Argonne National Laboratory

INSTITUTIONAL PLAN

FY 1998 - 2003

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This July 1997 *Institutional Plan* was originally prepared in the early spring of 1997. It generally describes the activities and plans of Argonne National Laboratory as of that time. Thus, for example, financial data for FY 1997 are mid-year projections. In addition, a few selected revisions to the *Draft Institutional Plan* of May 1997 are included to reflect comments received and major shifts in plans.

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I. Laboratory Director's Statement

In the fall of 1996, shortly after arriving at Argonne, I instituted an intensive, laboratory-wide review of Argonne's research programs. The review was very helpful for a new laboratory director. I learned about the work of the Laboratory, its research facilities and capabilities, its people, and its plans for the future. Generally, I was impressed by the technical quality, scope, and national importance of Argonne's research efforts. Through this review, we also established a framework for defining our strategic objectives and strategies.

In preparation for this year's *Institutional Plan*, we decided to formalize an annual strategic planning cycle. Figure I.1 shows the key features of the planning cycle. The Strategic Planning Council, comprising Argonne's senior management and chaired by the laboratory director, reviews the strategic plans of the Laboratory's individual planning units and sets overall priorities and strategies. As the figure shows, we began the strategic plan update in early February and completed it in late April. I gave an

overview of our strategic plan and our planning process to the University of Chicago Board of Governors for Argonne at its quarterly meeting in early May.

Strategic priorities established during this planning process were incorporated into our recent call for Laboratory Directed R&D (LDRD) proposals for FY 1998. These priorities will help guide the Strategic Planning Council in making LDRD funding allocations in September. Our strategic plan for FY 1998-FY 2003, adjusted for actual congressional appropriations for FY 1998, will form the basis for our FY 1998 operating plan, which we will report to the Board of Governors and then to DOE.

During our spring planning, the Strategic Planning Council reviewed and approved some 26 area strategic plans prepared by our research divisions, technology programs, and operations and support organizations. We are pleased to include summaries of each of these area plans in this *Draft Institutional Plan*.

Figure I.1 Annual planning cycle.

The *Institutional Plan* contains other central elements of Argonne's strategic plan. Chapter II of this document discusses the Laboratory's mission and core competencies. Chapter III presents the "Science and Technology Strategic Plan," which summarizes key features of the external environment, presents Argonne's vision, and describes how the Laboratory's strategic goals and objectives map onto and support DOE's four business lines. The balance of the chapter comprises the science and technology area plans, organized by the four DOE business lines.

Chapter IV describes the Laboratory's ten major initiatives, which cover a broad spectrum of science and technology. Our proposal for an Exotic Beam Facility aims at, among other things, increased understanding of the processes of nuclear synthesis during and shortly after the Big Bang. Our Advanced Transportation Technology initiative involves working with U.S. industry to develop cost-effective technologies to improve the fuel efficiency and reduce the emissions of transportation systems. The Laboratory's plans for the future depend significantly on the success of its major initiatives.

Chapter V presents our "Operations and Infrastructure Strategic Plan." The main body of the chapter comprises 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 Argonne is adopting to improve the quality and cost-effectiveness of its operations.

The structure and content of this document depart from those of the *Institutional Plan* in previous years. Emphasis here is on directions for the future; coverage of ongoing activities is less detailed. We hope that this streamlined plan is more direct and accessible. A companion preliminary operating plan will be available shortly. It will provide much of the descriptive information about ongoing activities that was contained in previous plans.

We look forward to the On-Site Review.

Dean E. Eastman

II. Missions and Core Competencies

Argonne National Laboratory is a large multi-program 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.

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. 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 effectively perform its missions for the Department of Energy 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 sciences, 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 following foldout chart describes the scientific and technological capabilities underlying these eight core competencies.

Argonne National Laboratory

**CORE COMPETENCIES
BASED IN SCIENCE
AND TECHNOLOGY**

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

Linear Algebra and Optimization	★ ○ ■
Automated Reasoning	■ ★ ○ ■
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	★ + ○ ■

Accelerator Physics and Technology

Accelerator Systems and Design	● ▲ ★ ○ ■
RF Superconducting Technology	● ○ ■
Advanced Particle and Photon Detectors	● ▲ ★ ○ ■
Magnetic Field Measurement and Analysis	■ ● ★ ○ ■
RF and High-Voltage Power Systems	● ★ ○ ■

High Energy and Nuclear Physics

Particle Physics	★ ○ ■
Heavy-Ion Physics	★ ○ ■

National Research Facilities

Advanced Photon Source	● ▲ ◆ ○ ■
Intense Pulsed Neutron Source	● ▲ ○ ■
Argonne Tandem Linear Accelerator System	● ○ ■
High-Voltage Electron Microscope Facility	■ ● ▲ ○ ■
Hot Fuel Examination Facility	■ ○ ■
Experimental Breeder Reactor II	■ ★ ○ ■
Transient Reactor Test Facility	■ ★ ○ ■
Fuel Cycle Facility	■ ★ ○ ■
Alpha-Gamma Hot Cell Facility	■ ○ ■
Structural Biology Center	▲ ○ ■
High-Performance Computing Facility	■ ★ ○ ■

TECHNOLOGIES

Advanced Nuclear Technology

Reactor Design and Analysis	■ ★ ○ ■
Reactor Decommissioning/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	■ ● ▲ ◆ ○ ■
Pyro- 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	▲ + ○ ■
Ultra-High Vacuum Science and Technology	■ ● ★ ○ ■

Transportation Systems

Batteries and Fuel Cells for Electric Vehicles	▲ ◆ ○ ■
Maglev Systems Design, Analysis, and Testing	◆ ○ ■
Advanced Vehicles	◆ ○ ■
Alternative Fuels	◆ ○ ■

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

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

A. External Environment

A number of external issues and uncertainties have affected the design of Argonne's strategic plans or will affect the Laboratory's ability to carry them out. The most globally and immediately pertinent factor is the availability and stability of funding for major initiatives and ongoing programs.

1. R&D Funding Trends

Aggregate federal support for R&D has been declining in real terms for the past decade. For the past several years, federal funds for civilian R&D, outside the programs of the National Institutes of Health, have also declined. Efforts by the administration and Congress to reduce the federal budget ensure continuing pressure on federal R&D spending.

The Laboratory can offset modest funding reductions by redoubling its efforts to streamline operations and reduce overhead costs. In the longer run, continuing funding reductions will force substantial reductions in research effort.

On the positive side, the President's budget submission for FY 1998 included a 3.0% increase (in current dollars) in funding for DOE's Office of

Energy Research (DOE-ER), the same percentage increase requested for the National Science Foundation and the National Institutes of Health. Administration and congressional support for DOE-ER is important to Argonne, because the office provides 46% of the operating funds that the Laboratory receives from DOE.

Another favorable development is the apparent improvement, compared with previous years, in congressional support for DOE programs in energy efficiency and renewable energy. The Laboratory has launched major initiatives in transportation and industrial technologies, which seek funding from DOE's Energy Efficiency program.

Although the Laboratory will receive only about \$15 million from private industry in FY 1997, during the past year it entered into several major, multiyear agreements with the private sector. Argonne plans to continue to expand its work for U.S. industry. Nationally, industrial funding of R&D now exceeds federal support; unlike federal funding, industrial R&D funding is growing in real terms.

2. Other Issues and Developments

A number of other external developments not directly related to funding trends promise to affect Argonne's planning environment:

- Implementation of the Government Performance and Results Act (GPRA) of 1993 requires that federal agencies develop strategic plans and annual performance plans and submit these plans to the Office of Management and Budget, starting with the FY 1999 budget submission that occurs in the fall of 1997. Results will be reported to Congress as part of the FY 1999 budget cycle. GPRA is causing sweeping changes in DOE's strategic planning and performance tracking, and therefore it may greatly affect planning and performance evaluation by the national laboratories as well.

- Under its Strategic Alignment Initiative and in response to the Galvin and Yergin advisory committee reports, DOE over the last four years has substantially cut its work force and costs. The Department's employment has been reduced by 16% and its contractor work force by 27%. The Secretary of Energy has committed the Department to improving its productivity and effectiveness further.

- The Laboratory Operations Board, established in response to the Galvin report, is conducting a sweeping review of DOE programs and management practices. Among the activities and accomplishments of the Board are preparation of the Strategic Laboratory Missions Plan, which defines the mission roles of the multiprogram laboratories; development of recommendations for improving DOE's management of its R&D programs, including the selection of R&D performers; review of the Department's processes for evaluating the quality of technical work; and review of DOE's strategic planning and institutional planning processes.

Many factors, beyond R&D funding trends and the Department's planning and management initiatives, shape Argonne's strategic plans. These factors — including those in the scientific, technical, political, and economic arenas — are discussed in the area plans presented in this document. The remainder of this chapter includes plans for the Laboratory's scientific and technical programs. Chapter V includes plans for operations and infrastructure.

B. The Argonne Vision

Argonne's vision is to be a world-class provider of high-quality science, technology, engineering, and technical services, with the excellence of its research recognized by the Department of Energy, by other public and private sponsors, and by the many scientists and engineers from across the country who are research collaborators or users of Argonne's facilities.

The Laboratory regards three business goals as critical to achieving this vision:

- To understand and serve the needs and desires of the Laboratory's customers and stakeholders
- To lead in responding to market opportunities, as measured by quality of solutions, cycle time, and customer satisfaction
- To earn and maintain trust as a national research performer, as a regional science and technology resource, and as a valued neighbor in the community

Three underlying goals are essential to the success of the business goals above:

- Manage the recruitment and development of human resources to maximize the long-term creativity and productivity of Laboratory staff
- Provide continuous improvement in management and administrative systems as a prerequisite to achieving and maintaining efficient, cost-competitive performance
- Evaluate and reward organizational and individual performance on the basis of objective performance measures

C. Strategic Objectives by DOE Mission Area

Argonne supports the Department of Energy in pursuit of the Department's defined statutory missions.

For each DOE mission area, this section provides a general statement of Argonne's overall R&D goal, followed by a brief description of the Laboratory's strategic objectives. A number of these objectives involve the development of R&D initiatives, which are discussed in the context of the Laboratory's area plans in Section D of this chapter. The Laboratory's major initiatives are described more fully in Chapter IV.

1. Science and Technology

GOAL: To contribute significantly to the science and technology base needed to accomplish DOE and other national technology development

goals; to develop and operate national user facilities that support the advancement of U.S. science and technology; to develop innovative experimental concepts and instrumentation that support fundamental research in energy and matter; to enrich science and mathematics education in the United States.

Fundamental Science

- Strengthen Laboratory capabilities for materials synthesis, processing, and characterization, including primary synthesis procedures applicable to many kinds of materials.
- Conduct research to establish the fundamental physics of advanced materials having important properties, including high-temperature superconductors.
- Exploit the Laboratory's multifaceted capabilities for chemical synthesis in a program to prepare and characterize new types of compounds, catalysts, and extractants for use in energy production and environmental control processes.
- Conduct research to resolve fundamental questions concerning the characteristics and dynamics of nuclear and subnuclear degrees of freedom in nuclei and nuclear matter.
- Develop advanced detector systems for use at high energy physics accelerators. Develop and test advanced concepts and experimental equipment for particle acceleration, such as the Demonstration Wakefield Accelerator.
- Develop algorithms and tools for advanced computer architectures, particularly for parallel systems, and apply these capabilities in areas such as global climate modeling, computational chemistry, materials science, and computational biology.
- Develop the innovative technique of DNA sequencing by hybridization on oligonucleotide chips, focusing on automation, biochemistry, mechanical processing, and computing.
- Develop, from a base of traditional environmental research, a synchrotron-based program in environmental molecular science.

National Research Facilities

- Operate the Advanced Photon Source (APS) — a superintense source of high-energy X-rays — to meet the evolving needs of a very large and diverse community of users. Optimize operational reliability and efficiency and continue to improve accelerator systems and experimental capabilities.
- Develop APS research facilities for collaborators from across the United States. Complete centers for research with synchrotron radiation in basic energy sciences and structural biology; develop the associated instrumentation and techniques through efforts by research groups from inside and outside the Laboratory.
- Develop a facility to accelerate beams of unstable nuclei, capitalizing on the capabilities of the Laboratory's existing heavy-ion accelerator, the Argonne Tandem-Linac Accelerator System (ATLAS), by using it as the postaccelerator in a two-accelerator design.
- Operate laboratories in computing and communications to explore integration of multimedia technology with scientific supercomputing, virtual environments for scientific visualization, and advanced communications technologies based on high-performance networks.
- Improve existing instruments at the Intense Pulsed Neutron Source (IPNS), doubling the capabilities of most; lead the development of instrumentation and techniques for the National Spallation Neutron Source and train an expanded user community.
- Build on expertise in atmospheric science, remote sensing, advanced computation, information processing, and facility management to develop a prototype user facility, and ultimately a novel national observatory, for weather research.
- Develop advanced instrumentation and techniques for analytical, high-resolution, and high-voltage electron microscopy, and support a broadly based electron microscopy center that is oriented toward collaborative research.

2. Energy Resources

GOAL: To develop technologies that improve the safety and reduce the costs of fission energy systems; to develop, test, and carry to prototype new energy efficiency technologies.

