pain. When necessary, Argonne uses probability encoding to quantify the judgments of health experts about the occurrence of health effects at subclinical exposure levels — levels at which few scientific data exist. These models allow the EPA to evaluate, for example, alternative standards for criteria pollutants in the face of incomplete, but telling, information. Another current project is developing tools to analyze data on hazardous

and toxic substances found at sites designated for cleanup under the Superfund Authorization and Recovery Act. Displaying the data to highlight geographic aspects is a particular interest.

Through the Environmental Technology Initiative, jointly funded by DOE and EPA, regulatory prototypes for the petroleum refining industry that were identified and evaluated by Argonne are being presented to stakeholder groups for review.

Argonne provides analytical support to the Global Change Division regarding industrial technologies and new policies that may mitigate emission of greenhouse gases. The Laboratory is studying industrial cogeneration and other technology options and analyzing scenarios involving high industrial energy efficiency, by using the National Energy Modeling System and the Argonne Multisector Industry Growth Assessment Model.

The EPA is providing funding for the Pacific Basin Consortium for Hazardous Waste Research and Management, of which Argonne is a founding member. The Consortium's activities currently include conferences and exchange of information on hazardous waste problems.

For EPA Region V, Argonne is extending methods of analyzing cumulative environmental risks in urban areas, by enhancing the availability and performance of scientifically sound procedures, models, analytical tools, and guidelines. One objective is to identify areas within the metropolitan Chicago region where exposures of the general population to individual pollutants or combinations thereof may be significant.

Also for the EPA, Argonne is parallelizing weather models to be used in studies of general climate models.

For the EPA's Great Lakes National Program Office, the Laboratory is analyzing 12 years of water quality data obtained via annual monitoring of the Great Lakes. Argonne will evaluate the sampling network used in the monitoring program and will interpret the results.

2. Federal Emergency Management Agency

Argonne's support to the Federal Emergency Management Agency involves three major areas relating to radiological and hazardous materials: (1) analysis and evaluation of the capabilities of U.S. industry, nearby communities, and host states to respond to emergencies involving the materials; (2) R&D on guidance for emergency planning, exercises to test emergency plans, and response activities; and (3) the development and conduct of training activities in support of area 2.

3. Department of State and International Atomic Energy Agency

Since 1976 Argonne has been the host institution for U.S. participation in the training activities of the International Atomic Energy Agency (IAEA). Argonne staff serve as instructors for more than 75 courses, covering topics such as radiation protection, environmental monitoring, nuclear safety, and energy and environmental analysis. Training is conducted for 25-28 weeks each year.

The IAEA, along with the State Department, has supported Argonne's development of analysis tools for decision making on energy and the environment. These tools are distributed to the ministries for energy and electric utilities in IAEA member states. In addition, Argonne staff members participate in IAEA missions providing technical assistance in the recipient countries. Activities include training local experts to use the decision analysis tools developed at the Laboratory.

4. Department of Health and Human Services

The National Institutes of Health support a broad range of fundamental studies at Argonne. These investigations generally apply techniques developed in DOE-supported programs to studies in biophysics, carcinogenesis, mutagenesis, and physiology.

The majority of these studies emphasize structure-function relationships or mechanisms underlying biological responses. One project focuses on the identification and characterization of genes that are induced in cultured cells following exposure to 60-hertz electromagnetic fields and other stress-inducing agents. The objective is to determine mechanisms for inducing specific genes. A related project isolates genes induced by ultraviolet light and studies their expression patterns. This research complements DOE studies on target genes and the mechanisms of radiation-induced damage. In another study aimed at identifying new genetic regulatory elements, the Laboratory is using two-dimensional electrophoresis to investigate changes in protein expression resulting from chemical exposures. A database of species-specific protein changes is being created.

Biophysical studies are addressing the properties of human antibody light chains that lead to pathologic deposition in myeloma. Investigations of *in vitro* aggregation of light chains consider their structure and pathologic characteristics. Two studies are investigating the mechanisms by which cadmium causes bone loss and are relating the findings to human exposure.

5. Department of Transportation

For the Research and Special Projects Administration of the Department of Transportation and in conjunction with the Federal Emergency Management Agency, Argonne continues to support two interconnected nationwide electronic bulletin boards with 30,000 registered users. The purpose of the bulletin boards is to disseminate information on hazardous materials that is needed for emergency planning. Argonne is also preparing emergency planning and response guidance documents, developing and using related computer modeling systems, and creating and maintaining related computer information systems for hazardous materials transportation emergencies.

6. Department of Agriculture

As part of an ongoing program for the Commodity Credit Corporation of the U.S. Department of Agriculture (CCC/USDA), Argonne supports remediation of sites having contaminated groundwater and soil by integrating field sampling, groundwater modeling, and engineering cost analyses. The Laboratory is also evaluating sources of contamination in the soil and methods of treating groundwater. New cone penetrometer technologies are being assessed for potential contributions to the CCC/USDA's remediation requirements.

In other work for the USDA, the Laboratory is developing a decision support system to evaluate alternatives to certain pesticides under USDA review.

7. National Science Foundation

As part of a national research project to develop enabling technology for the National High-Performance Computing and Communications Software Exchange, Argonne works on advanced Web resource management tools. Argonne is also a partner in the National Computational Science Alliance, recently funded by the National Science Foundation (NSF) Partnerships for Advanced Computational Infrastructure program. Researchers are developing software for collaborative problem solving, distributed computing technology and advanced visualization tools, and parallel input/output technology. Other NSF-funded computational science research at Argonne includes use of metacomputers to enable solution of large-scale optimization problems in science, engineering, and economics.

Together with Boeing Computer Services and several universities, Argonne is participating in an NSF-funded project to develop a numerical library that uses domain decomposition for the solution of large-scale aerodynamics and acoustics problems. Researchers are expected to base their applications modules on the PETSc software library developed by Argonne.

Argonne is a member of an NSF-sponsored Science and Technology Center for High-Temperature Superconductivity with the University of Illinois at Urbana-Champaign, Northwestern University, and the University of Chicago.

With Rice University and several other universities and national laboratories, Argonne participates as a partner in the NSF-sponsored Science and Technology Center for Research on Parallel Computation.

The Laboratory participates in a joint NSF-NOAA (National Oceanic and Atmospheric Administration) project examining the importance of episodic events for coastal processes in the Great Lakes. Argonne's roles in the five-year program include making in situ measurements of physical conditions within one meter of the lake bottom and determining very low concentrations of radioactive tracers in lake sediments.

8. National Aeronautics and Space Administration

For the National Aeronautics and Space Administration, Argonne is (1) investigating the use of automated differentiation techniques to provide reliable, fast derivatives for large-scale FORTRAN programs, (2) exploring three-dimensional visualization of remote astrophysical data, (3) conducting studies in microgravity of an integral cell membrane protein, and (4) developing surface analysis capabilities to study trace elements on wafers that have been exposed to the solar wind.

9. Department of Commerce

Argonne works with two organizations within the Department of Commerce: NOAA and the National Institute of Standards and Technology (NIST).

The Laboratory is collaborating with NOAA's Great Lakes Environmental Research Laboratory and Ohio State University to develop algorithms for interpreting multispectral satellite observations of the Great Lakes. This work involves field studies of the Great Lakes' optical properties and the development of specialized radiative transfer models appropriate for the optically complex

waters typical of the Great Lakes.

The NIST Advanced Technology Program (ATP) requires participating private companies to match NIST funding. The private sector can then choose to subcontract to the national laboratories in the pursuit of new technology. See Section D.3 below for further discussion.

D. Nonfederal Organizations

1. Electric Power Research Institute

Argonne conducts research for the Electric Power Research Institute (EPRI) on topics related to the risk of a severe accident at a nuclear power plant. Major experiments were conducted to measure the release of fission products in aerosol form when concrete is attacked by molten core materials. Resulting data are now being analyzed. Argonne's current work on the Melt Attack and Coolability Experiment program is particularly important. This work investigates the ability of water to quench and cool a pool of molten core debris without formation of a continuous insulating crust, thereby terminating an accident and preventing basemat penetration. The work has attracted worldwide attention because of its importance to strategies for managing accidents at existing plants and its great relevance to design decisions for future light-water reactors. These experiments are sponsored by the 15-nation Advanced Containment Experiments program headed by EPRI, which pursues realistic understanding of the consequences of an accident involving core melting.

Complementary Argonne programs have directly measured the thermophysical properties of core debris and concrete and have addressed the ability of melted core materials to spread to a readily coolable configuration on concrete. Argonne programs for EPRI generally have the objective of resolving key safety issues through a combination of analysis and experiments. Recently developed computer codes (MELTSPREAD and CORQUENCH), based on data from these experimental programs, are being used to analyze accident phenomena. The nuclear industry is attempting to close unresolved issues with the NRC. The Laboratory's contributions are a key part of the work needed to meet that objective.

2. Gas Research Institute

With the Gas Research Institute, Argonne is developing advanced techniques for geologic exploration.

3. Private Firms

Argonne conducts research for a number of private firms, making use of its unique facilities and technical resources. Current work includes the following:

- Amoco Research Center: Modeling a fluid catalytic cracker for the refining industry.
- Genencor International: Development of continuous biocatalytic systems for producing chemicals from renewable resources.
- General Atomics: "Smart sensor" technology to monitor conditions in the compartments of ships. (Funding is from the Naval Research Laboratory.)
- General Motors Electromotive Division: Improvement of the efficiency and emissions characteristics of diesel engines.
- Global Science and Technology: Gas pipeline infrastructure and emergency management.
- IBM: Development of computational models suitable for execution on advanced parallel-processing computers.
- M-C Power and others: Molten carbonate fuel cells. (EPRI also supports work in this area.)
- Superior Graphite Company: Development of nonintrusive process controls for die casting. (Funding is from the NIST ATP.)

In addition to the activities administered under Argonne's Work for Others program, as discussed in this Supplement 1, the Laboratory also performs work for its CRADA partners. These activities are discussed in Supplement 2.

Argonne is funded by Eastman Chemical; Genencor International; Electrosynthesis, Inc.; and Microgenomics, Inc., to collaborate in the second largest NIST ATP project ever awarded by the Department of Commerce. This $31.3 million program aims to develop technology for continuous biocatalytic production of chemicals. Over half of the funding is supplied by the industry partners. Argonne contributes expertise in genetic engineering, microbiology, bioengineering, and bioinformatics.