Nuclear Technology

- Develop the International Nuclear Safety Center, with an initial focus on the safety of Soviet-designed reactors.
- Support the U.S. light-water reactor industry in areas such as life extension; fuel minimization; and improved safety, reliability, and general operation.

Energy Efficiency

- In cooperation with U.S. transportation industries, develop cost-effective, energy-efficient technologies, focusing on electric batteries and fuel cells, advanced compression ignition engines, computational techniques for vehicle design and manufacture, and improved recycling of obsolete vehicles.
- In cooperation with U.S. industry, expand research to improve technologies that reduce energy consumption and waste production in the petrochemical, forest products, metals, and other energy-intensive industries.
- Explore biochemical pathways for processing technologies to convert biomass into useful chemicals.

Superconductivity Technology

- Develop high-temperature superconducting materials with current density and mechanical properties suitable for application in electric utility systems.

Environmental and Energy Systems

- Develop technologies to reduce environmental and economic impacts associated with (1) use of depletable natural resources, particularly energy resources, and (2) emissions from energy production and use at local, national, and international scales.

Fossil Energy

- Undertake fundamental studies of technical issues limiting advanced fossil fuel technologies, such as materials performance and inspection capabilities. Improve predictive understanding of mass, heat, and fluid transport phenomena.

Fusion Energy

- Develop advanced materials and critical technologies for high-performance, environmentally attractive in-vessel fusion power systems: first wall, blanket, and divertor.

3. Environmental Quality

GOAL: To continue to strengthen existing programs and broad capabilities in environmental sciences and technology, while undertaking research that contributes significantly to the cleanup of DOE sites and the solution of other national environmental problems.

Environmental Science and Technology

- Develop improved energy system models and planning tools that predict environmental impacts; research the transport, deposition, and environmental effects of energy-related pollutants; and enhance techniques and tools, such as remote sensing and geographic information systems, for monitoring and analyzing over time the sustainability of natural resources.
- Develop the Argonne electrometallurgical treatment technology to condition DOE spent fuel into a standard form that eliminates concerns about chemical reactivity and that allows disposal in a geologic repository at substantially reduced cost.
- Develop safe, cost-effective technologies for decontamination and decommissioning (D&D) and use the CP-5 Reactor and other Argonne nuclear facilities as test beds for these and other technologies. Deploy D&D technologies and provide technical services for DOE sites and electric utilities.

- Develop a comprehensive program in the assessment and management of risk, to investigate hazards, exposure pathways, and impacts.

DOE Sites

- Help DOE implement waste management and environmental restoration, including innovative site characterization techniques; provide innovative decision tools, environmental pathway models, and environmental technologies for more cost-effective and timely approaches to waste minimization, pollution prevention, and cleanup at DOE sites.
- Develop (1) technologies for treating mixed wastes and (2) new waste forms, both tailored to the needs of specific DOE facilities and waste streams.
- Support DOE programmatic initiatives by preparing environmental impact statements for major DOE facilities.

4. National Security

GOAL: To apply the Laboratory's unique technical resources, in nuclear technology and other areas, to define and solve problems encountered in the development of advanced arms control, nonproliferation, verification, and defense technologies.

- Support extension of the Reduced Enrichment for Research and Test Reactors program to additional Russian research reactors, to other countries not previously participating, and to reactors for which fuels with suitably high uranium densities have been unavailable.
- Support U.S. nonproliferation policy objectives worldwide, including development of methods for protecting nuclear materials and sensitive nuclear technologies.

D. R&D Area Strategic Plans

As part of its 1997 strategic planning, Argonne management asked that individual

Argonne's Strategic Plans

1. Fundamental Science and National Research Facilities

- Advanced Photon Source
- Materials Science
- Basic Energy Sciences Synchrotron Radiation Center
- High Voltage Electron Microscope-Tandem Accelerator
- Chemical Sciences
- Nuclear Physics
- Argonne Tandem-Linac Accelerator System
- High Energy Physics
- Mathematics, Computing, and Information Sciences
- Intense Pulsed Neutron Source
- Mechanistic Biology and Biotechnology
- Environmental Research
- Support for Science and Engineering Education

2. Energy Technologies

- Energy and Industrial Technologies
- Advanced Nuclear Technology

3. Environmental Technologies

- Electrometallurgical Technology
- EBR-II Termination
- Radioactive and Mixed Waste Treatment Technologies
- D&D Technology
- Energy and Environmental Systems and Services

4. National Security:

Arms Control and Nonproliferation

5. Industrial R&D Partnerships

strategic plans be developed for 22 planning units that span the Laboratory's major mission areas, as delineated in Chapter II. The balance of this chapter presents summaries of strategic plans for each of these units, grouped into (1) Fundamental Science and National Research Facilities, (2) Energy Technologies, (3) Environmental Technologies, (4) National Security, and the cross-cutting goal of (5) Industrial R&D Partnerships.

The inset box on page 11 lists the 22 strategic planning areas.

The planning areas for fundamental science and national research facilities correspond closely with Argonne's scientific divisions. In contrast, Argonne's technology programs cut across Laboratory divisions to exploit multidisciplinary capabilities. (See the organization chart for Argonne at the end of this volume.)

1. Fundamental Science and National Research Facilities

a. Advanced Photon Source

Situation

The APS is Argonne's highest-priority research facility. Its successful operation is central to the Laboratory's performance in science and technology. Prestigious national advisory committees have endorsed this high-brilliance X-ray source as the highest priority among the present generation of materials sciences research facilities. The APS promises to enhance U.S. productivity in a broad spectrum of scientific and technological areas. International competition in these research areas comes primarily from two similar X-ray centers: the European Synchrotron Radiation Facility, now operating, and SPring-8, under construction in Japan and scheduled to begin operations early in 1998.

The APS began operating in 1996 as a national user facility available to the entire U.S. community of X-ray researchers. The U.S. government made a major investment of \$812 million to construct the APS over the seven-year period from 1989 to 1996. The resulting world-class photon source today provides the brightest X-ray beams available for a wide range of research from materials science to structural biology. Collaborative access teams — composed of investigators from private industry, universities, government, and other institutions — have initiated many research programs at the APS. Forty of the 70 X-ray beamlines available at the APS have been allocated to collaborative access teams. The remaining beamlines can be developed for new research programs. The number of users is expected to increase from approximately 1,600 in

FY 1998 to roughly 3,000 when all 70 beamlines have been developed. Built and operated for DOE-Basic Energy Sciences, the APS is accessible to all qualified users of synchrotron radiation.

Vision

The APS will function as a dependable and preeminent source of synchrotron radiation for the X-ray research community. It will serve research across a wide range of frontier science and technology, addressing questions of importance both nationally and internationally. Excellence at the APS will include highly reliable operation and high availability of accelerator and beamline systems over a large number of operating hours; high-quality user support; and innovative R&D supporting both continuous improvement of accelerator systems and enhancement of experimental capabilities. Through productive partnerships with its users, the APS will better serve these primary customers, thereby creating a rewarding and enriching R&D environment and enhancing the facility's worldwide leadership role.

Mission

The mission of the APS includes the following major elements:

- To operate and improve a source of high-brilliance X-ray beams that meets the evolving requirements of a very large and diverse user community
- To optimize operational reliability, availability, and scheduled operating time to achieve excellence in serving all research users
- To develop leading-edge accelerator and experimental technologies that advance X-ray research capabilities of investigators from across the United States and around the world

Goals and Objectives

The overall goals of the APS are (1) to increase beam availability and scheduled operating time, (2) to use insertion devices and bending magnets to provide synchrotron radiation

dependably to APS users, and (3) to provide the technical and administrative support needed to maximize the productivity of the researchers. Major objectives are as follows:

- To improve accelerator operations to better than 95% availability within five years
- To increase operating time scheduled for users to 5,000 hours per year within five years
- To advance APS accelerator systems beyond original specifications for orbit stability, emittance, and beam current
- To provide seamless support to APS users in the areas of technical support, safety, administration, and general services
- To advance the state of the art in the production and specialized use of synchrotron radiation, through strategic research

In all these endeavors, highest priority is given to ensuring the health and safety of employees, users, and visitors and to protecting the environment.

Issues and Strategies

The APS is a high-quality research facility with excellent, experienced staff. All technical design parameters of the accelerator systems have been achieved, and accelerator physics at the facility now focuses on achieving ever-increasing levels of operational reliability and availability. The near-term objective is routine operations with 90% reliability and first top-up operation for users in FY 1997. Within the five-year planning period, the longer-term objective is 95% availability with up to 5,000 hours of operating beam time scheduled for users each year. In addition to hardware upgrades, opportunities for improvement include vibration abatement, monitoring of beam stability, orbit control, and orbit control feedback.

The APS will maintain the excellence of its accelerator research capabilities by pursuing midterm objectives involving extension of positron beam performance to higher current, higher energy, and lower emittance. Longer-term research objectives will involve tests to evaluate novel undulator concepts — such as small-gap, superconducting, helical, or long undulators — and segmented or multiple undulator systems. In coordination with other national research groups,

APS staff are conducting research aimed at a fourth-generation light source, including investigations of particle beam characteristics suitable to excite self-amplified spontaneous emission of coherent photon beams.

Increasing numbers of users at the APS during the planning period will require technical and administrative support beyond that presently available. Development of an optics fabrication laboratory will necessitate a cleaning facility in a clean-room environment. To shift resources to these higher-priority user support activities, the program supporting exchange of beamline components among users will be phased out. As beamline construction is completed, appropriate technical staff will be reassigned to user support operations.

Fourteen sectors at the APS remain available for future user research programs, and DOE gives high priority to using this capacity fully and effectively. Development of new research initiatives is needed. Argonne is proposing an X-ray beamline development program under which the remaining sectors will be developed. (See Section IV.C.)

b. Materials Science

Situation

Advanced materials have been identified as critical technologies in every comprehensive study of materials science conducted in recent years. New materials technologies offer important benefits across a nearly universal spectrum of applications, including the major technological priorities in DOE's core business lines.

Argonne's work on materials includes important experimental and theoretical studies that are distinguished by the integrated application of multiple scientific disciplines and specialized facilities. The large strategic research programs conducted by the Laboratory would typically not be feasible at a university or private firm.

Argonne establishes and maintains unique materials research facilities for outside users and regularly designs and develops more capable instruments for these facilities. Laboratory researchers frequently work closely with

colleagues at industrial corporations and universities. Work with industry often aims at developing for commercial applications new materials discovered in Argonne's basic research program.

Significant Laboratory programs are addressing superconductivity, radiation effects, surface and interface phenomena, bulk and thin-film oxides and nitrides, and magnetic materials. Argonne's contributions to the fundamental understanding of materials' properties and the development of new materials continue to be well recognized internationally.

Vision

Argonne will foster world-class science, forefront instrumentation, and unique user facilities enabling cutting-edge materials research that provides the knowledge and technology needed for DOE and the nation to achieve their scientific and technical goals. This work will include the development of new materials and the characterization of materials' properties, both built on improved understanding of the underlying fundamental science.

Objectives

Specific objectives of Argonne's research on materials include the following:

- To develop and apply innovative experimental techniques to exploit the unique capabilities of the APS and the IPNS
- To establish the fundamental physics of high-temperature superconductors and develop valuable new applications of such materials
- To develop and characterize new magnetic materials suitable for permanent magnets and other applications
- To improve the interface and surface properties of materials, particularly to benefit materials processing, catalytic action, and environmental effects
- To develop and apply new techniques for electron beam microcharacterization that provide improved analytical methods at greater spatial resolution

- To establish an integrated understanding of modifications of materials resulting from irradiation with electrons, ions, and neutrons and to develop means of mitigating radiation damage

Issues and Strategies

Primary issues are (1) maintaining stable funding from the DOE Office of Basic Energy Sciences and (2) supporting DOE's technology missions more broadly and directly.

To meet these challenges, more effective ties to applied materials programs and other relevant R&D programs throughout the Laboratory continue to be established. Formal mechanisms are now coordinating basic and applied work in engineered materials and related fields into integrated thrusts toward stronger partnerships in more areas.

Argonne is participating extensively in efforts to strengthen partnerships among the materials science programs of all the national laboratories. An important mechanism is strong participation in the Center of Excellence for Synthesis and Processing sponsored by the Division of Materials Sciences of DOE's Office of Basic Energy Sciences. Argonne is involved in several thrusts aimed at integrating the development of interlaboratory programs with industrial collaborations. The Laboratory has a primary coordinating responsibility for a program to develop better permanent magnets.

The Laboratory's work in superconductivity benefits from close coupling with the National Science Foundation-supported Science and Technology Center for Superconductivity, a consortium including Argonne, Northwestern University, the University of Illinois, and the University of Chicago.

c. Basic Energy Sciences Synchrotron Radiation Center

Situation

The APS will dramatically enhance research within DOE's Basic Energy Sciences (BES) programs. The Basic Energy Sciences Synchrotron

Radiation Center (BESSRC) at the APS is being developed as a joint venture among Argonne's Chemistry, Materials Science, and Physics Divisions, in partnership with Argonne's BES-Geosciences program and Northern Illinois University. The APS facility — consisting of two bending magnet beamlines, one undulator, and an elliptical multipole wiggler — is designed to provide state-of-the-art capabilities for both traditional and forefront methods of synchrotron-based science.

Construction of the BESSRC facility is well underway. The undulator beamline and one bending magnet beamline will operate near the end of FY 1997 or in early FY 1998. The final bending magnet is being planned for later development. An important enabling development has been the design of improved monochromators that are cryogenically cooled to accommodate the high heat loads present in APS beams. This innovation has already benefited a number of other beamlines at the APS, as well as beamlines at other synchrotron facilities.

Forefront capabilities at the BESSRC will include the following:

- Inelastic X-ray scattering
- Real-time studies in short time domains
- *In situ* studies of chemical and physical processes
- High-energy X-ray diffraction
- Photoionization and photoexcitation in atomic and molecular physics

Vision

The BESSRC facility will provide forefront capabilities enabling innovative research and important breakthroughs in broad areas relevant to DOE's BES programs, including chemistry, materials science, atomic physics, and geoscience.

Issues and Strategies

Technical aspects of the BESSRC are proceeding very well. A primary issue is the availability of sufficient funds for operation. Funding is being sought from DOE, from other

federal agencies, and from partnerships developed with other institutions.

d. High Voltage Electron Microscope-Tandem Accelerator

Situation

Argonne's High Voltage Electron Microscope-Tandem Accelerator is a national user facility that provides a unique combination of electron microscopy interfaced with ion beam irradiation. No other U.S. facility can provide the same capabilities, which are important for characterizing materials. Studies conducted at the facility primarily involve (1) dynamic *in situ* analysis and (2) development of techniques for analyzing and observing microstructural changes resulting from irradiation, mechanical deformation, and gas-solid reactions of materials. A general advantage of an electron microscope operating at higher energies is that samples require less stringent preparation before testing.

Time at this national user facility is allocated through a formal proposal procedure. Heaviest usage is by researchers from universities. Other users are from Argonne programs, other national laboratories, and industry. Through support from the DOE Office of Basic Energy Sciences, the facility is made available for nonproprietary research at no charge to users.

Vision

Argonne will operate a state-of-the-art facility combining electron microscopy with ion beam irradiation to enable research providing important new insights into processes having major technological implications, such as radiation effects in high-temperature superconductors, radiation-induced segregation and phase transformation, hydrogen embrittlement, and solid-state amorphization reactions.

Issues and Strategies

The present electron microscope has aged to the point where its replacement must be considered if the facility is to continue providing high-quality service to its users. Because modern

high-voltage electron microscopes are costly, Argonne is approaching modernization of the facility with both a near-term and a longer-term strategy.

In FY 1995, an intermediate-voltage electron microscope was added to the facility without disturbing the existing high-voltage microscope. Both microscopes are interfaced with existing ion beams. Although it does not have the advantage of high-energy electrons, the new microscope provides spatial resolution substantially higher than that available from the much older microscope. This improved capability will be very useful for both outside users and Argonne researchers for many years, even if the high-voltage microscope were to become unusable.

For the longer term, Argonne is developing plans for full replacement of the existing high-voltage microscope. The replacement instrument will have substantially greater capabilities, including higher spatial resolution and much greater possibilities for *in situ* experimentation.

e. Chemical Sciences

Situation

Chemistry has been a core capability of Argonne since the Laboratory's earliest days. Today the Laboratory is conducting cutting-edge research in eight areas: radiation and photochemistry, the separation sciences of the heavy elements, electron transfer and photosynthesis, the chemical physics of combustion processes, heavy hydrocarbon chemistry, metal cluster chemistry, fluid catalysis, and advanced battery science. Results from this research will underpin advances in energy efficiency, energy conversion, cleanup and disposal of radioactive and nonradioactive wastes, and industrial chemical catalysis.

Vision

Argonne will continue to be a leading U.S. performer of chemical sciences research, as judged from metrics such as peer review and citation counts, and will provide major economic and environmental benefits to the United States by conducting a chemical sciences program of the highest quality.

Goals, Issues, and Strategies

Argonne's goal is to sustain preeminence in its eight research focus areas while undertaking several important new activities.

Three facilities are being built for research at the APS with funds from the Enhanced Research Capabilities at DOE User Facilities Initiative. Upon completion of these facilities, Argonne plans (1) studies of transient molecular structures in photochemically induced reactions important in solar energy conversion, (2) research on the molecular and environmental science of actinides, and (3) studies of static and dynamic order in condensed phases using a time-resolved anomalous small-angle X-ray scattering facility now under construction. Pursuit of these new high-priority efforts is expected to be significantly constrained by the availability of operating resources.

Argonne proposes a new integrated program in the fundamental chemistry of radioactive waste. This program of experimental and theoretical research will respond to a national need for fundamental knowledge of the chemistry underpinning technologies for the cleanup and disposal of radioactive waste, a need highlighted, for example, by "hydrogen burping" problems in DOE waste tanks. Further related issues requiring research include developing more efficient, cost-effective separation techniques for treating mixed waste, transuranic waste, and high-level waste; creating and characterizing new waste forms; oxide degradation processes that could limit some plutonium disposal options; and developing monitoring and characterizing sensor systems for research in waste management applications. Argonne is uniquely qualified to undertake this initiative through its core capabilities in chemical separations science, heavy-elements chemistry, radiation chemistry, and theoretical chemistry, as well as through its facilities for research with radioactive materials, including its cobalt-60 irradiation facility, the facility for actinide studies at the APS, and its megacurie and kilocurie hot cells.

Argonne is planning research on all of the issues relating to radioactive waste identified above. One initial effort involves investigating the chemistry of nitrogen oxides in homogeneous and

heterogeneous systems, in connection with understanding the generation and reactivity of radiolytically produced nitrogen oxides in waste tanks. Nonlinear laser spectroscopy of actinide ions within representative glass matrices is being used to develop correlations between electronic energy levels and structural defects induced by microscopic radiation damage in glass waste forms. Use of X-ray absorption spectroscopy has shown that modifying a clay mineral surface by adding an organic coating is a good technique for sequestering uranium. Already planned is research leading toward relativistic quantum codes suitable for addressing issues in heavy-elements chemistry.

Building on these activities, Argonne plans a major research program with the following objectives:

- To study radiation chemistry in highly concentrated waste solutions and suspensions in order to improve understanding of the fundamental processes contributing to the radiolytic generation of chemical products in waste tanks
- To develop new separations procedures that can both provide the underlying technology to meet the challenges posed by mixed waste and continue contributing to the solution of high-level waste problems, such as removal of the fission product cesium, strontium, and technetium from high-level waste
- To investigate radiation effects in waste forms — especially bubble formation and transport in silicate glasses — and also develop new waste forms suitable for nuclear waste stabilization, including ceramic materials that are superior hosts for plutonium disposal
- To advance relativistic quantum code development sufficiently for simulation of systems containing a large number of atoms (including several that are heavy elements), thereby increasing the contribution of chemical theory to the radioactive waste management program (work supported in part by a Grand Challenge from the DOE Office of Computational and Technology Research, Mathematical Information and Computational Sciences Division)

Funding for these activities, reaching \$5 million by FY 2000, is sought from the Chemical Sciences Program (KC-03) and the Environmental Management Science Program.

Argonne proposes to upgrade its present linac to a new pulse radiolysis facility with capabilities for studying the very rapid chemical phenomena that are important for understanding both the radiolytic processes occurring in radioactive waste (see the discussion above) and other fundamental issues in chemical reactivity, such as the chemistry of reactive intermediates, charge and electron transfer and transport, and ion solvation. The new laser-driven electron accelerator device will revolutionize generation and detection capabilities for pulse radiolysis experiments.

Many basic research studies needed to investigate the fundamental issues identified above are not possible with any existing accelerator, because the required time resolution is not attainable and detection capabilities are limited. The new facility will supply the needed shorter pulses with synchronized laser beams for pump-probe measurements. The facility will also provide a much higher current in 50-ps pulses, facilitating many studies of rapid phenomena that are not presently possible.

The new pulse radiolysis facility will include a linear accelerator based on novel technology for the injector and acceleration sections and will reuse much of the existing linac transport system in a simplified configuration. Design goals are electron pulses with energy greater than 10 MeV and a charge per pulse of 3 nC for a pulse less than 1 ps wide and 50 nC for a pulse 50 ps wide. The new accelerator will be designed to be user friendly, allowing establishment of a pulse radiolysis user facility.

f. Nuclear Physics

Situation

Review committees have consistently identified Argonne as one of the nation's centers of excellence in nuclear physics research. Strengths of the Argonne program include (1) low-energy heavy-ion physics, which is largely performed at the ATLAS facility (discussed in

Section III.D.1.g); (2) medium-energy nuclear physics, which emphasizes the use of lepton beams (at Fermilab, TJNAF [the Thomas Jefferson National Accelerator Facility], and DESY [Deutsche Elektronen Synchrotron]) as probes into the nuclear medium; and (3) nuclear theory, which focuses on developing fundamental understanding of nuclear dynamics and subnucleonic particles in the nucleus.

Vision

Argonne's nuclear physics program will resolve fundamental questions concerning the characteristics and dynamics of nuclear and subnuclear degrees of freedom in nuclei and nuclear matter. This work will involve continuous development of more powerful research apparatus and methods and the use of unique research facilities at Argonne and throughout the world.

Objectives, Issues, and Strategies

Argonne's work in low-energy heavy-ion physics will take full advantage of the unique capabilities of ATLAS to explore and understand nuclei at the limits: at high excitation energies, in exotic shapes, at rapid rotation, and at extreme proton-to-neutron ratios far from stability. Producing and detecting previously unknown isotopes and studying their structures can benefit greatly from secondary (radioactive) beams, which can make accessible regions of nuclei not currently reachable with stable beams. To this end, Argonne is proposing a national Exotic Beam Facility that will be based largely on novel superconducting accelerator technology originally developed at the Laboratory and used for ATLAS. (See Section IV.B.)

Argonne's work in medium-energy nuclear physics uses energetic lepton beams to increase understanding of quark and meson degrees of freedom in nuclei and the role of the quark-gluon structure of nucleons in shaping the character of nuclear forces. To advance the state of the art of lepton-scattering studies in electron storage rings, the Laboratory is developing new technologies for internal polarized nucleon targets to be used in facilities such as DESY. Laboratory researchers are playing a leading role in the research program at TJNAF, including use of a general-purpose

magnetic spectrometer constructed at the facility by the Argonne group.

Argonne's work in nuclear theory addresses many-body aspects and the dynamics of mesons and quarks in hadrons, nuclei, and nuclear matter. Using the new IBM SP system at Argonne and other forefront computing facilities, the Laboratory recently set world standards for calculations on nuclear many-body problems, work that promises answers to fundamental questions. The Argonne theory program is providing important guidance for future experimental programs at TJNAF and for Brookhaven's Relativistic Heavy Ion Collider, a new national accelerator facility currently under construction.

g. Argonne Tandem-Linac Accelerator System

Situation

The ATLAS is a DOE-designated national accelerator facility for research in nuclear physics that employs beams of low-energy heavy ions. The accelerator provides high-quality beams of all the stable elements up to the heaviest, uranium. A recently completed electron cyclotron resonance ion source has increased beam intensity by an order of magnitude. ATLAS is based on a technology developed at Argonne that employs superconducting radio-frequency accelerator cavities. The ATLAS facility serves a broad community of about 300 users from more than 40 research organizations and universities.

Vision

The ATLAS facility will operate reliably and provide its national community of users with unique heavy-ion beams for research at the forefront of nuclear, atomic, and applied physics. Argonne will collaborate with U.S. industry to search for new applications of the superconducting radio-frequency technology pioneered for ATLAS.

Objectives, Issues, and Strategies

The ATLAS program continues to optimize its operations and develop new linear accelerator

technology to provide beams of higher intensity with excellent phase space and fast timing. Operational issues are reviewed continuously, and the facility's capabilities are frequently enhanced. Argonne will be investigating technical and research issues relating to acceleration of beams of short-lived nuclei, as a basis for proposing development of an Exotic Beam Facility based on ATLAS. (See Section IV.B.)

h. High Energy Physics

Situation

Argonne performs cutting-edge research on the physics of elementary particles and develops the instruments and accelerators needed to make that physics accessible. This work in high energy physics leverages a range of diverse resources that generally are available only at a national laboratory. Argonne's program includes six experiments at different stages of preparation or data taking, a varied theoretical program, and R&D on advanced methods of particle acceleration potentially suitable for future research facilities.

Argonne researchers perform experiments at high energy accelerator facilities in the United States and Europe. Other experiments are performed in special laboratory facilities without accelerators. In all these projects, special attention is given to collaboration with university groups. This collaboration encompasses joint work on detectors and detector subsystems, as well as support for students working on theses in association with Argonne staff members.

Vision

To deepen and extend understanding of the physics of elementary particles, Argonne will provide scientific leadership and will design and assemble major components of the required experimental systems. The Laboratory will choose studies in theoretical physics for relevance to the Laboratory's experimental program or for general potential to advance understanding of interactions between elementary particles. The Laboratory will collaborate extensively with high energy physicists based at universities and will help them

use Argonne's broad capabilities to maximum effectiveness.