Argonne's work for private firms often grows out of industry-laboratory collaborative projects. An example is the Argonne Laser Applications Laboratory, which conducts R&D to support the use of high-power lasers in materials processing for manufacturing. Industrial partners include automotive manufacturers and suppliers and several small businesses. Current work focuses on applying laser ablation in decontamination and decommissioning (D&D) activities funded by the Environmental Management Science

Program. The Laser Applications Laboratory also provides technical service to several private companies. Processes being pursued include high-power beam shaping and delivery, fiber optics, surface modification, and welding. In addition, the Laser Applications Laboratory does work in support of Argonne's major facilities and programs, such as the Advanced Photon Source, the Intense Pulsed Neutron Source, the fusion power program, and D&D of reactor systems.

4. Universities

Argonne is a major participant in an NSF-sponsored Science and Technology Center for High-Temperature Superconductivity, with the University of Illinois at Urbana-Champaign, Northwestern University, and the University of Chicago. Research at the Center focuses on theory, synthesis and structure, bulk properties, and vortex phenomena. All of these areas of research are important to Argonne's work for DOE, which the Center complements extremely well. In the Center's educational activities, Laboratory personnel play key roles in all areas, particularly precollege and minority education. Argonne personnel also play key roles in linking the Center's basic research program to the needs of U.S. industry.

5. International Organizations and Foreign Countries

Argonne is working with the World Bank and countries borrowing from the Bank on energy and environmental analyses addressing issues such as planning least-cost expansions for electrical generating systems, estimating marginal costs of electricity production, and simulating the operation of mixed hydrothermal systems. Argonne typically conducts these studies in close cooperation with system planners in the borrowing counties, who are often trained to use the analytical techniques themselves.

Argonne scientists pioneered in developing the technology for niobium superconducting radio frequency accelerating structures (resonators) used in heavy-ion nuclear accelerators. The Laboratory recently developed a new prototype cryogenic resonator for the Nuclear Science Centre in New Delhi, India, and is now fabricating accelerating structures by following that design.

In nuclear reactor technology, Argonne's unique capability to perform severe-accident experiments with real reactor materials is utilized by international sponsors. The Laboratory currently works with Atomic Energy of Canada, Ltd., on an experiment to explore molten fuel-fluid interaction for the CANDU reactor. In the area of structural and seismic engineering, Argonne collaborates with the Korea Atomic Energy Research Institute on testing of material for seismic-isolation bearings.

The Laboratory is collaborating with Egypt's Cairo University to establish there a state-of-the-art Center for Environmental Hazard Mitigation. This five-year project will address Egyptian environmental problems such as urban encroachment onto the fertile lands of the Nile Delta, sea shoreline erosion, seismic hazards, and air and water pollution. Also being evaluated are the environmental impacts of the Salam Canal and the New Valley Project, as well as the origins of groundwater in the newly reclaimed lands in Egypt's western and eastern deserts.

Argonne works directly with many foreign countries to provide energy and environmental analyses along with training in the use of supporting computer models, including Argonne's ENergy and Power Evaluation Program (ENPEP). Also under way is a project to provide technical assistance and energy and environmental analyses to the Turkish Electricity Generation-Transmission Corporation and the Turkish Ministry of Energy and Natural Resources.

Supplement 2: Technology Transfer

In pursuit of its R&D and technology transfer missions, Argonne interacts extensively with industrial researchers and with companies interested in using the Laboratory's new technologies. Interactions with industrial firms — in many cases through R&D partnerships — enhance the Laboratory's programs and ensure that research findings and methods developed at the Laboratory can be exploited commercially.

Argonne's Industrial Technology Development Center is an organizational mechanism dedicated to achieving effective technology transfer and industrial collaboration. Reporting to Argonne's director, the Center manages industry-laboratory collaborative agreements, including cooperative research and development agreements (CRADAs) and High-Temperature Superconductivity Technology Center agreements (HTSCAs); protects and licenses intellectual property developed by the Laboratory; conducts outreach activities; and serves as a point of contact for inquiries concerning Argonne technology.

The Laboratory's director leads technology transfer, particularly by defining relevant Argonne policies. An advisory committee of the Laboratory's Board of Governors provides guidance. Technical staff in Argonne's research divisions generate new technology and work toward its transfer to industry.

Industrial partnerships are a pervasive mechanism that the Laboratory employs to maximize the commercial applications and benefits to the nation resulting from its R&D. Managers from relevant Argonne programs meet weekly as the Industrial Partnerships Committee, to explore opportunities for technology transfer to industry and for R&D programs that will lead to such transfers. In addition, five subcommittees meet regularly to coordinate opportunities in focus areas based on the Laboratory's research: (1) materials development, (2) manufacturing technology, (3) transportation technology, (4) energy and environmental technology, and (5) electric utility technology.

Argonne plans to continue its aggressive pursuit of technology transfer. Table S2.1 summarizes the funding and staffing associated with these plans.

Table S2.1 Technology Transfer Funding and Effort[a]

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Funding ($1,000)							
Industrial Technology Development Center[b]	2,300	2,200	2,300	2,400	2,500	2,600	2,700
ER-LTR[c]	2,400	2,163	3,266	4,000	4,000	4,000	4,000

High-Temperature Superconductivity Technology Center	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Other cost-shared contracts	1,500	1,500	1,500	2,000	2,000	2,000	2,000
Total Federal Cooperative Research Funding	29,056	31,200	34,800	40,400	45,500	50,600	55,700
Staffing (FTE)							
Industrial Technology Development Center Activity	16	17	18	18	18	18	18

[a] Includes only activities of Argonne's Industrial Technology Development Center.

[b] Includes funding for outside patent attorney services, at $225,000 annually, escalated for inflation.

[c] The Energy Research-Laboratory Technology Research Program.

A. Research and Development Agreements

Argonne's collaborative research with industry is usually conducted under CRADAs and HTSCAs. Other types of agreements employed include personnel exchanges, contracts for reimbursable work for sponsors other than DOE ("work for others"), and Technical Services Program agreements.

1. Cooperative Research and Development Agreements

CRADAs have proved valuable to both industry and the Laboratory. Argonne's industrial partners have created new products and processes, new markets, and new jobs. The Laboratory's scientists have access to industrial expertise and facilities that are not available on-site. Cooperative research also has generated a substantial number of Argonne's inventions, several as joint industry-Laboratory inventions.

Under a typical CRADA, both the partnering organization and Argonne contribute to the cost of the research. Proprietary information is kept confidential, and results of the work can be protected from disclosure for up to five years. A company may obtain rights to intellectual property developed by Argonne under the agreement.

Argonne promotes fairness of access to CRADA opportunities at the Laboratory by publicizing its capabilities and interests through wide-ranging vehicles such as technical conferences, trade shows, direct mailings, announcements in *Commerce Business Daily*, and articles in trade journals and other publications.

From October 1, 1993, through June 1, 1998, the Laboratory executed 212 CRADA actions — 132 new agreements and 80 amendments. The total value of these CRADA contracts was approximately $242 million, with the government contributing $51 million and industry contributing $149 million for efforts by its own researchers, plus an additional $42 million directly to Argonne to support Laboratory efforts. These investments give strong evidence of the value that industry places on partnership with Argonne. The remainder of this section is devoted to highlighting some of the Laboratory's significant industrial partnerships.

Rapid advances in medicine, health care, and agriculture are expected from a joint research project with Motorola, Inc., and Packard Instrument Company. The project aims at commercializing and marketing advanced biochips and related analytical technologies and is expected to make the process of decoding genes, for humans or other living things, a thousand times faster than with current technologies. Motorola will develop manufacturing processes to mass-produce biochips, and Packard will develop and manufacture the analytical instruments to process and analyze the biochips. Argonne's contribution, in conjunction with its Moscow research

partner (the Russian Academy of Science's Engelhardt Institute of Molecular Biology), is intellectual property in the form of 19 inventions related to biological microchips. This CRADA is one of the largest joint biotechnology research agreements ever signed by a DOE laboratory.

Argonne has several CRADAs with the oil-refining industry. These agreements directly support DOE's Refinery of the Future initiative, which promotes energy conservation and minimization of environmental impacts. One of these CRADAs — with Amoco Oil Company, Phillips Petroleum Company, Chevron Research and Technology Company, and UOP, Inc. — is using state-of-the-art laser optics instrumentation to test commercial fluid catalytic cracking unit feed nozzles. Test data from this unique collaboration will allow the development of more efficient nozzles.

In other work with oil companies, Argonne recently completed a joint research project with Shell Development Company to examine methodologies for mitigating fouling of refinery heat exchangers. Another recently completed CRADA with Chevron Research and Technology Company was aimed at defining a treatment process for efficiently identifying corrosion-producing acids in vacuum gas oils and crude oils.

A large project with Illinois-based NTEC EDSep, Inc., involves the development of advanced electrodialysis technology for preventing pollution in various process industries. Work in a different area with NTEC-Versol could result in the replacement of millions of pounds of toxic industrial solvents by environmentally friendly solvents made with ethyl lactate. Under this CRADA, Argonne researchers have developed a new process that substantially cuts the cost of manufacturing ethyl lactate. The key technology is a new patented purification-separation system. NTEC-Versol is planning a commercial demonstration plant. This innovative technology was named the 1998 Discover Award winner in its category. It also won a 1998 Presidential Green Chemistry Challenge Award, which recognizes technologies that benefit industry and prevent pollution.

Argonne has several projects with the transportation industry that also focus on reducing energy use and minimizing environmental impacts. Contracts with the U.S. Council for Automotive Research (USCAR, a partnership among the Big Three automakers) focus on pollution control, laser beam welding, and the development of advanced batteries for electric vehicles. Under the USCAR umbrella, a continuing CRADA with 3M and Hydro-Quebec also aims to develop lithium-polymer batteries for electric vehicles. Elsewhere, a CRADA with the American Association of Railroads (the trade association for the North American railroad industry) and the General Motors Electro-Motive Division focuses on improving combustion and pollution control technology.

Argonne will work with three private firms to develop near-frictionless carbon coatings to increase engine efficiency, extend wear life, and reduce maintenance costs for motor vehicles. Argonne's partners in the project are Front Edge Technology, Inc.; Stirling Thermal Motors, Inc.; and Diesel Technology Co. The coatings earned one of three *R&D* 100 Awards won by the Laboratory for 1998 (see also the discussion of "Outreach and Business Development" in Section S2.C). In addition, this new technology was a finalist in its category in the 1998 Discover Award competition.

An early warning expert system developed at Argonne, known as MSET (multivariate state estimation technique), is the basis for a new company as well as a CRADA. The Laboratory is testing MSET for application to sensor monitoring on space shuttle engines under a CRADA with Expert Microsystems, using Small Business Technology Transfer funding provided to the company by the National Aeronautics and Space Administration. The new company, SmartSignal, was formed by ARCH Development Corporation to commercialize MSET software packages. MSET is one of three Argonne R&D 100 Award winners in 1998 (see also Section S2.3).

Argonne CRADAs also involve foreign partners, as directed by the Nunn-Lugar Act. Under that legislation, the United States is helping countries of the former Soviet Union divert the staff of their weapons institutes to nonmilitary activities. The Newly Independent States Industrial Partnership Program (NIS-IPP) and the United States Industry Coalition (USIC) were developed to facilitate cost-shared commercialization projects that further those objectives. In 1995 Argonne played a significant role in the development of the intellectual property agreements now used throughout the NIS-IPP and executed three CRADAs with USIC members: with U.S. Bioscience, Inc., for the evaluation of radioprotectors; with SI Diamond Technology, Inc., for the development of nanocrystalline diamond thin-film cathodes for field emission displays; and with Phase Metrics, Inc., for the development of flux-imaging systems for analyzing superconducting materials.

2. High-Temperature Superconductivity Technology Center Agreements

Under a typical HTSCA, both the partnering organization and Argonne contribute to the cost of the research. Proprietary information is kept confidential, and the results of the work can be protected from disclosure for up to two years. Under an HTSCA, a company may obtain the rights to intellectual property developed by Argonne.

From October 1, 1993, to June 1, 1998, Argonne executed 33 HTSCAs — 10 new agreements and 23 amendments. The total value of contract contributions, by both Argonne and industry, was $18.5 million. Of this amount, $7.1 million was provided directly to the Laboratory by industrial partners. The firms involved range in size from Fortune 500 companies to start-up companies with only a

few employees. Industrial interest remains high, and many firms renew previous contracts.

Under HTSCAs, the Laboratory has developed several enabling technologies that are now being used by industry, such as vacuum calcination for powder synthesis, microstructural texturing, silver composite processing, and melt processing. In addition, the Laboratory has developed four product-oriented technologies: a cryogenic fluid level sensor, current leads, magnetically levitated bearings, and superconducting wires.

Argonne's strength in advanced materials development has been coupled very effectively with industrial expertise and facilities to achieve dramatic advances toward practical superconductors. Cooperative research with the Laboratory in this leading-edge technology area has been particularly valuable to small companies that were formed to pursue commercial applications of high-temperature superconductivity. One such company, Superconductive Components, now manufactures four varieties of high-temperature superconducting powders by using an Argonne process that won an *R&D* 100 Award in 1994. Compared with alternatives, this method reduces processing time by 60% and yields cost savings estimated at 40% (which is about $180 per pound of material produced).

Intermagnetics General Corporation and Argonne worked together to meet the challenge of producing ceramic superconductors in the form of long wires and tape suitable for practical applications. An HTSCA led to the fabrication of a magnet containing approximately 480 meters (1,500 feet) of flexible superconducting tape, which produced a record-breaking magnetic field of 2.6 tesla. Work with Argonne on next-generation superconductors has positioned Intermagnetics General to expand its product line to high-temperature superconductors. The company has already manufactured prototype high-temperature superconductor products that are close to commercialization.

3. Work for Others

Argonne conducts work for sponsors other than DOE, including industrial firms, universities, and state and local governments. This "work for others" is discussed in Supplement 1.

4. Personnel Exchanges

Argonne exchanges scientific staff with industrial firms through a variety of mechanisms, including CRADAs and guest agreements. Appointments generally range from three months to one year but may be as brief as a few days. As of June 1, 1998, the Laboratory had conducted 23 personnel exchanges supported by DOE's Energy Research-Laboratory Technology Research (ER-LTR) Program.

Personnel exchanges most often involve a scientist or engineer from industry working at the Argonne site and using the Laboratory's expertise and facilities to pursue technical challenges of mutual interest. These exchanges give Argonne researchers the benefit of industrial perspective, and mutual familiarity and understanding often lead to subsequent collaborations.

5. Technical Services Program Agreements

Argonne provides technical assistance to companies through its Technical Services Program, which is supported by the ER-LTR Program. Technical Services Program agreements allow Argonne scientists to use their unique expertise to provide limited scientific assistance, typically to help small businesses solve immediate technical problems where such expertise is not otherwise available. From the program's inception in FY 1994 to June 1, 1998, the Laboratory has assisted 76 companies in this way. In some cases, a CRADA or other wider-ranging collaboration has resulted.

B. Patenting and Software Licensing

In FY 1992 the University of Chicago began using federal funds to patent inventions and to register copyrights for software. Income from this intellectual property is used primarily to support CRADAs, HTSCAs, and other cost-shared collaborations. Acquisition by industry of intellectual property developed by Argonne under programs that were not directed toward cost-shared collaborations has generally been pursued with private funding provided by the ARCH Development Corporation, an affiliate of the University of Chicago.

The acquisition and protection of Argonne intellectual property have been pursued aggressively under both federal and ARCH funding. From October 1, 1993, to June 1, 1998, ARCH and Argonne took title to a total of 177 inventions. Patent applications were filed on 290 and patents issued for 195. Where appropriate, filings under the Patent Cooperation Treaty were made to preserve foreign patent rights for licensees.

To manage decisions about the disposition of Argonne inventions, the Laboratory established an Intellectual Property Decision

Group. For each invention, a meeting of the group is convened. Attendees include the inventors, their managers, Argonne's chief patent counsel, representatives of the Industrial Technology Development Center, and, where appropriate, ARCH Development Corporation. The group attempts to decide how best to handle the invention. Election to patent may be made by Argonne, ARCH, the inventors, or DOE, depending on the end uses envisioned. New management at ARCH has focused more strongly on the development of new companies. In the future, the role of ARCH in managing Argonne's intellectual property will diminish. The Laboratory will play a more dominant role. ARCH is not permitted to copyright Argonne software. If ARCH wishes to commercialize software developed by Argonne, it must license the software from the Laboratory. ARCH has executed 39 licenses and license options and created 6 new companies since FY 1987, all based on Argonne inventions.

Laboratory inventions and software are protected with federal funding to prepare for potential licensing to existing industrial partners and to establish technical leadership in areas in which the Laboratory is interested in forming industrial collaborations. Detailed procedures for electing, patenting, cost-tracking, and licensing inventions under federal funding have been developed and implemented. Relational databases are used to coordinate intellectual property acquisitions and licensing arrangements with collaborative agreements that have been executed or are in process.

The number of licenses, license options, and assignments executed by Argonne under federal funding has increased steadily, from 5 in FY 1993 to 12 in FY 1998. (These numbers include only licenses and options relating to specific, identified intellectual property; in contrast, CRADAs generally include an option to acquire any intellectual property generated under the agreement.) Initial fees and running royalties associated with executed licenses vary from no-cost licenses up to potential payments of millions of dollars. To encourage cost-shared partnerships, the negotiated terms of licenses are generally very favorable to industrial partners. In addition to licenses granted to industry, a few software program copyrights are distributed publicly under no-cost licenses.

The reporting and transfer of Argonne software have been increasingly successful. From October 1, 1993, through June 1, 1998, more than 90 software codes were formally reported. DOE approved the Laboratory's requests to assert copyright to 72 of these. Copyright registration is pursued both for codes to be transferred to industry and for codes to be broadly provided under free licenses. Twenty licensed software codes are now earning royalties. Publication copyrights are increasingly emphasized. Trademarks associated with copyrights are registered, where appropriate, and licensed with the copyrights.

Argonne has carefully developed a comprehensive set of policies and procedures for copyrights and software to satisfy DOE orders and to meet the full range of the Laboratory's administrative concerns. To support existing partners in cost-shared agreements and encourage new agreements, Argonne has developed procedures to ensure that intellectual property is adequately protected and that industrial partners are informed about inventions and software developed under their cost-shared agreements or otherwise related to their R&D areas.

Work performed by Argonne and its partners under cost-shared agreements such as CRADAs and HTSCAs is sometimes at the cutting edge of technology and generally has been very productive. From October 1, 1993, through June 1, 1998, 83 inventions were reported as conceived under these agreements.

Table S2.2 describes the amounts and uses of income from the licensing of Argonne inventions. The royalties received to date stem from two sources: up-front payments for licenses and options and running royalties from the sale of products.

Table S2.2 Licensing Income and Use

	FY97	FY98	FY99	FY00	FY01
Licenses[a]					
Number of New Licenses					
ARCH	2	2	2	2	2
Argonne	14	15	15	15	15
License Income ($1,000)					
ARCH	30	150	150	150	150
Argonne	103	800	300	500	700
Total	133	950	450	650	850
Use of Income ($1,000)					
ARCH Administration[b]	22	112	112	112	112
ORTA Administration	0	0	0	0	0

Laboratory R&D[c]	77	150	150	150	150
Awards and Inventor Payments[d]	33	88	88	88	88
Total	133	350	350	350	350

[a] Includes licensing, options to license, and assignments to industry.

[b] Equals 75% of ARCH royalties.

[c] Equals 75% of Argonne royalties.

[d] Equals 25% of total royalties.

Royalties from federally funded commercialization began in FY 1994. Royalties remaining after shares are disbursed to inventors and authors are used by Argonne to support the further development of intellectual property and its transfer to private industry. The Laboratory's share of these royalties is used to initiate selected work-for-others projects that otherwise would require overly burdensome up-front payments from small businesses. When the Laboratory completes its work under such an arrangement and the small business sponsor pays, the Laboratory's royalty account is to be replenished.

C. Outreach and Business Development

Argonne works diligently to communicate its capabilities to industry, to disseminate information about technology transfer, and to facilitate access to the Laboratory's resources. The Laboratory reaches companies directly and through state and local economic development organizations. Argonne's Industrial Technology Development Center coordinates outreach activities and serves as the central point of contact for companies wishing to explore Laboratory capabilities and industry partnerships. Program development and communications functions within the Laboratory are closely coordinated. Attention centers on five major industrial focus areas (materials development, manufacturing technology, transportation technology, energy and environmental technology, and electric utility technology).

One major channel of communication is publication of articles in scientific and technical journals. In addition, Argonne publishes a quarterly newsletter, *Tech Transfer Highlights*, targeted to industrial firms. Circulation is approximately 4,500. Participation in trade shows often involves formal Argonne exhibits. Standard public relations techniques such as press releases are employed extensively.