Objectives

Major objectives of Argonne's work in high energy physics are as follows:

- To maximize the output and impact of new physics generated from the Laboratory's experiments
- To complete the demonstration of the Argonne Wakefield Accelerator and exploit the facility for further experiments in advanced acceleration technology
- To advance the technology of high energy physics detectors by improving existing detector devices and inventing new ones

Issues and Strategies

High energy physics experiments are conducted in most cases by large international collaborations. Increasingly, accelerator or collider facilities are unique and are not duplicated elsewhere in the world. Accordingly, Argonne's work in high energy physics is increasingly conducted at foreign accelerators. Work on the ZEUS experiment at the German DESY facility began in 1985, and ZEUS continues to provide unique data from high-energy electron-proton collisions. A major luminosity upgrade will be operational at ZEUS in 2000, permitting a new focus on extreme values of kinematic variables where rates are low. More recently, the Laboratory began a project that will use the Large Hadron Collider (LHC) being planned at CERN in Switzerland. Argonne researchers have established leadership roles in the ATLAS (A Toroidal LHC Apparatus) detector, one of two major detectors planned for the LHC (and unrelated to the ATLAS facility located at Argonne). The U.S. government recently initialed an agreement with CERN detailing the scope of U.S. participation in the LHC and the level of funding to be provided by DOE and the National Science Foundation.

Argonne will be carefully considering expansions or new directions for many of its programs in high energy physics, in order to

preserve their effectiveness in the next decade. Argonne researchers participating in the underground Soudan 2 experiment have formed a new collaboration, "MINOS," whose plans for a long-baseline study of neutrino oscillation, employing a neutrino beam from the new Fermilab main injector, have been approved by Fermilab. The "far" detector is to be underground, adjacent to the current Soudan 2 detector in Minnesota. By the year 2005, the CDF (Collider Detector at Fermilab) program will be either upgraded to enable a new emphasis on the physics of the b-quark or replaced with a specialized b-detector. Argonne's Wakefield Accelerator R&D program is now preparing for the second phase of its demonstration program; in order to explore ways of using this new accelerator technology in future experimental facilities, the Laboratory will be discussing possible collaborations and alliances with researchers at other institutions. Sources of equipment funding for additions to Brookhaven's Relativistic Heavy Ion Collider facility and Brookhaven's STAR detector have, to a large extent, been identified in Japan and within DOE's Nuclear Physics program. The profile of future funding is still uncertain and needs to be clarified.

Two recently initiated detector projects are expected to grow substantially in the near term, requiring annual funding of roughly \$3 million. The ATLAS detector at the CERN Laboratory in Europe is designed to solve the fundamental puzzle concerning the mechanism of electroweak symmetry breaking and the origin of mass. A phase of final design and fabrication of detector components will be initiated in FY 1998. Calorimeter fabrication will begin in FY 1998 and must be completed by mid FY 2002, when installation begins. Argonne will contribute to design of the trigger for ATLAS during FY 1998-FY 1999, with system components to be built, tested, and commissioned during the following five years. Also expected to grow substantially is the MINOS long-baseline neutrino oscillation experiment, which focuses on unsolved questions about neutrinos. Following major technical decisions in FY 1997, detailed design and prototyping will be performed in FY 1998. Fabrication of the first third of the far detector and installation in the Soudan mine will be completed by FY 2001, permitting initial data acquisition.

The remaining two-thirds of the detector will be added by 2003.

i. Mathematics, Computing, and Information Sciences

Situation

Computers are becoming increasingly fundamental to the advancement of science and engineering, complementing and, in some cases, substituting for conventional methods of theory and experiment. In the future, the most cost-effective way of exploiting the full power of computers — which often are distributed in various sites across the nation — will be to link them via high-speed networks.

An important milestone in Argonne's program in high-performance computing and communications was its acquisition of a state-of-the-art massively parallel IBM SP computer system. The SP has been linked to Argonne's Cave Automated Virtual Environment (CAVE), enabling researchers to simulate multidimensional phenomena in real time. Recently, Argonne began upgrading these computational facilities, adding a high-capacity mass storage server and an advanced multimedia server. With collaborators from industry, universities, and other national laboratories, Argonne researchers are developing the parallel algorithms, software tools, and visualization technologies needed to make such new capabilities truly effective scientific resources.

Argonne has an extensive program to apply the latest advances in computer technology to decision systems and to the development and testing of improved information management systems. This work emphasizes the application of emerging technologies — such as artificial intelligence, heuristic systems, and object-oriented databases — to management problems of the federal government and U.S. industry that can benefit from advances in information systems and decision-making procedures. Working in partnership with other national laboratories, with universities, and with industry, the Laboratory strives to bring these emerging tools into wider use through design prototyping and testing in real applications that stress system capacities.

Argonne is taking a principal role in the DOE2000 initiative, participating in two critical components: (1) the development of novel computational tools and libraries that advance the concept of virtual laboratories and (2) the exploration of new communication paradigms needed for the interoperability of collaborative applications.

Vision

Argonne will make seminal contributions to the next generation of software, systems, and algorithms for DOE scientific computing applications. In response to the new federal emphasis on linking massively parallel computers and other scientific resources over advanced networks, Argonne will pursue a vigorous R&D program to explore high-end telecommunicating, next-generation Internet technology, and virtual environments. In addition, the Laboratory will build software and input-output environments to support computing at teraflops speeds. Argonne will also apply and improve the most advanced concepts of information science to serve planners and decision makers in the federal government and U.S. industry.

Objectives

Central objectives of Argonne's programs in computing and information sciences are as follows:

- To pioneer the study of advanced networking technology, including security mechanisms for wide-area computing and network management
- To make critical contributions to the software and input-output environments needed for effective computing at petaflops speeds in an interactive environment
- To provide leading-edge enabling technology for managing multidimensional data, remote access to user facilities, and high-performance internetworked computation
- To explore the close coupling of immersive virtual environments, supercomputing, and multimedia technology, in order to solve major scientific and industrial problems

Issues and Strategies

Argonne is responding quickly to the growing federal emphasis on large-scale parallel computers and national networks. An important step is the Laboratory's initiative to establish a Center for Computational Science and Technology. (See Section IV.A for further discussion of this initiative.)

Major new computer science technology will be needed for integrating scientific supercomputing techniques into a coherent body of tools and methods that will work effectively over high-speed networks. Argonne computer scientists are working on scalable input-output environments that can serve machines operating at teraflops speeds. These scientists are also playing a lead role in implementing a standard message-passing interface and in developing software tools to provide a uniform environment among different and remote computer architectures. Cooperative partnerships with vendors and national service providers, as well as potential scientific users of these tools, will be required to ensure their widespread acceptance and maximum national benefits.

In response to the federal government's emphasis on virtual laboratories, Argonne is increasing its commitment to projects such as LabSpace, a social virtual reality environment through which scientists can share remote facilities in virtual space. In addition, the Laboratory is exploring novel techniques for CAVE-to-CAVE experiments and an integrated media server that provides network-based video and audio services for collaborative work environments.

j. Intense Pulsed Neutron Source

Situation

The IPNS has operated as a national user facility since its commissioning in 1981. Among DOE neutron sources, it has one of the largest user programs: approximately 300 experiments per year, with over 200 scientists conducting at least one experiment. The IPNS is DOE's most cost-effective neutron source. The high scientific productivity and cost-effectiveness of the IPNS

have been noted frequently by national and international committees. The IPNS currently has 13 neutron-scattering instruments and facilities for studies of radiation effects. Additional funding provided by DOE's Scientific Facilities Initiative has allowed operations to increase substantially over the 18 weeks supported in FY 1995. This increase is in accord with earlier recommendations of the Panel on Neutron Sources of the Basic Energy Sciences Advisory Committee (BESAC). The IPNS operated for 25 weeks in FY 1996, and 23 weeks are scheduled in FY 1997.

The IPNS was surpassed as the world's most powerful pulsed spallation neutron source by the British facility ISIS in 1988. Pulsed spallation neutron sources have demonstrated important scientific capabilities in recent years, and efforts are underway worldwide to construct more powerful sources.

Vision

The IPNS will function as a reliable and accessible user facility for neutron-scattering research and as a successful developer of targets, moderators, and state-of-the-art neutron-scattering instrumentation. The staff will help qualified users conduct world-class research on condensed matter, addressing a wide range of questions important to both science and technology. Through the IPNS Enhancement initiative, the IPNS will maintain leading-edge capabilities in neutron scattering.

Objectives

Major objectives for the IPNS are as follows:

- To operate the IPNS in a highly reliable manner, with availability exceeding 95%, and to provide effective scientific assistance to qualified users
- To operate 32 weeks per year, with sufficient staff to support users fully
- To develop new technologies for targets, moderators, and instrumentation that will increase the capabilities of pulsed spallation neutron sources

- Through the Enhancement initiative, significantly improve instruments, target/moderators, and accelerator systems to bring scattering capabilities for many IPNS instruments up to the level of the ISIS facility in the United Kingdom

Issues and Strategies

The IPNS has historically been severely oversubscribed, understaffed, and underutilized. The additional \$4 million in IPNS operating funds included in DOE's Scientific Facilities Initiative now allows approximately 25 weeks of operation per year with a full complement of instruments serving users. A substantial portion of this funding has become part of the base funding for the facility.

On the basis of its broad experience in accelerator-based neutron sources, Argonne plans to continue conducting R&D in support of accelerators, targets, moderators, and instruments for advanced spallation neutron sources. IPNS personnel have been assigned the lead role for the design and construction of neutron scattering instruments for the National Spallation Neutron Source (NSNS). Testing of prototypes of these instruments at the IPNS will broaden the NSNS user community. Argonne's major initiative, IPNS Enhancement, is discussed further in Section IV.D.

k. Mechanistic Biology and Biotechnology

Situation

Biological research traditionally has focused on identifying the components and pathways involved in the metabolism of living organisms. Because of limitations on that type of knowledge, future study should move toward investigating the mechanisms by which the components of the pathways act and interact. That is, biological research should shift from a phenomenological focus toward one that is mechanistic.

Modern biology — cellular, molecular, structural, and computational — employs tools capable of revealing the fundamental molecular

mechanisms governing phenomena such as cell replication, differentiation, mutagenesis, and carcinogenesis. Applications of the resulting new understanding promise the prevention and cure of diseases, more efficient and effective environmental restoration, and improved industrial processes based on new biotechnologies.

Argonne's Center for Mechanistic Biology and Biotechnology, in partnership with other laboratories, is pursuing biological research that can help to address the following major national challenges:

- *Energy Resources and National Security.* Biomass production; assurance of the petrochemical supply; and detection, protection, and therapy measures against the hostile use of biological agents.
- *Health Care.* Intervention in disorders afflicting our aging population, including cancer, arthritis, heart disease, and Alzheimer's disease; detection of, prevention of, and therapy for infectious diseases such as HIV and Ebola; and human use of blood components produced by plants.
- *Environmental Quality.* Pollution control; waste disposal; and species-specific methods of control.

Vision

Argonne will continue to develop and execute a program of synergistic research — focused on cells, nucleic acids, and proteins — that will increase our understanding of the fundamental mechanisms of life and enable valuable advances in injury prevention, disease therapy, environmental restoration, and industrial processing.

Objectives

Major objectives of Argonne's Center for Mechanistic Biology and Biotechnology are as follows:

- To continue developing the technique of sequencing as a tool for more efficiently unraveling genomic DNA sequences
- To identify and characterize genes and gene products involved in basic cellular

processes such as replication, programmed death, and maturation

- To learn from hyperthermophilic organisms how proteins can function at environmental extremes
- To develop the analytical approaches and software required to exploit massively parallel computers for exploring the three-dimensional structure of proteins
- To exploit the unique capabilities of the Structural Biology Center at the APS to explore currently intractable questions of reaction mechanisms and molecular structure

In this molecular era of biology, the foci of Argonne's research have shifted from radiation biology, chemical toxicology, and carcinogenesis to the cutting edge of new developments in genome research and in structural, cellular, and computational biology. Research is highly integrated and mutually reinforcing, bringing together branches of biology that are traditionally separate and exploiting state-of-the-art computation. The research ranges from fundamental studies of DNA sequences to practical applications, such as protein engineering, that are suitable for transfer to private industry for commercialization.

Issues and Strategies

Sequencing the human genome by using traditional gel-based methods would require an inordinate amount of time and effort. As a world leader in genome technology, Argonne is developing an alternative approach, called sequencing by hybridization on oligonucleotide microchips, which can increase the speed and efficiency of DNA sequencing by orders of magnitude, largely because it reads "phrases" of DNA rather than individual "letters" and because it can be highly automated.

Almost all enzyme reactions are limited to the relatively mild conditions in which normal organisms live. Conditions even slightly harsher can render normal enzymes inactive. However, the organisms known as hyperthermophiles produce enzymes that are stable and active at extremes of temperature, pH, osmotic pressure, and solvent environment. Argonne is beginning to study these

rare organisms, aiming ultimately to understand how proteins from normal organisms can be modified to function under extreme conditions. The resulting new biotechnologies could have high value in areas such as industrial catalytic processes and environmental remediation.