Each year the Industrial Technology Development Center responds to approximately 2,500 inquiries from industry. The Center typically connects the inquirer with one or more Argonne researchers and then, if appropriate, guides the interaction through to negotiation and execution of an agreement. In other cases, a referral is made to an outside organization, program, or service.

Awards for technology transfer, such as those presented by the Federal Laboratory Consortium, highlight some of Argonne's successful partnerships with industry. The Laboratory won its 17th such award in 1998, for the successful transfer to industry of a laser weld monitor. The monitor is now available in the commercial marketplace.

In 1998 the Laboratory won three *R&D* 100 Awards: for a carbon coating that is slicker than Teflon; for PRODIAG software that helps produce customized diagnostic systems for continuous thermal-hydraulic processes; and for the MSET advanced software that is applied to process and signal surveillance.

Argonne staff are knowledgeable about technology transfer. A technology transfer handbook for all Argonne employees is available in paper and on the Laboratory's technology transfer Web site. Laboratory staff are also informed via other avenues, such as an electric bulletin board.

Supplement 3: Site and Facilities

A. Laboratory Description

1. Overview of Site and Facilities

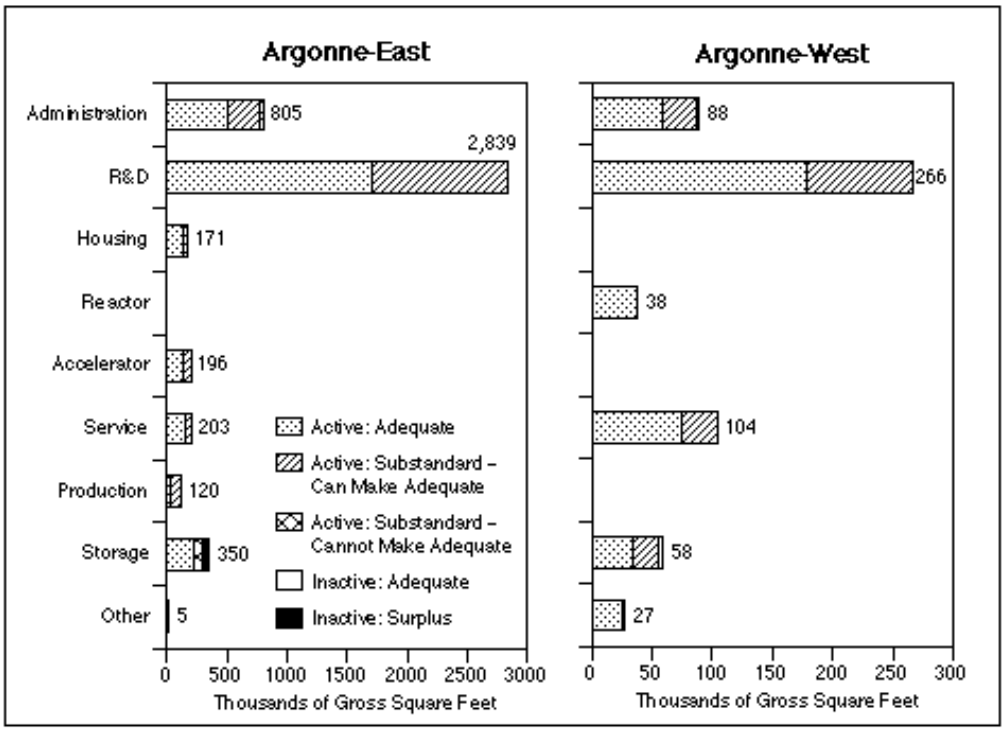
Argonne National Laboratory conducts basic and technology-directed research at two sites owned by DOE. Argonne-East is located on a 1,500-acre site in DuPage County, Illinois, about 25 miles southwest of Chicago. Argonne-West is located on an 800-acre tract within the Idaho National Engineering and Environmental Laboratory, about 35 miles west of Idaho Falls, Idaho. The facilities of Argonne-West are predominantly contained within a fenced area of about 90 acres. The only exception is the Transient Reactor Test Facility, which is located about a mile away. Argonne-West is devoted mainly to R&D on nuclear technology.

a. Argonne-East

Activities at Argonne-East support the full range of missions described in Chapter II. Major facilities at the site include the Advanced Photon Source (APS), the Laboratory's newest and largest user facility; the Intense Pulsed Neutron Source; the Argonne Tandem-Linac Accelerator System; and the High Voltage Electron Microscope. All these facilities are heavily used by researchers from outside Argonne. The Alpha-Gamma Hot Cell Facility supports examinations of materials for major Laboratory programs. Argonne-East also houses a full spectrum of administrative and technical support organizations, as well as the DOE Chicago Operations Office and the New Brunswick Laboratory, both of which use facilities operated and maintained by Argonne.

Programs for the DOE Office of Energy Research account for over half of the space usage at Argonne-East. Figure S3.1 summarizes the distribution of space at Argonne-East (and Argonne-West) by *functional unit* (administrative, housing, R&D, and so on) and by

condition of space, as a percentage of gross square footage.



	Space at Argonne-East					Space at Argonne-West		
	Active			Inactive		Active		
		Substandard					Substandard	
	Adequate	Can Make Adequate	Cannot Make Adequate	Adequate	Surplus	Adequate	Can Make Adequate	Cannot Make Adequate
Administration	511	255	39	0	0	58	28	2
R&D	1,705	1,134	0	0	0	178	88	0
Housing	130	41	0	0	0	0	0	0
Reactor[a]	0	0	0	0	0	38	0	0
Accelerator	140	57	0	0	0	0	0	0
Service	151	47	0	0	5	74	30	0
Production	30	86	5	0	0	0	0	0
Storage	223	1	75	26	25	34	21	3
Other	4	0	1	0	0	25	2	0
TOTAL[b]	2,894	1,620	120	26	30	407	169	5

[a] The reactor building at Argonne-West and some support facilities are being prepared for shutdown activities.

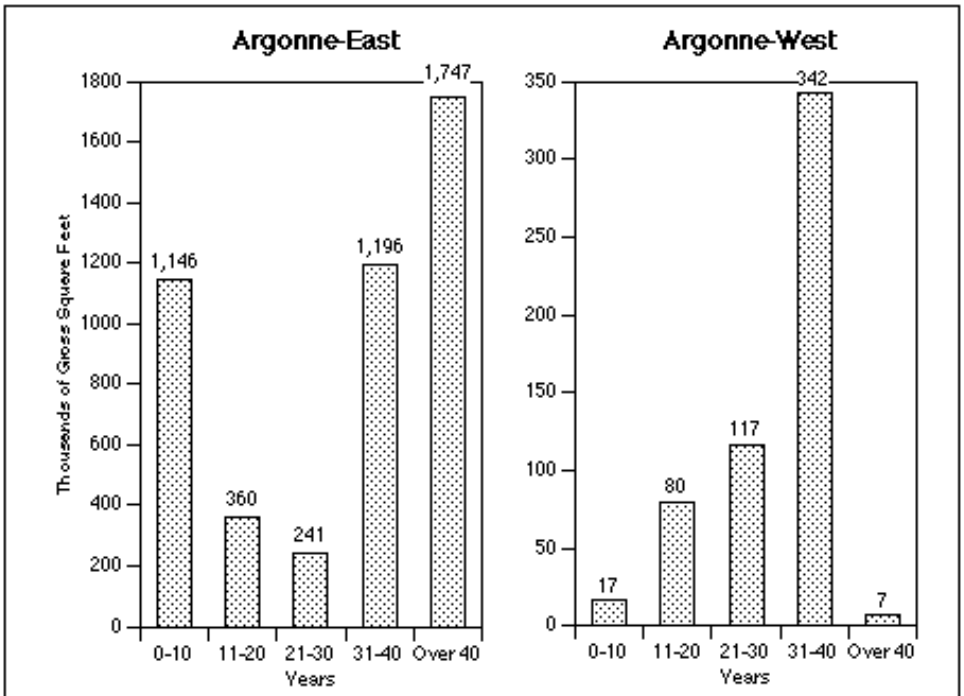
[b] Totals and column entries were rounded independently.

Figure S3.1 Distribution of space at Argonne-East and Argonne-West in 1998 by function and condition.

Altogether, Argonne-East houses roughly 6,000 persons, including employees of DOE and contractors, visiting users of research facilities, and other guests. The Argonne-East site includes 112 buildings having 4.7 million total square feet of floor space. Nearly two-thirds of the facilities are more than 30 years old. The Laboratory is also leasing 77,000 square feet of office space in a commercial park near the Argonne-East site to alleviate a space shortage. (See Table S3.1, which includes small additional amounts of space leased off-site.) Figure S3.2 summarizes the ages of Argonne-East (and Argonne-West) facilities. The replacement value of existing facilities at Argonne-East is estimated to be $1.74 billion. (See Table S3.2.)

Table S3.1 Argonne-East Space Distribution	
Location	Area (thousands of square feet)
Main Site	4,692
Leased Off-Site	109

Total	4,801



Active	1,146	360	241	1,167	1,720		17	80	117	342	7	
Inactive[a]	0	0	0	29	27		0	0	0	0	0	

[a]Inactive space is too small to be displayed graphically. Entries were rounded independently.

Figure S3.2 Age of Laboratory buildings at Argonne-East and Argonne-West in 1998.

Table S2.2 Replacement Value of Argonne Facilities (millions of FY 1997 dollars)		
Facilities Types	Argonne-East	Argonne-West
Buildings	1,025	177
Utilities	129	24
All Others	583	165
Total	1,738	366

Adequate land area is available to accommodate Argonne's plans for expansions of programs in basic research and other areas. Site infrastructure generally can accommodate modest growth, provided that support systems are maintained or upgraded to meet current standards for environmental protection, safety, and reliability. Facilities are now almost fully occupied, so additional construction will be required to continue the planned removal of obsolete and deteriorated facilities and to satisfy growing programs.

b. Argonne-West

Argonne-West conducts R&D and operates facilities for DOE. With termination of the Integral Fast Reactor program in FY 1994, the programmatic mission of the Argonne-West facilities changed significantly. Current research focuses are (1) the use of electrometallurgical techniques to condition the driver and blanket assemblies from the Experimental Breeder Reactor-II (EBR-II), (2) reactor and fuel cycle safety, and (3) decontamination and decommissioning (D&D) technology. In addition to Nuclear Energy, Science and Technology, DOE programs using Argonne-West facilities include (1) Nonproliferation and National Security and (2) Environmental Management.

The Waste Characterization Area (WCA) within the Hot Fuel Examination Facility (HFEF) at Argonne-West is used for sampling and characterizing waste ultimately bound for the Waste Isolation Pilot Plant (WIPP). The WCA features remote operations and glove boxes for sampling of various kinds, from gas sampling to core drilling. In conjunction with the Gas Generation Project, a glove box operation in the Zero Power Physics Reactor (ZPPR) facility, the WCA will allow monitoring of potential gas buildup in waste packages bound for the WIPP.

The ZPPR, now shut down, was used for physics testing of new reactor core designs. The facility includes a large fuel storage vault that provides state-of-the-art storage for special nuclear materials. Associated Argonne experience in the care and treatment of special nuclear materials has been the basis for efforts to help the former Soviet Union with nonproliferation technology.

The main cell of the HFEF is a large, multipurpose hot cell filled with inert gas, in which operations on highly radioactive fuels and materials can be performed. The HFEF is being used to disassemble spent fuel from the EBR-II and to place the fuel elements or pins into containers for temporary storage. The HFEF is an extremely versatile facility suitable for work such as nondestructive or destructive examination of radioactive materials and development of spent-fuel waste forms, as well as other kinds of work requiring remote handling of radioactive materials.

The EBR-II has now been shut down and defueled. It is serving as a demonstration facility for the development of D&D methods for nuclear plants. A key technological issue is treating EBR-II spent fuel to stabilize it from a mixed hazardous waste to a final form that will meet the requirements of a geologic repository. This problem is being addressed at the Fuel Conditioning Facility, where sodium is being removed from inside the EBR-II fuel, and the spent fuel will be converted from a mixed hazardous waste to a stable metallic and mineral waste form.

The Sodium Processing Facility treats sodium from the EBR-II and other sources, converting elemental sodium first to sodium hydroxide and then to sodium carbonate for ultimate disposal. Technology from the facility could be adapted to sodium processing for the Fast Flux Test Facility.

The Transient Reactor Test Facility is not operating, but the facility is hosting the Plasma Hearth Project, which is testing a means of using a plasma arc torch to turn low-level waste into a stable, glass-like substance. The torch melts both the waste container and its contents, converting them into a highly stable form for disposal.

The Fuel Manufacturing Facility (FMF), previously used to fabricate fuel for the EBR-II, has completed manufacturing dummy stainless steel subassemblies for replacement purposes in the defueling of the EBR-II. The FMF has glove boxes and a storage vault for special nuclear materials. Equipment for materials testing and characterization is being installed in the glove boxes to support treatment of spent fuel.

Supporting the major facilities at Argonne-West is an array of shops, warehouses, laboratories (including a newly refurbished analytical chemistry laboratory), offices, and utility systems.

Argonne-West houses about 760 employees. The site has 52 buildings with 600,000 gross square feet of floor space. Most of the buildings and other infrastructure were built during the mid to late 1960s. Figure S3.2 summarizes the ages of Argonne-West facilities. Replacement value of existing facilities at Argonne-West is estimated to be $352 million. (See Table S3.2.)

2. Status of Existing Facilities and Infrastructure

Because most building and facility infrastructure systems have a life expectancy of 25-35 years, many Argonne facilities constructed in the 1950s and 1960s require upgrading or replacement. This aging of facilities has caused the accumulation of a large inventory of needed revitalization. Furthermore, as costs related to space continue to escalate — notably heating, cooling, lighting, and maintenance — effective use of that space has become increasingly important.

Argonne’s management of site and facilities includes a systematic and comprehensive program to ensure that facilities effectively meet research needs as well as requirements for safety, health, security, and environmental acceptability. The Laboratory’s ongoing facilities planning includes site development planning, condition assessment surveys, and prioritization of asset resource requirements. The following discussions for Argonne-East and Argonne-West describe the current status of each site in the context of this management program.

a. Argonne-East

The objectives of the management of site and facilities at Argonne-East are to improve use of facilities, eliminate substandard facilities, and upgrade strategic facilities and systems. Demolition of substandard buildings has reduced both energy costs and operating and maintenance expenses. These actions have eliminated many unsightly areas, and cleared sites have been restored and made available for future Laboratory facilities. Upgrading has included improvements in energy efficiency that have helped to reduce

the Laboratory's bills for fuel and electricity.

The aggressive facilities management program at Argonne-East includes a computerized system for maintenance control and reporting. This system allows better planning of work, tighter control of resources, and more accurate measurement of results. The other main thrust of the facilities management program involves upgrading or revitalizing strategic buildings, utility systems, and other infrastructure. Included are modifications of existing facilities to accommodate new initiatives; to increase safety, health, and environmental acceptability; to save energy; and to replace obsolete building systems that require excessive maintenance. Part of this work has already been completed, and some is currently in progress. However, much more is needed. Preliminary planning has been completed for remaining upgrading needs. The DOE Chicago Operations Office and DOE Headquarters have been closely involved in the upgrading program since its inception and have actively supported it. The rehabilitation program would not have been possible without strong endorsement and funding from the DOE Multiprogram Energy Laboratories — Facilities Support (MEL-FS) program and its predecessors.

The principal challenges facing Argonne-East today still stem from the normal aging of buildings and infrastructure and the resulting substantial needs for updating. Some substandard facilities require replacement. In addition, some facilities require D&D or modifications to meet changing program needs or new environmental regulations. Existing space is over 97% utilized. Figures S3.1 and S3.2 summarize the condition and age, respectively, of facilities at Argonne-East (and Argonne-West). Overall, utility systems are adequate for anticipated needs. Selected aspects of several utilities still require upgrades for compliance with standards and increased reliability.

b. Argonne-West

The property management program at Argonne-West aims to (1) meet the needs of the Laboratory's programs; (2) meet safety, health, and environmental requirements; (3) provide a workplace that encourages high productivity and creativity; and (4) protect the large government investment in the site's facilities.

The major programmatic facilities at Argonne-West have been well maintained, and all are projected to have useful lives of at least 15 more years. General purpose facilities have been maintained in a workable state of repair with limited funds by giving priority to jobs critical or necessary to prevent much more costly future repairs, but a backlog of needed repairs and rehabilitation that will cost several million dollars has accumulated. Figures S3.1 and S3.2 summarize the condition and age, respectively, of facilities at Argonne-West.

The analytical laboratory now operating at Argonne-West has been upgraded to meet the key roles it plays in activities at the site. Originally built in the late 1950s, many of its components and systems were recently replaced. To meet today's requirements for handling plutonium-bearing fuels, a new ventilation system was installed, hot cell windows were refurbished, and new remote manipulators were purchased.

B. Facilities Plans and Options

Argonne remains fully committed to its formal planning processes for site development and management of facilities. A key ongoing objective is development of a work environment that stimulates creativity and high productivity. The major long-range objective of Argonne's site and facilities planning is preservation of the Laboratory's substantial investment in capital facilities, while technical and programmatic needs are met. Long-range facilities planning remains flexible to accommodate changing missions and directives.

1. Argonne-East

On the basis of current programmatic planning, the major challenges at Argonne-East over the next 10-15 years will include improving the cost-effectiveness of facilities support for the Laboratory's changing programs in basic research and industrial technology. Long-range development plans for Argonne-East provide for the Laboratory's initiatives described in Chapter IV, while the needs of existing programs are met.

Planning and construction of the APS have exemplified the effectiveness of the Laboratory's long-range planning. Land in the 400 area used for APS construction has access to all site services. Existing utilities have sufficient capacity for both the APS and its associated initiatives without disrupting current activities.

The Laboratory remains strongly committed to collaborative research and technology transfer. Long-range site planning includes land in the east area dedicated to construction of a technology transfer center. Modifications, upgrades, or expansion of existing facilities will also be undertaken as required to accommodate other scientific initiatives.

The Laboratory is continuing its initiative to replace deteriorated, substandard structures. A new transportation and grounds facility in

the east area, completed in 1994, permitted the demolition of several substandard buildings located in the west area. Additional plans call for a new central supply facility.

Argonne-East has also developed plans to upgrade, as funding allows, permanent laboratory and office facilities; electrical, steam, and chilled-water systems; roads and sidewalks; and the central heating plant.

Environmental activities command the highest priority at Argonne. At Argonne-East, these activities fall into two major categories: (1) modification, replacement, or upgrading of existing processes for handling wastes and (2) cleanup of inactive contaminated facilities and sites. The Laboratory has developed plans for D&D of facilities no longer in use, ensuring removal or containment of potential environmental hazards and allowing reuse of the land or facilities. The Laboratory's plans for D&D of inactive surplus facilities are discussed in Section S3.D.

Energy efficiency and conservation are also strong priorities at Argonne. The Laboratory is conducting detailed studies of its energy usage and is retrofitting facilities as required. Strategies being considered to further reduce energy consumption and its associated costs include energy savings performance contracting and competitive procurement of electricity from deregulated utilities. The Laboratory is also benefiting from participation in the demand-side load management program of its electric utility, Commonwealth Edison.

Efforts continue to enhance the appearance of the Argonne-East work environment, which contributes to productivity and creativity and helps to attract superior scientists and engineers. Projects include renovation of many public areas, improved landscaping and parking areas, and general enhancements of the site's appearance to reflect its status as a world-class research facility. Argonne-East has expanded and remodeled its Visitor Reception Center to house the Argonne Information Center, which features interactive displays and exhibits describing the Laboratory's programs, outreach activities, and accomplishments. The Center also accommodates special functions that allow interaction with the general public.

Along with rehabilitation, demolition, D&D, and site enhancement, maintenance of facilities at Argonne-East continues to receive high priority. This ongoing process improves productivity, increases efficiency, and generally directs resources to their most effective applications. Argonne inspects its facilities through a formal Condition Assessment Survey process. The Laboratory maintains a management information system for work requests and processing of backlog information in order to better integrate implementation of tasks and use of resources.

2. Argonne-West

The mission of Argonne-West is part of the Laboratory's overall mission in nuclear technology, which has two major elements. The first is termination of the Integral Fast Reactor program and associated activities, including shutting down the EBR-II. The second major element addresses issues such as the treatment of spent nuclear fuel, reactor and fuel cycle safety, and development of technologies for the D&D of reactors and other nuclear facilities.