Determining the three-dimensional structure of a protein today requires the application of X-ray diffraction to individual protein crystals, a technique that is time- and labor-intensive. Argonne's program in computational biology is a leader in using state-of-the-art, massively parallel computers to develop the capability to solve protein structures solely from knowledge of the DNA coding sequence. This capability promises to enhance significantly the engineering of proteins to serve specific industrial and medical purposes.

The Structural Biology Center at the APS, the only facility of its kind, is beginning to enable effective approaches to difficult biochemistry problems that cannot be solved today by conventional means, including understanding of structure-function relationships in macromolecules, study of intermediates in molecular processes and reactions, and improving X-ray data derived from macromolecular crystals. Representative molecules for which the Center's capabilities will be particularly valuable include chaperone proteins, cytochromes, immunoglobulins, and cancer suppressor genes.

Argonne treats as a major initiative its integrated programs in the Human Genome, Computational Biology, and the Structural Biology Center. This Mechanistic Biology initiative is discussed more fully in Section IV.E.

Argonne's biological research is beginning to pay off in other areas as well. Being transferred to the private sector for commercialization are diagnostic biochips and more efficient enzymes for biotechnology. Other biological findings of the Laboratory with significant commercial potential include gene products that could lead to pharmaceuticals to control obesity, modulate immune responses, and restrain bacterial infections.

I. Environmental Research

Situation

Environmental issues continue to be a leading national concern, reflecting population growth, economic development, and the environmental legacy of past activities and practices. The focus is shifting from effluent control technologies and associated regulation toward waste and resource management, site remediation, facility decontamination, and global environmental issues. This shift and decreasing federal funding are increasing the importance of basic and applied research leading to more cost-effective environmental technologies and practices. Moreover, new technology and information — such as geographic information systems, computer imaging, and satellite survey data — have created opportunities to address hitherto intractable environmental problems.

Vision

Argonne will continue to provide national and international leadership in key areas of environmental research by developing innovative and cost-effective solutions to high-priority environmental problems, such as improved site characterization and remediation and more accurate weather and climate forecasting. Laboratory researchers of recognized professional standing, complemented by state-of-the-art facilities and instruments, will address problems at the frontiers of environmental science that are technically challenging, broadly relevant, and unlikely to be resolved in a timely fashion through private-sector R&D alone.

Objectives

Central objectives of environmental research at Argonne are as follows:

- To establish the Argonne National Atmospheric Observatory as a user facility generating data required to advance weather research
- To develop synchrotron-based techniques for molecular environmental science, based on the high-brilliance X-rays of the APS

- To develop new methods for identifying, characterizing, remediating, and restoring contaminated environments

Issues and Strategies

Argonne has significant core capabilities in bioprocessing and bioremediation; ecology; modeling and measuring environmental pathways; atmospheric science; quantifying and modeling emissions of greenhouse gases and assessing their impacts; developing "clean" technologies; control and remediation technologies; inorganic and isotope geochemistry; and development of decision models for rapid, cost-effective remediation of DOE sites. This foundation provides important opportunities for fruitful integration of applied environmental studies with fundamental capabilities in physics, chemistry, and biology.

Cost-effective resolution of the important environmental issues facing the nation and the world generally requires the integrated application of multiple scientific disciplines. Argonne believes that the future of environmental research at the national laboratories lies in increased emphasis on basic and applied research conducted by multidisciplinary teams able to exploit fully the major research facilities and other unique capabilities of the laboratories. Better solutions to environmental problems can be achieved by both expanding the knowledge base and better applying what is already known.

As the first step toward establishing the Argonne National Atmospheric Observatory, Argonne is constructing a prototype facility in southern Kansas, within the Southern Great Plains Cloud and Radiation Testbed of DOE's Atmospheric Radiation Measurement Program. The prototype is designed for studies of the planetary boundary layer. This effort builds on the Laboratory's recognized expertise in atmospheric science, remote sensing, advanced computation, information processing, and facility management. The goal is to expand the prototype facility to a national atmospheric observatory featuring state-of-the-art instrumentation and supporting infrastructure. Detailed, high-quality, continuous data for a meteorologically important region will be made available to a very large, diverse user community in near real time via Internet access,

supporting both individual studies and mission-driven, agency-supported research.

The central goal of Argonne's work in synchrotron-based environmental science is a molecular-level understanding of structure and processes in environmental systems. Initial studies will focus on developing synchrotron-based imaging techniques for environmental and biological samples and on understanding the speciation, binding, distribution, and mobility of heavy metals and radionuclides in soil-fluid-biota systems. These multidisciplinary efforts will build on the Laboratory's widely recognized research at the forefront of molecular radiation science and environmental science and will involve several new internal and external collaborations.

Argonne is building and strengthening collaborations among ongoing programs in site characterization, soil ecology, and bioremediation to develop new and improved techniques for evaluating and remedying the impacts of human activities on the environment. For example, the Laboratory's successful field programs in the bioremediation of petroleum products and explosives provide a foundation for important new applications, such as fungal technologies to treat explosives contamination and the use of surfactants to enhance bioremediation. In other work, the Laboratory is continuing R&D on environmental tools such as QuickSiteSM, a methodology that has become the basis for the pending ASTM (American Society for Testing and Materials) standard for expedited site characterization.

m. Support for Science and Engineering Education

Situation

Argonne has maintained very active and wide-ranging interactions with the academic community throughout its existence. The activities range from programs that support science education at the high school level to mutually beneficial research partnerships between university faculty and Argonne research staff in virtually all of the Laboratory's scientific and technical areas. These activities are supported by the Laboratory (through work for others) and by DOE.

Argonne's educational programs serve both teachers and students. Core programs at the university level provide opportunities for research participation for outstanding undergraduates and faculty, as well as for thesis research by graduate students. The quality and value of these programs attract applicants from throughout the country.

Vision

Argonne will enrich science education in the United States through activities in which the Laboratory's facilities and research staff can make unique contributions.

Objectives

Argonne's primary near-term objectives in support of science education are as follows:

- To continue to attract a large, diverse pool of highly qualified undergraduate students to research participation programs
- To establish the Laboratory's educational user facility as a valuable and widely used resource providing hands-on laboratory experience for science teachers in the region
- To strengthen programs that support the use of computers to enhance classroom science education
- To continue to foster student interest in science education and science careers through a variety of outreach efforts
- To fruitfully integrate graduate students, postdoctoral fellows, and faculty into Laboratory research programs

Issues and Strategies

For its university-level programs, Argonne plans special efforts to develop supplementary activities that will broaden the science horizons of undergraduates. Programs for high school students and teachers will focus primarily on hands-on laboratory work using Laboratory facilities dedicated to educational activities. In addition, the Laboratory will continue to develop programs exploiting computer technology to enhance classroom science education. Important workshop

and conference activities, such as the annual Women in Science conference and a special program for underrepresented minorities, will continue.

Funding is the most important issue currently facing Argonne's educational programs. The Laboratory's research divisions plan to continue their strong support for the core programs in research participation and thesis research at the undergraduate, graduate, and faculty levels. Support for the operational costs of programs directed at precollege teachers in nearby school districts and in the Chicago Public Schools will be sought from the districts themselves, as well as from the state of Illinois and agencies of the federal government. Laboratory management will provide support for the minimal infrastructure required to manage and administer these programs. At the same time, the Laboratory will work with DOE in an effort to restore congressional support for the Department's educational programs.

2. Energy Technologies

a. Energy and Industrial Technologies

Situation

Argonne's Energy and Industrial Technologies program encompasses the Laboratory's development of new nonnuclear energy technologies. Areas of application emphasized include advanced transportation, "industries of the future" designated by DOE, and superconductivity. In addition, the program coordinates the Laboratory's efforts to transfer its technologies to the private sector.

Transportation accounts for about 25% of U.S. energy consumption and is 97% dependent on petroleum. Because half of the nation's oil is imported, implications for energy security and the balance of trade remain major issues. Moreover, emissions from motor vehicles are primarily responsible for urban air pollution: 66 urban areas exceed federal standards for ozone, and 29 exceed carbon monoxide standards. Switching to nonpetroleum fuels or increasing energy efficiency in transportation would alleviate these problems.

Process industries convert raw materials into ingredients useful for fabrication and assembly in the automotive, electronics, aerospace, construction, and similar industries. Six 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 manufacturing waste, cause 95% of the total air pollution attributable to manufacturing, and account for more than 30% of U.S. carbon dioxide emissions. Because they use so much energy and produce so much waste, the federal government has set goals for U.S. process industries for the year 2010 in terms of energy reduction, oil displacement, cost savings, and pollution reduction.

The electric power industry is today faced with a wide range of major challenges, including deregulation, aging infrastructure, global warming policies, and dependence on imported oil. Power wheeling across long distances puts a premium on efficient and robust transmission and distribution of electric energy, and greater interconnectedness demands better technologies to protect against overloads and fault currents. Renewable energy sources are increasingly attractive, but solar or wind energy is intermittent and requires energy storage. High-temperature superconductivity is being pursued by DOE and increasing numbers of electric power utilities and their suppliers as a promising response to many of these challenges.

Responding to the administration goal of improving the productivity of U.S. industry by appropriately using national technical resources, Argonne is developing a broad range of partnerships with industrial firms, based on the Laboratory's acknowledged leadership in many areas of science and technology. The Laboratory's midwestern location in the nation's industrial heartland provides exceptional regional opportunities. R&D partnerships between the national laboratories and U.S. industry have become even more critical to the economic health of the nation over the past two decades, as increasingly competitive markets have forced companies to focus on the near term rather than investing in long-term R&D. Partnerships with industry play an important role in shaping many new Argonne R&D programs.

In addition to developing partnerships with large companies, Argonne explores opportunities to work with small and medium-sized companies. A particular concern is making Laboratory resources available with fairness of opportunity to all. Because industrial demand for R&D partnerships far exceeds the resources available to the Laboratory, Argonne has been forced to restrict commitments to the opportunities most likely to add exceptional value to private efforts and complement the Laboratory's core research programs.

Vision

Argonne will develop new technologies that increase the productivity of U.S. industry and decrease its environmental impacts, particularly through increases in energy efficiency and reductions in intensity of petroleum consumption. As an integral part of pursuing all of its missions in science and technology, the Laboratory will develop relationships with industry to maximize the effective commercial applications and benefits to the nation from its R&D.

Goals and Objectives

To implement this vision, central Argonne goals are the following:

- To develop unique scientific and technological capabilities that interest both the industrial and scientific communities
- To establish strategic partnerships with key industrial firms in areas where applying the Laboratory's technical strengths are most likely to lead to valuable commercial successes
- To implement effective regional outreach to industry, capitalizing on the Laboratory's midwestern location
- To exploit the Laboratory's capabilities and core competencies to satisfy industry's precompetitive technological needs

Many U.S. industries have worked with the federal government to create technology development planning "roadmaps" that will help

to ensure that federally sponsored R&D has maximum benefits to the nation. Consistent with these roadmaps, Argonne has established the important research objectives summarized below.

Advanced Transportation

- Work with the Partnership for a New Generation of Vehicles (which includes the DOE Office of Transportation, Ford, General Motors, and Chrysler) (1) to develop by 2004 an 80-mpg family sedan that is fuel flexible, meets all applicable emission and safety standards, and costs no more to own and operate than 1997 vehicles of comparable size and (2) to develop processes for economically recycling virtually all the material from obsolete automobiles.
- Work with DOE and truck engine manufacturers (such as Cummins, Detroit Diesel, Navistar, and Caterpillar) to advance the state of diesel engine technology and allow high-efficiency, compression-ignition, direct-injection engines to be used in vehicles of all sizes.
 - For heavy-duty (tractor trailer) trucks, develop flexible-fuel, low-emission engines achieving 10 mpg rather than today's 6 to 8.
 - For medium-duty (commercial delivery) trucks, adapt high-efficiency engine technology from heavy-duty trucks.
 - For light-duty (pickup) trucks, develop fuel-flexible, efficient, low-emission diesel engines with gas mileage 35% better than in 1997.
- Develop new technology enabling the 6,000-hp, 16-cylinder, 4-stroke, diesel-locomotive engine of the General Motors Electro-Motive Division to meet federal emissions requirements expected in 2004 and still achieve high efficiency.
- Develop other advanced railroad technologies identified in consultation with the Association of American Railroads and other industry stakeholders.

- Develop and help to implement new technology and techniques allowing improved traffic control and safety in "intelligent transportation systems," under sponsorship of the U.S. Department of Transportation and the transportation authorities of Illinois, Indiana, and Wisconsin, focusing on the Gary-Chicago-Milwaukee Corridor.

Industries of the Future

- Expand Argonne research benefiting the chemical industry, from the current work on materials recycling into the areas of catalysis and process engineering.
- Further develop advanced technologies that improve petroleum refining.
- Investigate the possibility of developing a major user facility at Argonne as a focus for research on fluid catalytic cracking.
- Conduct expanded research for the forest products industry, building on current work in the areas of recovery of nonprocess elements, application of sensors and instrumentation, and neural net process control.
- Maintain the momentum of current research on metals recycling; expand work on instrumentation, materials, and fabrication technologies for the steel, aluminum, and metal casting industries.