Environmental activities command high priority at Argonne. The objective of Argonne-West's environmental program is to ensure that the Laboratory has no adverse effect on the environment and complies with existing environmental regulations. Major activities include (1) replacing transformers containing polychlorinated biphenyls; (2) sampling and analyzing past releases of hazardous materials into ponds, ditches, and other areas; (3) replacing underground scrap and tanks; (4) upgrading the radioactive scrap and waste facility; and (5) seeking permits from the U.S. Environmental Protection Agency and the state of Idaho for certain ongoing activities; (6) providing a facility for remotely handled mixed transuranic waste; and (7) converting elemental sodium to sodium carbonate for disposal.

After the upgrading of Argonne-West's fire protection system was about half completed, funding for completion of the program was withdrawn. To date, about $3.4 million has been expended to improve fire protection for major facilities. Other higher-priority plans for correcting deficiencies at the site address roofing and insulation, roads, storm drainage, water supply isolation valves, deep-well pumps, electrical duct banks and feeders, steam and condensate lines, communications systems, and lines carrying radioactive liquid waste. Lightning protection will also be improved. The general aims of these rehabilitation plans are to avert troublesome and expensive failures and to comply more closely with DOE criteria for general purpose facilities.

C. General Purpose Facility Plans

Argonne's planning for general purpose facilities focuses on maintaining facilities that are both safe and efficient.

1. Argonne-East

At Argonne-East the main issues for general purpose facilities are substandard facilities and infrastructures and shortages of space. New facilities are currently planned to serve the following functions: central supply, multiprogram laboratories and offices, and technology transfer. This construction will allow demolition of several substandard facilities remaining on the site after current consolidation of space usage is complete.

Argonne-East is also proposing to upgrade a number of facilities to meet fire and electrical safety requirements and to facilitate a transition of environment, safety, and health (ES&H) regulation to the Occupational Safety and Health Administration. Other planned upgrades address electrical services; steam distribution and mechanical systems; and various roads, sidewalks, and parking areas.

2. Argonne-West

At Argonne-West the main issue for general purpose facilities is facility aging, with its normal attendant requirements for upkeep and renovation. Planned or under construction are new facilities for programmatic support, including environmental activities, waste handling, and related efforts. Correction of facility-related deficiencies is a planning focus.

D. Inactive Surplus Facilities Plan

1. Argonne-East

Argonne-East, in collaboration with the DOE Chicago Operations Office, has developed a program for timely D&D of facilities no longer in use at Argonne-East, ensuring appropriate removal or containment of potential environmental hazards and allowing reuse of facilities where warranted. The program is funded by DOE-Environmental Management (DOE-EM).

Several major D&D projects were recently completed. After completion of work at the Experimental Boiling Water Reactor in Building 331, the building has been converted to a transuranic storage facility, resulting in substantial savings relative to new construction. More than 60 contaminated surplus glove boxes in Building 212 were decontaminated and downsized. Appropriate waste was packaged and sent to Hanford; remaining transuranic waste will reside in the new storage facility. Offices and laboratories in the area containing the glove boxes are now being used by other Argonne programs. Five of the hot cells in the M-Wing of Building 200 were decontaminated sufficiently to reduce radon releases, previously the largest source of off-site exposure from Argonne-East, by more than 95%. The cells are now available for future programs. The D&D of the Fast Neutron Generator (Building 314) was completed, and the area is being used for general support services. The D&D of the JANUS reactor (Building 202) has also been completed. Field work was completed in less than a year, and the facility is now available for reuse.

The D&D of the CP-5 Reactor is continuing and will be completed in 1999. The D&D program at CP-5 has been combined with the CP-5 Large Scale Demonstration Program. The combined program, under the direction of the Strategic Alliance for Environmental Restoration, is demonstrating and evaluating new D&D technologies. The Alliance includes Argonne, Commonwealth Edison, Duke Engineering and Services, Florida International University, ICF-Kaiser, and 3M. Identified for future D&D are the Argonne Thermal Source Reactor (Building 315), the Zero Power Reactors 6 and 9 (Building 316), the Juggernaut Reactor, the 60-Inch Cyclotron, surplus retention tanks (Building 310), and the Waste Ion Exchange Facility (Building 594).

More than half of the D&D work identified in the DOE-EM *Baseline* for Argonne-East has been completed. With adequate funding, the remaining D&D work can be completed in less than five years at a cost of approximately $40 million.

Surplus facilities that are not contaminated have also been a long-standing concern at Argonne-East. During the 1980s, the Laboratory added roughly 300,000 gross square feet of new space, while demolition of substandard buildings and removal of temporary trailers resulted in a net loss of 270,000 gross square feet. More recently, the Laboratory removed over 90,000 square feet of trailers and obsolete buildings. Argonne’s plans call for continued removal and clearing of the old east and 800 areas of the site, which will reduce substandard space by approximately 110,000 square feet. Concurrently, the Laboratory is planning to release 77,000 square feet of off-site leased space by FY 2000. However, progress on this front depends on continuing receipt of funding to construct suitable replacement space.

2. Argonne-West

All facilities at Argonne-West are being actively used, including EBR-II facilities, which, in addition to supporting defueling activities, are providing power switching, site monitoring, cooling water, compressed air, and other services.

E. Facilities Resource Requirements

Table S3.3 describes all facility projects for which capital funds have been appropriated or requested, or that will be proposed in the near future. The projects fall into three broad categories: (1) direct support for specific programmatic objectives, (2) environmental remediation, and (3) rehabilitation of the physical plant. The last category includes general plant project (GPP) and multiprogram general purpose facility projects. Construction funds required for Laboratory initiatives are discussed in Chapter IV.

Table S3.3 Major Construction Projects ($ in millions BA)

	TEC	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Funded Projects									
AF-95									
Office of Nuclear Energy, Science and Technology Nuclear Energy Research and Development									
General Plant Projects, ANL-West[a]	1.5	1.5	-	-	-	-	-	-	-
Modifications to Reactors, ANL-West[a]	2.7	2.7	-	-	-	-	-	-	-
39-EX-31									
Office of Environmental Management Waste Management (Non-Defense) Rehabilitate Waste Management Building 306, ANL-East (91-E-600)	4.8	1.8	(0.2)	-	-	-	-	-	-
General Plant Projects, ANL-West[a]	0.6	0.3	0.3	-	-	-	-	-	-
KB-02									
Office of Energy Research Nuclear Physics Accelerator Improvements, ANL-East[a]	0.9	0.5	0.4	-	-	-	-	-	-
KC-02									
Office of Energy Research Basic Energy Sciences Materials Sciences Advanced Photon Source, Accelerator Improvements, ANL-East	5.9	3.0	2.9	-	-	-	-	-	-
KC-03									

Office of Energy Research Basic Energy Sciences Chemical Sciences General Plant Projects, ANL-East[a]	9.6	4.8	4.8	-	-	-	-	-	-
39-KG-01									
Office of Energy Research Multiprogram Energy Laboratories — Facilities Support General Purpose Facilities Central Heating Plant Rehabilitation - Phase I ANL-East (95-E-301)	9.9	2.5	3.4	-	-	-	-	-	-
39-KG-02									
Office of Energy Research Multiprogram Energy Laboratories — Facilities Support Environment, Safety, and Health Support Fire Safety Improvements - Phase II, ANL-East (93-E-320)	5.3	0.2	-	-	-	-	-	-	-
Fire Safety Improvements - Phase III, ANL-East (95-E-307)	3.0	1.0	0.7	-	-	-	-	-	-
Building Electrical Service Upgrade - Phase I, ANL-East (96-E-330)	7.9	1.1	5.3	0.3	-	-	-	-	-
Electrical System Upgrade - Phase III, (MEL-001)	7.6	0.0	1.4	5.0	1.2	-	-	-	-
TOTAL FUNDED PROJECTS	59.7	19.4	19.0	5.3	1.2	0.0	0.0	0.0	0.0
Budgeted Projects									
KB-02									
Office of Energy Research Nuclear Physics Accelerator Improvements, ANL-East[a]	0.4	-	-	0.4	-	-	-	-	-
KC-02									

Office of Energy Research Basic Energy Sciences Materials Sciences Advanced Photon Source, Accelerator Improvements, ANL-East[a]	3.1	-	-	3.1	-	-	-	-	-
KC-03									
Office of Energy Research Basic Energy Sciences Chemical Sciences General Plant Projects, ANL-East[a]	7.4	-	-	7.4	-	-	-	-	-
39-KG-01									
Office of Energy Research Multiprogram Energy Laboratories — Facilities Support General Purpose Facilities Central Supply Facility (MEL-001)	6.4	-	-	1.9	3.4	1.1	-	-	-
TOTAL BUDGETED PROJECTS	14.7	0.0	0.0	10.2	3.4	1.1	0.0	0.0	0.0
TOTAL FUNDED AND BUDGETED PROJECTS	74.4	19.4	19.0	15.5	4.6	1.1	0.0	0.0	0.0
Proposed Projects									
39-AF-95									
Office of Nuclear Energy, Science and Technology Nuclear Energy Research and Development Security Upgrade, ANL-West (00-CH-067)	6.0	-	-	-	4.0	1.0	1.0	-	-
General Plant Projects, ANL-West[a]	2.0	-	-	-	0.0	0.5	0.5	0.5	0.5
Remote Treatment Facility, ANL-West	90.0	-	-	-	0.0	-	-	10.0	30.0
KB-02									
Office of Energy Research Nuclear Physics Accelerator Improvements, ANL-East[a]	4.0	-	-	-	0.8	0.8	0.8	0.8	0.8
KC-02									

Office of Energy Research Basic Energy Sciences Materials Sciences Advanced Photon Source, Accelerator Improvements, ANL-East[a]	30.2	-	-	-	7.6	7.6	5.0	5.0	5.0
KC-03									
Office of Energy Research Basic Energy Sciences Chemical Sciences General Plant Projects, ANL-East[a]	44.2	-	-	-	8.0	8.4	8.8	9.3	9.7
39-KG-01									
Office of Energy Research Multiprogram Energy Laboratories — Facilities Support General Purpose Facilities Building Replacement, Multiprogram Laboratory-Office Building	13.5	-	-	-	-	13.5	-	-	-
Building Rehabilitation and Upgrade Laboratory Space Upgrade - Phase I	7.0	-	-	-	-	-	7.0	-	-
Building Mechanical and Control Systems Upgrade - Phase II	9.0	-	-	-	-	-	9.0	-	-
Building Electrical Service Upgrade - Phase III	6.0	-	-	-	-	-	6.0	-	-
Building Mechanical and Control Systems Upgrade - Phase III	9.0	-	-	-	-	-	-	9.0	-
Building Electrical Service Upgrade - Phase IV	6.0	-	-	-	-	-	6.0	-	-
Laboratory Space Upgrade - Phase II	8.0	-	-	-	-	-	-	-	8.0
Building Electrical Service Upgrade - Phase V	8.0	-	-	-	-	-	-	-	8.0
Laboratory Space Upgrade - Phase III	6.0	-	-	-	-	-	-	-	6.0
Rehabilitation and Upgrade of Utility Distribution Systems Steam System Upgrade - Phase I	7.5	-	-	-	-	7.5	-	-	-
Electrical System Upgrade Phase IV	6.0	-	-	-	-	-	6.0	-	-
Roads/Parking/Walks/Street Lighting Upgrade	5.5	-	-	-	-	-	-	5.5	-

Central Heating Plant Upgrade - Phase II	6.0	-	-	-	-	-	-	-	6.0
39-KG-02									
Office of Energy Research Multiprogram Energy Laboratories — Facilities Support Environment, Safety, and Health Support, ANL-East Fire Safety Improvements - Phase IV (00-CH-058)	8.4	-	-	-	3.3	5.1	-	-	-
Mechanical and Control Systems Upgrade - Phase I (00-CH-056)	8.6	-	-	-	0.6	6.5	1.5	-	-
Building Electrical Service Upgrade - Phase II (00-CH-062)	7.8	-	-	-	0.5	2.5	4.8	-	-
Fire Safety Improvements - Phase V	6.0	-	-	-	-	-	-	6.0	-
[a]Funded from operating funds.									