Superconductivity Applications

- Continue Argonne's role in the development of the second generation of high-temperature superconductors, building on successes with powder-in-tube technology.
- Develop a practical energy storage device based on high-temperature superconducting bearings.
- Design a totally new high-temperature superconducting fault-current limiter that represents a major advance in the state of the art.
- Develop an electric motor based on a new design using high-temperature superconductors.

Issues and Strategies

Recent congressional appropriations have severely curtailed funding explicitly available for participation by DOE and other federal agencies in industrial partnerships. Unless this new trend is reversed, many of Argonne's industrial partnerships will end prematurely.

To maximize the likelihood of establishing effective industrial partnerships in the most promising areas of technology, Argonne has developed explicit selection criteria based on the Laboratory's scientific and technical capabilities and its core competencies. Intensive coordination among the Laboratory's program managers has been implemented in the major industrial focus areas. In addition to identifying promising industrial partners in these and other areas, Argonne is seeking opportunities to include other national laboratories and universities in productive strategic collaborations.

The Laboratory has already established a vigorous regional outreach program whose broad goal is to help manufacturers in the Midwest. The Laboratory measures the success of its industrial partnerships through their lifetimes and beyond, by considering the significance and impact of the work accomplished by the partnerships, the satisfaction of industrial partners, and, ultimately, the successful commercialization of new technologies.

Responding to customer-defined needs for precommercial research, Argonne is undertaking important initiatives in each of its major focus areas for industrial partnerships.

Argonne proposes to establish a Center for Advanced Transportation Technology. (See Section IV.F.) This initiative comprises three major research areas: (1) automobiles; (2) heavy-vehicle technology, including railroads; and (3) intelligent transportation systems (ITS). Across these three areas, Argonne conducts comprehensive research on advanced diesel engines (combustion modeling, emissions, sensors, coatings, lubricants, and assessments), energy storage devices (batteries and ultra-capacitors), low-friction materials for vehicles, hybrid vehicles, fuel cells, transportation-related supercomputing, vehicle recycling, railroad

systems, and ITS sensor and data processing technology.

The DOE Office of Industrial Technologies will increasingly use industry-guided roadmaps to define the related federal research agenda. Argonne is working closely with the following industry associations and groups to identify promising opportunities to apply the Laboratory's skills, facilities, and core capabilities:

- Chemicals: Council for Chemical Research
- Refining: American Petroleum Institute
- Forest products: American Forest and Paper Association
- Steel: American Iron and Steel Institute
- Aluminum: Aluminum Association
- Metal casting: Cast Metal Coalition
- Glass: Glass Implementation Team

Argonne's Industries of the Future initiative is discussed further in Section IV.G.

There is increasing conviction among electric utilities and their suppliers that new technology based on high-temperature superconductivity will provide substantial benefits. This industry support is reflected in administration proposals to increase DOE funding of R&D in the area. Several respected international studies have predicted that global annual sales for all technologies based on high-temperature superconductivity will reach billions of dollars by the year 2020. International competition for these sales will be strong, particularly from Japan and Western Europe.

Argonne is uniquely positioned to develop new technologies based on high-temperature superconductivity. The Laboratory's program of basic science in the field is the strongest in the world. Close cooperation with the Laboratory's applied superconductivity program, which has already resulted in many notable achievements, is the basis for future efforts. Argonne plans to be a major contributor to the development of the second-generation conductor, building on industrial successes already achieved with first-generation powder-in-tube technology. The Laboratory also is developing a flywheel incorporating superconducting bearings that could be among the first commercially successful electric

power equipment based on high-temperature superconductivity. Argonne will expand the range of utility applications on which it works, taking advantage particularly of new ideas for fault-current limiters and motors based on superconductivity. Work in nonutility applications will expand as well, on the basis of innovative ideas in areas such as magnetic separation.

b. Advanced Nuclear Technology

Situation

Argonne has played a leading role in the development of nuclear reactors in the United States and worldwide over the past half century. As a result, Argonne has broad, unique expertise in the full range of nuclear reactor technology. The U.S. nuclear technology infrastructure, which once led the world, has been eroded seriously and could be lost almost entirely if the present trend continues. DOE has established a nuclear technology R&D program at Argonne that uses the Laboratory's technical capabilities and facilities to help solve high-priority, nearer-term missions. The program currently envisioned will encompass two major elements:

- An international nuclear safety center and other activities aim at improving the safety of nuclear reactors throughout the world; the initial focus is on Soviet-designed reactors.
- A program serving domestic reactors, including spent fuel minimization, nuclear safety R&D, reactor materials research, and application of advanced computing.

Vision

Argonne will continue its role of technical leadership in nuclear technology. The Laboratory will develop innovative technologies, demonstrate them at Argonne-West facilities and elsewhere, and ultimately apply them to the highest-priority issues facing the nuclear industry. The DOE Office of Nuclear Energy, Science and Technology will continue to be one of the primary providers of direction and support for these programs.

Goals

The overall goals of Argonne's nuclear technology program are to vigorously and aggressively pursue the important technical issues associated with the use of nuclear energy, both domestically and internationally; to support the related nuclear science and technology programs of DOE; and to maintain levels of technical expertise and knowledge in nuclear technology sufficiently broad and deep to address a full range of national needs.

Strategies

Argonne is proposing a program focusing on the following objectives:

- To provide a complete core competency in nuclear technology and develop technologies to improve nuclear plant systems, so that a nuclear option remains available to the United States for the long term
- To improve the safety of nuclear facilities, particularly Soviet-designed reactors, through international collaboration on safety R&D
- To 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

This Nuclear Energy Security initiative is discussed further in Section IV.H.

Key strategies of Argonne's nuclear technology programs are as follows:

- Development of the International Nuclear Safety Center and associated international R&D collaborations, in order to distribute information about nuclear safety and to develop technology to improve the safety of nuclear facilities, particularly Soviet-designed reactors
- Application of Argonne nuclear expertise and advanced technologies to support the U.S. light-water reactor industry in life extension of aging reactors, fuel minimization, improved reliability, reduced operating costs, improved safety, and other areas.

3. Environmental Technologies

a. Electrometallurgical Technology

Situation

The Department of Energy currently is responsible for approximately 2,700 metric tons of spent nuclear fuel in storage at several DOE sites (Idaho National Engineering and Environmental Laboratory [INEEL], Hanford, Savannah River, Oak Ridge, and others). A recent evaluation identified over 130 different types of fuel in this inventory, representing a wide variety of fuel forms and storage problems. Some fuels are stored in water basins, where they are deteriorating to various degrees, and some are in temporary dry storage.

Until its spent fuel can be conditioned for final emplacement in a geologic repository, DOE plans to repackage the fuel and place it in stable dry storage. The total cost of interim storage and licensing for the many different types of spent fuel is expected to be very high. Moreover, final disposal of certain fuel types would remain problematic, because they are not amenable to efficient direct disposal. For example, some fuel types still contain highly enriched uranium, which can cause concerns about criticality in a repository. A larger part of the DOE spent fuel cannot be disposed of directly because it is chemically reactive or pyrophoric and so is prohibited from repository disposal by Nuclear Regulatory Commission regulation.

A standard, cost-effective means is needed for treating different kinds of DOE spent fuel for ultimate disposal. The electrometallurgical treatment process being developed at Argonne has the potential to meet these requirements. Use of this process would allow all of the spent fuel stored at INEEL and at Hanford, as well as all of the non-aluminum-matrix fuel in storage at the Savannah River Site, to be treated by one common method, producing two common high-level waste forms. One form is a mineral waste containing most of the fission products in a ceramic material produced by hot-pressing a composite of borosilicate glass and zeolite. The composition of this waste form is essentially invariant, regardless of the type of spent fuel processed. The other

waste form is a metal alloy whose composition depends largely on the types of structural materials present in the fuel. Most DOE fuels are clad with stainless steel or zirconium alloy, resulting in a very stable metal waste form with an iron-zirconium alloy matrix.

The first logical application of the electrometallurgical technology is to the Experimental Breeder Reactor-II (EBR-II) Termination program (discussed below). The EBR-II spent fuel has three characteristics that necessitate treatment before disposal: (1) it is metal fuel, prohibited from direct disposal because it is flammable; (2) it contains a reactive metal, sodium, that is also prohibited in a final repository; and (3) it contains highly enriched uranium, implying criticality concerns. Treatment of EBR-II fuel before disposal is mandatory. Furthermore, DOE has a formal agreement with the state of Idaho to remove EBR-II fuel from the state.

The potential applicability of Argonne's electrometallurgical technology for the treatment of DOE spent nuclear fuel is the subject of an ongoing review by a special committee of the National Academy of Sciences. The committee already has confirmed that the technology represents a promising approach and that it warrants continued R&D support.

Vision

Argonne will develop and demonstrate the viability of its electrometallurgical technology so that DOE can decide to apply it to the standardized, cost-effective disposition of DOE-owned spent nuclear fuel.

Objectives

The most important near-term milestone is to complete demonstration of the electrometallurgical technology on EBR-II spent fuel by June 1999. If this demonstration is successful, then DOE will make two decisions: (1) whether to proceed with electrometallurgical treatment of the remaining EBR-II spent fuel and (2) whether progress and potential are sufficient to warrant continued R&D on electrometallurgical treatment for other types of DOE spent fuel.

Issues and Strategies

Demonstration of EBR-II spent fuel treatment began in Argonne's Fuel Conditioning Facility (FCF) in June 1996. National Environmental Policy Act (NEPA) documentation limits the scope of the demonstration to 100 driver assemblies and 25 blanket assemblies. To determine the success of the demonstration, a well-defined set of performance criteria is needed. The following four criteria have been proposed:

- Demonstration that 125 EBR-II assemblies can be treated in the FCF within three years, with a throughput rate of 16 kilograms per month for driver assemblies (sustained for a minimum of three months) and a blanket assembly throughput of 150 kilograms for one month
- Quantitation — for both composition and mass — of recycle, waste, and product streams that demonstrates projected material balances with no significant deviations
- Demonstration that the process is dependable and predictable overall, considering uptime, repair and maintenance, and operability of linked process steps
- Demonstration that safety risks, environmental impacts, and nuclear materials accountancy are quantified and acceptable within regulatory limits

An issue associated with the limited-scope demonstration is the schedule for waste form development. Waste form development and qualification will extend well beyond the schedule for the EBR-II spent fuel demonstration, because licensing of the new waste forms for ultimate disposal in a repository requires completion of an extensive behavior characterization database, reflecting both short-term tests and long-term tests with actual radioactive wastes, extending 10 years or more. Nevertheless, tests with surrogate fission products and limited tests with actual radioactive waste forms will provide sufficient data at the end of the demonstration phase to allow informed technical judgments regarding the viability of the new waste forms.

b. EBR-II Termination

Situation

The EBR-II Termination program involves two major elements: (1) shutdown and closure of the EBR-II reactor plant and (2) treatment of EBR-II spent nuclear fuel so that it can be stored in a geologic repository. The major activities in the program and their status are as follows:

EBR-II Reactor Plant

- Removal of fuel: Completed.
- Draining of sodium coolant: Completed for secondary sodium system; design of drain system for primary sodium in progress.
- Chemical reaction of sodium coolant: Sodium process facility completed and currently operating on sodium coolant from the Fermi reactor.
- Chemical reaction of sodium remaining in the reactor system after draining: Engineering in progress.
- Closure of reactor systems: Planning in progress.
- Closure of support systems: Planning in progress.

EBR-II Spent Fuel Treatment

- Modification and operation of the FCF: Operations with spent EBR-II fuel in progress.
- Demonstration of technical feasibility of application of electrometallurgical treatment: In progress.
- Treatment of balance of EBR-II fuel: Planning in progress.

The capabilities necessary to complete EBR-II Termination successfully — including unique facilities and personnel — are in place. The key facilities are the Hot Fuel Examination Facility (HFEF, for the receipt of fuel from EBR-II and the waste forms from fuel treatment), the Sodium Component Maintenance Shop (SCMS, for the receipt and cleaning of major components from the EBR-II reactor), the Sodium Process Facility (SPF, for the conversion of elemental sodium to

sodium carbonate), the Radioactive Scrap and Waste Facility (RSWF, for the interim storage of EBR-II spent fuel and waste form products from fuel treatment), and the Fuel Conditioning Facility (FCF, for the electrometallurgical treatment of EBR-II spent nuclear fuel). Engaged in the termination activities are staff who operated and maintained EBR-II over its 30 years of operation, staff who operated the hot cells (HFEF and FCF), staff who provided technical and analytic support for operations and research programs at Argonne-West, and support staff in areas such as radiation protection and safeguards and security. Closure of the EBR-II reactor requires many of the same capabilities as earlier activities.

Collaborators in EBR-II Termination have similar interests in closing other sodium-cooled reactors, such as the Fast Flux Test Facility (FFTF) on the Hanford reservation and the Fermi reactor owned by Detroit Edison. Potential future collaborators include international partners in the United Kingdom and Kazakhstan.

The EBR-II Termination activities, funded at approximately \$70 million per year, are projected to continue through 2003.