1. Argonne-East

Funding for upgrading or replacing substandard facilities at Argonne-East has generally been provided through the MEL-FS program. Continuation of the current sitewide revitalization will require continued funding. Funding through the MEL-FS and GPP programs has allowed the Laboratory to replace or rehabilitate portions of the on-site infrastructure and many severely deteriorated facilities.

Additional funding is needed to further rehabilitate building systems in permanent office and laboratory buildings; to upgrade various utility systems, especially those critical to reliability of service and continued environmental safety; and to provide suitable space for support activities.

A small number of substandard structures remain in use. Removal of old supply facilities in the east area will be complete when the old structures are replaced by a new central supply facility being proposed for FY 1999 funding. Additional future funding will be needed to replace modular buildings and other remaining substandard structures with more efficient facilities.

Appropriate levels of funding are essential to the continued vitality and efficiency of Laboratory programs and for operation of the Laboratory in a safe and environmentally acceptable manner. Plans to modify, replace, or upgrade existing facilities and to correct deficiencies have been developed by using an integrated approach to considering environmental, safety, health, and infrastructure needs. Increased funding will be needed if the Laboratory is to continue to address ES&H demands while it meets facility needs as they arise. Adequate funding will also prevent premature deterioration or failure of facilities and systems resulting from deferred maintenance or repairs, will ensure compliance with existing and new environmental regulations and permits, and will permit a rapid transition in regulation (from DOE to the Occupational Safety and Health Administration) in the near future.

2. Argonne-West

As facilities at Argonne-West age, a high priority is progress each year toward replacement and refurbishment of various facility systems. The annual expense of upgrading all facilities to "new" condition would be about $11 million. Normal maintenance, repair, and upgrade costs of about $2 million are needed annually to keep facilities functional and to stay abreast of escalating mandatory requirements in areas such as safety and environmental compliance.

The GPP funding requirements at Argonne-West are affected by the age and condition of the plant and by continuing concern for the protection of employees, the public, and the environment. Throughout the last decade, GPP funding was well below requested levels. As a consequence, many needs were deferred, and a backlog was created. Adequate GPP funding will prevent premature deterioration or failure of facilities and systems resulting from deferred repair and will also ensure compliance with ES&H

regulations and permits.

F. Asset Management

In partnership with DOE, Argonne plans for, acquires, operates, maintains, and disposes of physical assets as valuable national resources. This stewardship of physical assets to meet the Laboratory's mission is accomplished in a cost-effective manner. The associated planning process integrates mission, ecologic, economic, cultural, and social factors; considers the site's larger regional context; and involves stakeholder participation.

Argonne's assets are acquired, rehabilitated, and upgraded to support the Laboratory's mission. Real estate acquisitions are executed by DOE through a Department-certified real estate specialist. All modifications and improvements are designed and constructed in compliance with appropriate state, regional, and national building codes. Central considerations in design and construction are maintainability, operability, life cycle costs, and configuration integrity. Tools such as value engineering and trade-off analysis are used to improve the efficiency and cost-effectiveness of the Laboratory's acquisition of physical assets.

The DOE corporate physical assets database (the Facilities Information Management System) contains a current inventory of the Laboratory's physical assets. Periodically, this inventory is systematically reviewed, and the condition of the assets is assessed. To keep its assets functioning effectively, Argonne determines maintenance requirements and budgets. The Laboratory's work management system provides for the required maintenance (preventive, predictive, and corrective) so that assets are available to serve their planned missions; the process also ensures that assets are readied for disposal when appropriate. Backlogs associated with such maintenance, repairs, and capital improvements are managed through a systematic prioritization process. Energy usage and utility services are also managed efficiently and effectively. Integrity of all physical assets and systems is ensured through a configuration management process.

Surplus facilities are identified through the Laboratory's planning process and are reported to DOE in a timely manner. Transference of assets between program offices is performed through the process established by DOE. Disposal of real estate is subject to DOE approval. For the disposition of nuclear facilities, the Laboratory develops a decommissioning turnover plan and, if appropriate, a decontamination plan. A deactivation readiness review is completed before any physical work begins.

G. General Purpose Equipment

For Argonne to serve DOE as a premier multiprogram laboratory, its support infrastructure must include equipment allowing efficient performance. General purpose equipment (GPE) funds are the Laboratory's primary basis for purchasing equipment needed to perform vital support activities such as (1) plant maintenance; (2) health and safety; (3) monitoring and control of effluents to the environment; (4) motor vehicle services; (5) technological support, including administrative computers, machine shops, electronics, and analytical chemistry; and (6) administrative functions, including human resources, procurement, and accounting.

At Argonne-East, insufficient GPE funding over the past decade has led to serious aging and obsolescence of equipment for support activities and an inability to introduce major new equipment needed to meet current and future requirements in a timely manner. Current annual GPE funding of approximately $2 million permits acquisition of only critically needed equipment, and little progress can be made toward systematically replacing aged equipment. The average age of equipment now in use in critical areas (such as plant facilities and services, ES&H, electronics, and computing) significantly exceeds DOE guidelines for life expectancy.

To support Argonne's challenging programmatic and site-related initiatives during the next five years most effectively, substantially greater GPE funding will be needed to revitalize the Laboratory's support infrastructure. (See Table S3.4.) Increases are necessary for orderly elimination of the backlog of needed GPE equipment and for timely acquisition of equipment required to provide new capabilities. The Laboratory's emphasis on supporting additional safety and environmental activities — particularly responses to self-assessments and corrective actions to meet expanding DOE, federal, and state requirements — has caused further diversion from addressing the growing backlog in other areas.

Table S3.4 Projected General Purpose Equipment Funding for Argonne-East
($ in millions BA)

FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04
2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2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Supplement 4: Other Charts and Tables

This supplement contains charts and tables characterizing Argonne's activities in the following areas:

- Science and math education
- User facilities
- Human resources
- Subcontracting and procurement

A. Science and Math Education

Table S4.1 characterizes Argonne's existing educational programs. The total number of appointments and the number of minorities and women are shown for FY 1996 and FY 1997.

Table S4.1 Participation in Science and Math Educational Programs

	FY 1996			FY 1997			
Programs	Total	Under-represented Minorities[a]	Women	Total	Under-represented Minorities[a]	Women	FY 1997 Projected Total
Outreach Activities							
Students							
Instructional Vehicle	15,410	7,143	8,116	14,513	6,383	7,261	15,000
Student Conference	388	-	388	470	-	456	450
Teachers							
Internet Training	495	62	340	648	146	406	650

Argonne Community of Teachers	51	11	30	47	8	29	50
Microscale Chemistry	-	-	-	59	-	36	60
Undergraduate Programs							
Summer Research Participation	215	31	71	222	30	79	210
Science Engineering Research Semester	126	11	39	110	16	36	100
Instructional Laboratory	228	50	122	249	51	83	250
Undergraduate Research Symposium	195	-	-	202	-	89	250
Graduate Programs							
Thesis Graduate Students	135	6	42	175	5	48	175
Postdoctoral Fellows	166	4	29	142	4	25	144
Faculty Programs							
Faculty Research Participation	50	17	11	38	9	7	35
Sabbatical Leave	6	-	1	11	1	4	10
Faculty Visits	32	4	4	32	4	4	30
Diversity Initiative							
Student Interdisciplinary Research Training	26	26	14	29	27	14	15

[a] Underrepresented minorities include African-Americans, Hispanics, and Native Americans.

B. User Facilities

Table S4.2 describes experimenters at the Argonne user facilities that have been officially designated as such by DOE.

Table S4.2 Experimenters at Designated Argonne User Facilities — FY 1997

	Argonne	Other Federal and State Laboratories	University	Industry	Other[a]	Totals

	No. of Individuals	*Percent Use*[b]	No. of Individuals (Organizations)	*Percent Use*[b]	No. of Individuals (Organizations)	*Percent Use*[b]	No. of Individuals (Organizations)	*Percent Use*[b]	No. of Individuals (Organizations)	*Percent Use*[b]	No. of Individuals (Organizations)	*Percent Use*[b]
APS[c]	120	*22*	32 (11)	*6*	221 (51)	*41*	139 (28)	*26*	24 (6)	5	536 (96)	*100*
IPNS	60	*26*	29 (5)	*13*	91 (38)	*40*	6 (5)	*3*	42 (26)	18	228 (74)	*100*
ATLAS	42	*35*	7 (4)	*5*	84 (38)	*54*	1 (1)	*1*	6 (6)	5	140 (49)	*100*
High Voltage Electron Microscope-Tandem Accelerator Facility	19	*31*	21 (7)	*13*	39 (19)	*45*	0 (0)	*0*	13 (9)	11	92 (35)	*100*

[a] Includes foreign laboratories and institutes. Foreign universities and multinational industrial firms are counted with their U.S. counterparts.

[b] Percentage of experimental activity or use. Time devoted to maintenance or upgrading of the facility is not included.

[c] The numbers of experimenters indicated for APS operations in FY97 include all qualified users. Scheduled user beam time in FY97 amounted to 3,140 hours or 36% of the total year.