Mission

The primary mission of the EBR-II Termination program is to close the EBR-II plant with no hazards remaining for humans or the environment. In completing this mission, the technology for safely and efficiently closing a sodium-cooled reactor, including treatment of spent fuel for disposal, will be demonstrated. The near-term objectives are to demonstrate the safe and efficient operation of the SPF and, by June 1999, the viability and efficiency of the fuel treatment process. Plans call for the EBR-II plant to be successfully closed by December 2000, with all residual sodium reacted and treatment of EBR-II fuel in progress at full capacity.

If successful, much of the technology developed in the EBR-II Termination program can be applied to the decommissioning of other sodium-cooled reactors. Detroit Edison will soon be deciding whether to decommission the Fermi reactor fully, and the FFTF reactor is slated to use EBR-II technology. In addition, the electrometallurgical treatment technology developed for

EBR-II may be beneficially applied to a number of other spent fuels in U.S. reactors whose disposal presents problems.

Objectives

Key milestones for the EBR-II Termination program are as follows:

- Processing of sodium from the Fermi reactor will be completed by December 1997, after which processing of secondary-system sodium from EBR-II will start.
- Processing of secondary sodium from EBR-II will be completed by June 1998, processing of primary sodium by May 1999.
- Techniques for reacting the residual sodium will be developed and tested by December 1999.
- Demonstration of the electrometallurgical treatment of EBR-II spent nuclear fuel will be completed by June 1999.
- Closure of the EBR-II reactor systems will be completed by December 2000.

Goals

The primary goal of the EBR-II Termination program is to develop, demonstrate, and apply technology for closing sodium-cooled reactor systems safely and efficiently. A long-term goal is to explore the beneficial application of EBR-II technology to other U.S. reactor systems and associated fuels, taking full advantage of established Argonne capabilities.

Issue and Strategies

Projected funding requirements for the EBR-II Termination program from 1999 through 2003 exceed current DOE projections by approximately \$20 million annually. Insufficient funding would lengthen schedules, allow key personnel to dissipate, and increase overall costs in the long run. The impacts of reduced funding are being analyzed in detail to guide final decisions. A key issue is whether the plant could be closed without reacting residual sodium. The conclusion is that such a reduction in scope would make it

impossible to satisfy all environmental regulatory requirements. These issues are being discussed in the context of a formal environmental assessment now undergoing public review.

A panel of the National Academy of Sciences periodically reviews progress and planning for the treatment of EBR-II spent fuel. The panel has raised questions about the development and qualification of waste forms and about the integration of demonstration activities centered at Argonne-West and technology development activities centered at Argonne-East. To address these concerns more effectively, Argonne's work on fuel treatment is being organized as a discrete project with a fully integrated management structure.

c. Radioactive and Mixed Waste Treatment Technologies

Situation

Many of DOE's highest-priority business goals depend directly on the Department's environmental program, specifically on the objectives of the DOE Office of Environmental Management (DOE-EM), which is developing a ten-year plan that focuses on cleaning up most DOE sites within a decade. Included in the plan is application of new technologies that have reached various stages of development, with support from the DOE-EM Science and Technology Program. Nevertheless, despite extensive cleanup efforts and this planning, many DOE waste streams associated with weapons production are expected to require treatment beyond the coming decade. In addition, many high-level wastes, spent nuclear fuel, materials associated with plutonium disposition, and other special nuclear materials are expected to remain problematic. Beyond 2006, new science and technology will be needed to address these long-term concerns at DOE sites; the national laboratories must play an essential role in the development, demonstration, and implementation of that science and technology.

Planning by DOE has focused on "contained wastes," but DOE, the Department of Defense (DOD), other federal agencies, and industry are also responsible for substantial amounts of "uncontained wastes" that have interacted with the

environment and will continue to cause problems in the water, air, and soil or during waste handling and disposal. In the near term, optimized treatment for certain important mixed-waste streams and immiscible organic groundwater contamination will almost certainly remain problematic.

Argonne has demonstrated significant core capabilities in advanced environmental technologies, built on its broad competencies in nuclear technology and environmental science and technology; its existing nuclear facilities; and its extensive understanding of and experience in resolving complex environmental problems at sites of DOE, DOD, other federal agencies, and U.S. industry. Most notable are the Laboratory's capabilities in environmental R&D, especially in the effective integration of the full range of relevant basic sciences with complementary fields as diverse as economics, operations research, and computer applications, as well as the more traditionally complementary scientific and engineering fields. This integration of capabilities in environmental research, technology development and deployment, comprehensive assessment, and remediation applications is the basis for Argonne's continuing development of advanced environmental technologies tailored specifically to particular facilities and waste streams for many different types of customers.

Vision

Argonne will advance understanding of environmental problems and will develop technologies that allow cost-effective remediation or prevention of those problems for nuclear, mixed-waste, and other contaminants.

Objectives

Argonne's work on advanced environmental technologies has the following central objectives:

- To develop technologies for treating mixed waste
- To develop superior waste forms and methods of testing and validating techniques for predicting performance
- To develop innovative environmental technologies that exploit the state of the art in

separation science, chemical interactions, and advanced materials

- To integrate scientific research with field engineering experience and methodologies in order to develop cost-effective solutions to environmental problems

Issues and Strategies

Development of advanced technologies for mixed-waste treatment and D&D are logical extensions of Argonne's broad background in reactor technology. In mixed-waste treatment, Argonne plans to continue to specialize in remote-handling operations, transuranics, waste form development, environmental process monitoring, and nonthermal treatment options.

Argonne-West already deals with significant amounts of remotely handled radioactive and mixed wastes, which are stored at its RSWF. These wastes require additional characterization, segregation, treatment, and repackaging. In addition, the Laboratory has a number of R&D projects that support (1) DOE's Mixed Waste Focus Area, including work on the plasma hearth process, process monitoring and control, and chemically bonded phosphate ceramic waste forms; and (2) the Waste Isolation Pilot Plant (WIPP), including work on characterizing transuranic waste and experiments on gas generation. In future work, Argonne will integrate R&D with treatment of its own mixed waste.

The DOE Advanced Mixed Waste Treatment Project will treat, for subsequent disposal, large volumes of the Department's mixed waste residing at INEEL. Plans include a private-sector facility to treat alpha-contaminated low-level and transuranic mixed wastes, with sufficient flexibility to treat other regional and national waste streams as well. Argonne can provide technical support for this effort through facilities at its Idaho site and through expertise at both sites in handling and processing transuranics.

Development of superior waste forms and associated innovative technologies generally involves the integration of applied engineering, basic materials science, and basic chemical science. Development of stabilized waste forms is

very important for solving problems associated with high-level and mixed waste.

During the last decade, Argonne has performed a wide range of R&D contributing to waste form development, including work on the electrometallurgical treatment of spent nuclear fuel, long-term and accelerated testing of high-level waste glasses and technical support to the Yucca Mountain Project, development of chemically bonded phosphate ceramic waste forms, studies of glass compositional envelopes for DOE-EM, definition of performance specifications for Hanford low-level wastes, and the phosphate mineralization of actinides by the measured addition of precipitating anions. Argonne will continue to support DOE programs such as the high-level waste repository and WIPP. In addition, technical support will be provided to the DOE field offices and to site contractors at major sites charged with cleanup and waste management, such as Savannah River, Fernald, Rocky Flats, INEEL, and Hanford.

Argonne will also continue to support DOE-EM R&D aimed at long-term disposal of waste forms, through the Mixed Waste Focus Area, the Plutonium Focus Area, and the Environmental Management Science Program. This research centers around the physics and chemistry of surfaces and interfaces; development of new waste forms for "problem" wastes; and modeling, validation, and performance testing.

Argonne's major initiative on Mixed Waste Treatment and Waste Form Development is discussed in Section IV.I.

Argonne continues to play an important role in DOE-EM's environmental technology programs. DOE wastes containing radionuclides will remain a major issue well beyond 2006, justifying the development of better treatment technologies. Areas for future investigation include interactions of radioactive elements in various media and waste forms, extraction or separation of radioactive and hazardous chemicals and contaminants, characterization of DOE wastes and contaminants, and prediction and measurement of contaminant movement in and around DOE facilities. Argonne will continue to exploit its basic science programs and unique facilities, such as the APS and the IPNS, in order to explore

advanced innovative technologies serving environmental restoration and waste management at DOE sites.

Argonne is enhancing its capabilities in land restoration, site characterization, and chemical production facility D&D, particularly by adapting for DOD cleanup technologies originally developed for DOE, such as containment barriers, soil washing, ultrasonics, and groundwater cleanup via magnetic separation. Many of these technologies can also provide cost-effective solutions to the environmental problems of U.S. industry. In response to restrictions on the use of many chemical solvents, Argonne has established an Alternative Cleaning Technologies Consortium in partnership with the state of Illinois and private-sector groups, to facilitate the partners' access to Laboratory capabilities that could help to make chemical cleaning safer and more effective.

d. D&D Technology

Situation

The D&D of production and research reactors and nuclear manufacturing facilities represents a major challenge for DOE and the commercial nuclear industry. Over the next several decades, several hundreds of billions of dollars will be spent internationally to perform such D&D. Moreover, D&D of power reactors will be much more costly, and the deregulation of the electric utility industry will accelerate interest among utilities and regulators in all aspects of power reactor decommissioning. Problems associated with D&D include safe and effective dismantlement of contaminated and radioactive components; packaging, transportation, and disposal of waste; and recycling and reuse of the maximum possible amount of material.

Argonne is uniquely positioned to assume a leadership role in the development and demonstration of D&D technologies. A number of the technologies already developed or under development at the Laboratory can be applied to or adapted for D&D applications, including advanced cutting technologies (such as lasers, water jets, and plasma arcs), effluent control technologies (such as filters for aerosols and

dissolved contaminants), instrumentation, decontamination methods (both chemical and mechanical), and risk assessment methods. Moreover, D&D of a number of reactors and related facilities at the Laboratory is presently planned or is in progress. These facilities are prototypes of systems used commercially, and they therefore will provide excellent test beds for the demonstration of D&D technologies under controlled laboratory conditions. Techniques successfully demonstrated can be transferred to industry for use both domestically and internationally. This technology development and demonstration will be pursued simultaneously with the D&D of Argonne facilities and will complement that work without affecting its completion on schedule.

Argonne is building its D&D Technology program on a strong foundation of extensive experience in nuclear and environmental work, recent success in applying D&D technologies, and valuable strategic partnerships. The Laboratory has experience with the D&D of many types of nuclear facilities, including reactors, hot cells, and facilities containing glove boxes. Argonne also has a long history of developing and deploying both nuclear and nonnuclear technologies and is today playing a leading role in this country's largest technology demonstration program at a working D&D site, the CP-5 Large Scale Demonstration Project. The Laboratory has been instrumental in developing risk-based analyses for recycle and release criteria and for transportation. Argonne has also developed cost-engineering models that have been used to validate cost estimates throughout the DOE complex and has performed NEPA analyses for a wide variety of projects.

Argonne is a member of the Strategic Alliance for Environmental Restoration, which is directing the CP-5 Large Scale Demonstration Project. Other members are Commonwealth Edison, Duke Engineering and Services, Florida International University, ICF-Kaiser, and 3M. Under the project, which began in October 1995 and will last two years, over 25 technologies will be demonstrated and evaluated. Elsewhere, Argonne is active in several international organizations involved in D&D and has initiated information exchange programs with the International Atomic Energy Agency (IAEA), Japan, and Russia.

Vision

To optimize the cost-effectiveness and safety of D&D operations, Argonne's D&D Technology program will advance the development, demonstration, and deployment of cost-saving D&D technologies and will develop and execute analyses of risk, safety, environmental impacts, and cost for DOE, regulators, and the commercial sector. The program will also make seminal contributions to D&D education through training, workshops, and personnel exchanges.

Goals

The main goals of Argonne's D&D Technology program are the following:

- To provide substantive information on the use and value of D&D technologies for all end users
- To use Argonne facilities scheduled for D&D as test beds for the development, testing, and validation of new D&D technologies
- To coordinate a team of specialists that will coordinate research, development, demonstration, and evaluation of D&D technologies in order to achieve cost-effective D&D for the DOE complex
- To provide technical services and support in the areas of risk, safety, and cost analysis, as well as in planning and technology deployment
- To provide D&D training and participate in informational and educational exchange both domestically and internationally, including support for D&D in the former Soviet Union

Issues and Strategies

Key to the development of Argonne's D&D Technology program is formation of strategic alliances among national laboratories, utilities, universities, D&D contractors, and technology developers and providers. Argonne will continue to pursue appropriate alliances, with special attention to working with nearby Commonwealth Edison, the nation's largest nuclear utility; interactions with top management and technical

departments at ComEd have begun. In all its D&D technology efforts, Argonne is working closely with DOE-Chicago Operations, whose business plan is slated to include development of the Laboratory's D&D Technology Center. (See Section IV.J for more information about this Laboratory initiative.) Internationally, Argonne will take advantage of the Laboratory's strong international research reactor program, which dates back to Argonne's design of research reactors and, more recently, to the design and implementation of proliferation-resistant fuels for research reactors.

A number of external and internal factors will influence the success of Argonne's D&D Technology program. External factors include scheduling of D&D by DOE and utilities, effects from utility deregulation, and the availability of low-cost disposal sites for low-level nuclear waste. Internal factors include close integration of the Laboratory's diverse capabilities in technology and advanced technical services. Equally important is the formation of partnerships and strategic alliances with organizations outside the Laboratory.