In highly abbreviated terms, these facilities provide the following important scientific capabilities:

- *Advanced Photon Source (APS):* Became operational in 1996, providing super-intense X-ray beams meeting research needs in virtually all scientific disciplines and many critical technology areas; accommodates national research centers in basic energy sciences, advanced synchrotron radiation instrumentation, and structural biology, as well as academic and industrial research teams.
- *Intense Pulsed Neutron Source (IPNS):* Accelerates protons to obtain neutrons, which are particularly valuable for the study of materials through analysis of the motions and structures of atoms.
- *Argonne Tandem-Linac Accelerator System (ATLAS):* Accelerates ions of heavy elements for studies of their reactions, to advance basic understanding of the properties of atoms and atomic nuclei.
- *High Voltage Electron Microscope-Tandem Accelerator Facility:* Interfaces two electron microscopes (one high voltage, one intermediate voltage) with two ion accelerators for *in situ* studies of ion irradiation and implantation effects in metals and alloys, semiconductors, and ceramics.

C. Human Resources

Argonne's employees are highly educated. Table S4.3 summarizes the academic degrees held by permanent staff at the end of FY 1997. Table S4.4 describes the distribution of Argonne employees among various racial and ethnic categories.

Table S4.3 Academic Degrees of Argonne Staff[a]

Category	PhD	MS/MA	BS/BA	Other[b]	Total
Scientists and Engineers					
Supervisors	243	82	56	24	405
Nonsupervisors	568	316	305	122	1,311
Support Staff					
Officials and Managers	8	46	46	49	149
Administrators (Nonsupervisory)	15	63	99	87	264
Technicians	0	4	73	547	624
All Others	0	3	57	1,043	1,103
Laboratory Total	834	514	636	1,872	3,856

[a] Number of full- and part-time employees at the end of FY97. Scientists are included in the management and administrative category if that is their primary duty.

[b] Associate level degree or less.

Table S4.4 Population of Laboratory Employees[a]

September 30, 1997

	Total				Minority Total				White				Black				Hispanic				Native American				Asian			
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
Occupational Category	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Scientists and Engineers																												
Officials and Managers	369	91.1	36	8.9	31	7.7	4	1.0	338	83.5	32	7.9	2	0.5	1	0.2	3	0.7	1	0.2	1	0.2	0	0.0	25	6.2	2	0.5
Nonsupervisors	1,139	86.9	172	13.1	156	11.9	24	1.8	983	75.0	148	11.3	11	0.8	2	0.2	18	1.4	2	0.2	2	0.2	0	0.0	125	9.5	20	1.5
Support Staff																												
Officials and Managers	97	65.1	52	34.9	5	3.4	3	2.0	92	61.7	49	32.9	3	2.0	2	1.3	1	0.7	1	0.7	1	0.7	0	0.0	0	0.0	0	0.0
Administrators	113	42.8	151	57.2	8	3.0	22	8.3	105	39.8	129	48.9	4	1.5	8	3.0	2	0.8	4	1.5	1	0.4	1	0.4	1	0.4	9	3.4

Technicians	556	89.1	68	10.9	46	7.4	8	1.3	510	81.7	60	9.6	21	3.4	3	0.5	12	1.9	0	0.0	3	0.5	1	0.2	10	1.6	4	0.6
All Others	505	45.8	598	54.2	96	8.7	114	10.3	409	37.1	484	43.9	67	6.1	65	5.9	19	1.7	32	2.9	4	0.4	6	0.5	6	0.5	11	1.0
Totals	2,779	72.1	1,077	27.9	342	8.9	175	4.5	2,437	63.2	902	23.4	108	2.8	81	2.1	55	1.4	40	1.0	12	0.3	8	0.2	167	4.3	46	1.2

September 30, 1992

	Total				Minority Total				White				Black				Hispanic				Native American				Asian			
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
Occupational Category	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Scientists and Engineers																												
Officials and Managers	345	93.8	23	6.3	21	5.7	1	0.3	324	88.0	22	6.0	2	0.5	0	0.0	1	0.3	1	0.3	0	0.0	0	0.0	18	4.9	0	0.0
Nonsupervisors	1,303	88.4	171	11.6	180	12.2	27	1.8	1,123	76.2	144	9.8	11	0.7	3	0.2	15	1.0	4	0.3	3	0.2	0	0.0	151	10.2	20	1.4
Support Staff																												
Officials and Managers	159	76.4	49	23.6	10	4.8	7	3.4	149	71.6	42	20.2	1	0.5	7	3.4	4	1.9	0	0.0	2	1.0	0	0.0	3	1.4	0	0.0
Administrators	147	51.4	139	48.6	12	4.2	16	5.6	135	47.2	123	43.0	6	2.1	5	1.7	2	0.7	4	1.4	2	0.7	2	0.7	2	0.7	5	1.7
Technicians	530	91.5	49	8.5	39	6.7	7	1.2	491	84.8	42	7.3	20	3.5	4	0.7	7	1.2	0	0.0	3	0.5	1	0.2	9	1.6	2	0.3
All Others	598	45.7	711	54.3	118	9.0	127	9.7	480	36.7	584	44.6	87	6.6	79	6.0	22	1.7	30	2.3	4	0.3	8	0.6	5	0.4	10	0.8
Totals	3,082	73.0	1,142	27.0	380	9.0	185	4.4	2,702	64.0	957	22.7	127	3.0	98	2.3	51	1.2	39	0.9	14	0.3	11	0.3	188	4.5	37	0.9

[a]Includes both the Illinois and Idaho sites. Percentages are calculated separately within each occupational category.

D. Subcontracting and Procurement

Table S4.5 describes Argonne's subcontracts and procurements from universities. Table S4.6 describes procurements from small and disadvantaged businesses.

Table S4.5 Subcontracting and Procurement
($ in millions)

	FY 1996	FY 1997	FY 1998[a]

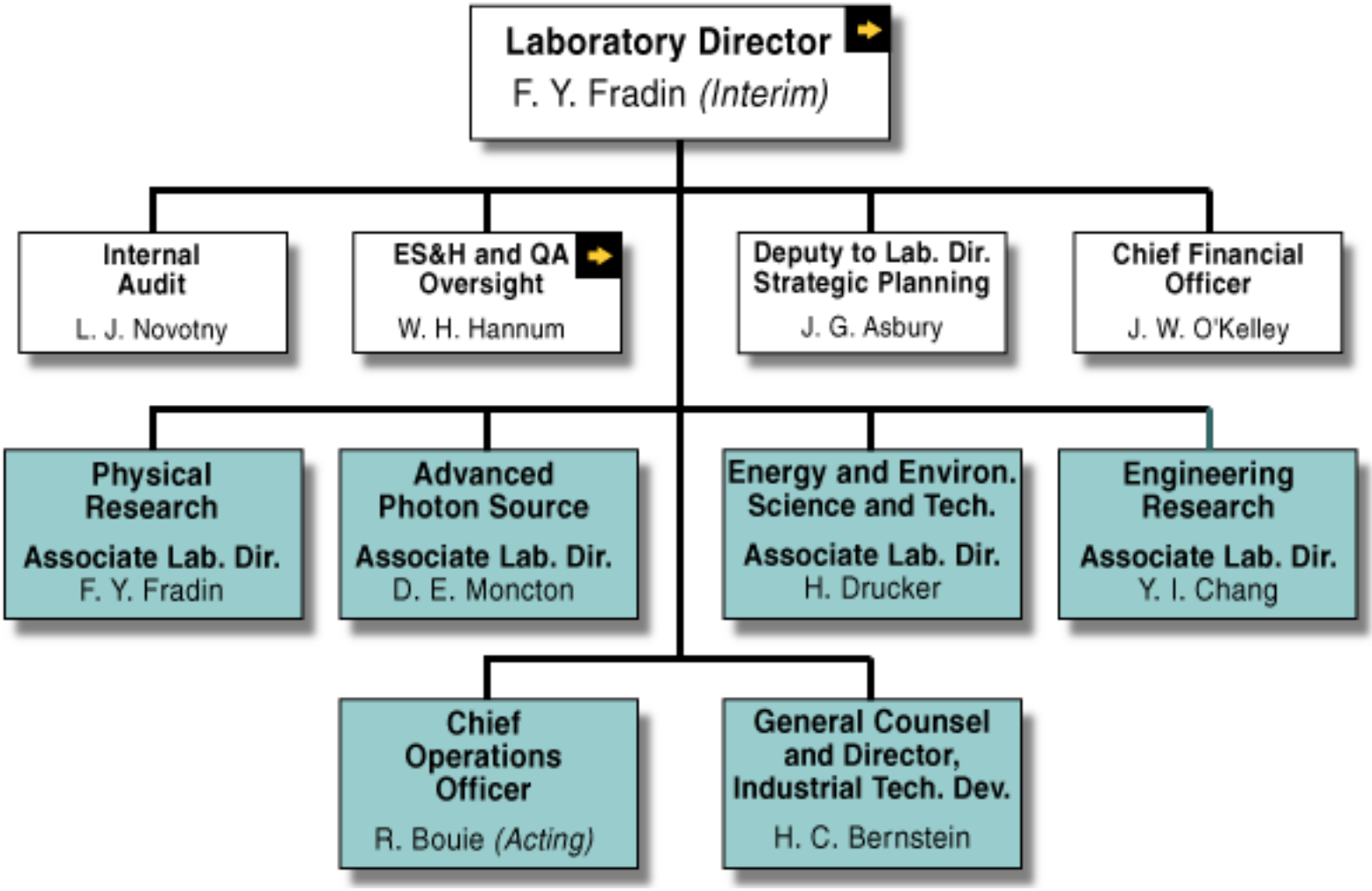
Subcontracts and Procurements from Universities	6.5	6.4	6.2
All Other Subcontracts and Procurements	166.0	137.3	124.2
Transfer to Other DOE Facilities	0.5	0.34	0.47
Total Subcontracts and Procurements	173.0	144.0	130.9
[a] Estimate.			

Table S4.6 Small and Disadvantaged Business Procurement
($ in millions)

	FY 1996	FY 1997	FY 1998[a]
Procurements from Small and Disadvantaged Businesses	10.4	11.3	6.8
Percent of Annual Procurement	6.6	9.0	6.0
[a] Estimate.			

October 1, 1998*

Argonne National Laboratory
Organization Chart



(Click on a colored box to expand that area of the organization chart.)

(Click on an arrow to go to another Argonne Web site.)

* This chart, included in the October 1998 *Institutional Plan*, may not now be the most recent available.