Argonne's D&D Technology Center initiative, discussed in Section IV.J, builds on the current Argonne D&D program to establish a wider range of activities in the areas of operations, technology development and evaluation, services, and education.

e. Energy and Environmental Systems and Services

Situation

Environmental issues continue to be very important to the nation. Issues relating to the availability of energy resources and their environmental impacts are increasingly contentious, especially where the cost of energy may be affected. Informed resolution of these issues — complicated by economic, security, and other concerns — requires effective use of huge amounts of disparate technical information. Argonne is positioned to address some of the most complex and important environmental issues facing the nation, particularly because of the

Laboratory's ability to integrate diverse technical resources to solve customers' problems.

Federal work on energy-related environmental issues is spread widely among agencies. No single agency has a mandate to examine the full range of issues relating to energy and the environment. The effectiveness and coordination of federal programs can suffer as a consequence, especially as federal budgets become more stringent. Argonne has unusually rich opportunities to use its technical capabilities to solve the environmental problems of both public and private customers. By applying scientific research, new technologies, and innovative processes, the Laboratory can develop solutions more effective than any available previously, especially by merging decision analysis, computer sciences, and economic evaluations with the engineering expertise and the physical, biological, and social sciences that traditionally undergird energy and environmental analysis.

The immediate drivers of Argonne's planning for Environmental and Energy Systems and Services are the following national needs:

- Environmental problems require more cost-effective solutions. While there is tremendous national interest in maintaining and enhancing environmental quality, there are limited resources to do so.
- The growing information glut facing federal and private-sector decision makers requires the development of better means of capturing and displaying critical information. To meet this need, Argonne is uniquely positioned to merge technical information into computer applications involving advanced visualization and data management techniques.
- Deregulation of electric utilities may lead to decreased emphasis on reliability and environmental protection, while new environmental regulations and heightened concerns about infrastructure security are requiring the development of new procedures and technologies by the utilities. Rational coordination of these processes, which is in the national interest, will require new federal efforts beyond the capabilities of the private sector.

- State-of-the-art assessment of complex issues relating to energy and the environment more than ever requires a multidisciplinary approach. Salient examples of these issues include (1) DOE's programs related to global climate change and (2) the wise management of depletable energy resources and the use of related technologies.

Vision

Argonne will continue to provide national and international leadership in generating innovative and cost-effective solutions to energy, environmental, and related information management problems and will be recognized as preeminent among national laboratories in this role.

Objectives

Key objectives of Argonne's program in Environmental and Energy Systems and Services are as follows:

- To expand the Laboratory's remediation and waste management activities to DOE field offices and other federal and private-sector sites
- To develop innovative information systems that benefit federal land managers and policy makers, as well as private-sector businesses facing new regulatory environments
- To develop for DOE and DOD new programs that enhance the security of the nation's oil, gas, and electricity infrastructure, as well as related U.S. capabilities in emergency services, resource supply, and transportation
- To refocus multidisciplinary assessments on issues of global climate change and energy resources, management, and utilization

Issues and Strategies

Argonne has considerable strengths in most scientific and technical areas relating to issues of energy and the environment. The Laboratory is unusually well organized to integrate its multidisciplinary expertise in research, development, and application of new technologies. Equally

importantly, Argonne staff and management have developed strong relationships with customers, based on a demonstrated ability to solve problems. Challenges facing the program include declining opportunities for funding from traditional sponsors, difficulty in identifying all the beneficial opportunities for external collaborations, and a need for broader recognition of the program's quality.

Strategies for overcoming these challenges include the following:

- Maintain and expand the program's customer base. To perform cost-effective environmental evaluations, Argonne staff must be allowed to work more closely with DOE field offices and management-operations contractors. Work for DOD will focus on issues relating to base realignment and closure, as well as new environmental requirements such as the munitions rule. Important opportunities exist to continue work for the Department of Agriculture and to create a new program for the Department of the Interior.
- Evaluate the data needs of DOD managers relating to downsizing of the military, particularly needs involving greater use of simulation models. The Laboratory's special abilities to merge technical expertise with simulation models can also serve a variety of needs in the private sector.
- Contribute to assuring the security of key U.S. infrastructure systems under external threats such as natural and technological disasters and political instability. Focus on the distribution systems for electricity, oil, and gas, in work for the Departments of Commerce and Transportation, as well as DOD and DOE. Explore the contributions that Argonne technology development can make to cost-effective infrastructure security efforts by electric utilities and other private industry.
- Continue to advance frontier Laboratory capabilities well beyond those available in the private sector, focusing on technical areas where development of more cost-effective solutions will have large benefits, such as in the site characterization required for remediation activities and postclosure monitoring.

- Fully exploit synergies and opportunities for collaboration among Argonne programs in site characterization, soil ecology, and bioremediation, to develop better techniques for evaluating and remedying environmental impacts. A salient example is QuickSiteSM, a Laboratory methodology that is the basis for the pending ASTM standard for expedited site characterization. Argonne is registering QuickSiteSM as a service mark and plans to continue improving the Laboratory's state-of-the-art site characterization methodologies in terms of both technical effectiveness and regulatory compliance, to explore beneficial applications of QuickSiteSM for private business, and to transfer QuickSiteSM principles widely to environmental remediation and monitoring programs.

- Combine innovative decision tools with field techniques to create applied environmental methodologies that advance the state of the art. Salient examples are Adaptive Sampling and Analysis Programs (ASAP) and PlumeTM software, both developed by Argonne in conjunction with Consolve, Inc., an M.I.T. spin-off company. PlumeTM has significant advantages over earlier methods; it achieves more cost-effective cleanups through better site sampling strategies and more flexible decision making based on rapid acquisition and evaluation of field data.

4. National Security: Arms Control and Nonproliferation

Situation

Argonne's Arms Control and Nonproliferation program coordinates all Laboratory activities directed at reducing the threat to U.S. national security posed by nuclear, chemical, and biological weapons. With the end of the Cold War, the principal threat to U.S. national security changed from large-scale nuclear war to asymmetric conflicts and terrorist activities by subnational groups. The early focus on technical means to verify treaty compliance therefore shifted toward developing ways to limit the spread of weapons of mass destruction.

Among the most pressing problems facing the United States is the breakdown of systems for controlling nuclear materials in the states resulting from dissolution of the former Soviet Union (FSU). The United States is one of several countries providing technical assistance to these newly independent states (NIS) to help improve their systems for control of nuclear materials. The NIS with significant nuclear energy programs have committed to nonproliferation of nuclear weapons and have requested U.S. assistance in achieving this goal.

Argonne's nonproliferation and national security programs, with an annual budget totaling approximately \$15 million, include several significant components:

- The Reduced Enrichment for Research and Test Reactors (RERTR) program, which develops new fuels and methods to enable research reactors throughout the world to replace their highly enriched uranium fuel with low-enriched uranium fuel
- The Nuclear Material Protection, Control, and Accountancy (MPC&A) program, which assists FSU successor states in upgrading their methods of protecting nuclear materials
- The Verification Technology program, which develops very sensitive and selective instruments to detect radiation and chemical and biological effluents that may indicate clandestine proliferation
- The Nuclear Technology Transfer Policy program, which provides technical assistance to DOE, including technical reviews of proposed exports of information technology and nuclear dual-use commodities, as well as development and implementation of the classified Proliferation Information Network System for coordinating license review and proliferation analyses

Mission

By exploiting the technical and analytical expertise of Laboratory staff and the Laboratory's facilities for physical and biological research, Argonne supports the efforts of federal agencies to detect and deter threats to national security due to the proliferation of weapons of mass destruction.

In addition, Argonne helps to implement associated U.S. policy initiatives.

Issues and Strategies

Argonne plans to consolidate and increase its support for nuclear nonproliferation initiatives, particularly by exploiting the Laboratory's unique expertise in nuclear and sensor technologies. RERTR activities will involve extensive cooperation with Russia, China, and other countries. The Laboratory plans to develop a new process to produce molybdenum-99, an important medical radioisotope, without the use of highly enriched uranium. The Laboratory also plans to develop new instruments to detect the presence of chemical and biological weapons. Argonne expertise will be used to enhance the security of nuclear materials at additional sites in the FSU. Other activities will focus on developing spin-off projects related to the Laboratory's established MPC&A and training programs in Kazakhstan and Ukraine. Argonne expertise is already being applied to enhance proliferation resistance for the blanket material of the BN-350 fast reactor in Kazakhstan, while Laboratory staff are providing general technical assistance to the facility's operating staff. Many of these activities will benefit from direct interaction of Argonne personnel with key staff of DOE-Nonproliferation and National Security, including interaction achieved through participation in the office's Science Council and other advisory bodies.

5. Industrial R&D Partnerships

Situation

Argonne's technology transfer program over the past decade has reinforced the Laboratory's reputation as a reliable, productive partner for industry, as Argonne researchers have come to better understand the technical needs and working relationships of private companies. In recent years, pursuit of opportunities for technology transfer has been facilitated by a new prime contract for the operation of Argonne and by new mechanisms for establishing agreements with business firms. However, DOE funding has declined in areas important for technology transfer, notably for research programs in

high-temperature superconductivity and — especially severe — for industrial partnerships.

Mission

Argonne will promote and facilitate the transfer of its technology to U.S. industry, to the benefit of both the Laboratory's R&D programs and U.S. productivity.

Goals/Objectives

Key goals of Argonne's technology transfer program are as follows:

- To maintain and further develop productive relationships with private industry, achieving the highest possible levels of customer satisfaction
- To maintain appropriate balance among types of collaborations with industry: large versus small businesses, long-term versus short-term agreements, and single-organization versus multiple-organization agreements
- To increase industrial funding of precommercial R&D at the Laboratory
- To maintain active roles in industrial and economic development groups
- To foster generally the commercial availability and industrial use of Argonne technologies

Issues and Strategies

Although ER-LTR funding for cooperative R&D agreements (CRADAs) has decreased, numerous CRADAs are still supported through programmatic activities. Argonne is increasingly using work-for-others (WFO) contracts for industrial agreements. To facilitate coordination of industrial interactions, the offices administering CRADAs and WFO have been merged, and improvements in WFO processing and communications are being implemented.

Argonne continues to increase the precommercial R&D that it performs for private industry. New approaches are being explored for matching Argonne's unique capabilities to the needs of U.S. industry.

E. Resources

Argonne's work is supported primarily by DOE's program secretarial offices, led by Energy Research and Nuclear Energy, Science and Technology. Further complementary work is funded by other DOE contractors and by non-DOE sponsors, including the Nuclear Regulatory Commission, the Department of Defense, other federal agencies, and nonfederal organizations such as the Electric Power Research Institute and private firms. Table III.1 summarizes the funding that Argonne plans to receive in FY 1998, along with historical data for FY 1996 and midyear estimates for FY 1997. Detailed resource projections are in Supplement 4.

The projected budget authorization (BA) figures in Table III.1 do not provide all the budget information required for planning. In particular, actual expenditures seldom match new authorizations, and this difference complicates the picture. During the early 1990s the Laboratory's budget authority exceeded expenditures, enabling the Laboratory to carry over funds into succeeding years and build a reserve. However, from FY 1994 through FY 1997, expenditures began to exceed budget authority. The difference will be about \$20 million in FY 1997.

For FY 1998, the Laboratory projects new authorization at \$470 million, which falls short of estimated expenditures by about \$7 million. Under this scenario, carryover for DOE-supported programs will fall to approximately one month of funding, the minimum feasible level. FY 1998 expenditures imply a 2.5% reduction in total FTEs. However, if the Laboratory achieves its planned reduction in overhead costs (see Section V.E.4), it will be able to maintain a constant level of R&D effort.

Table III.1 Resource Summary by Major Program (\$ in millions BA operating funds; % of total in italics)

Program	FY96	FY97	FY98
Nuclear Energy, Science and Technology	95.8 <i>21.4</i>	89.9 <i>20.4</i>	108.7 <i>23.3</i>
Energy Research	177.6 <i>39.6</i>	169.4 <i>38.5</i>	179.2 <i>39.2</i>
Energy Efficiency and Renewable Energy	17.5 <i>3.9</i>	18.4 <i>4.2</i>	23.2 <i>5.0</i>
Fossil Energy	5.3 <i>1.2</i>	4.0 <i>0.9</i>	4.7 <i>1.0</i>
Defense Programs	1.9 <i>0.4</i>	0.8 <i>0.2</i>	1.6 <i>0.3</i>
Nonproliferation and National Security	11.2 <i>2.5</i>	13.6 <i>3.1</i>	15.8 <i>3.4</i>
Environmental Management	53.3 <i>11.9</i>	49.7 <i>11.3</i>	40.2 <i>8.6</i>
Other DOE Assistant Secretarial Offices	7.2 <i>1.6</i>	4.0 <i>0.9</i>	4.3 <i>0.9</i>
Work for Other DOE Contractors	25.5 <i>5.7</i>	27.0 <i>6.1</i>	25.0 <i>6.4</i>
Work for Sponsors Other than DOE	64.3 <i>14.4</i>	75.0 <i>17.1</i>	67.2 <i>14.4</i>
Total Laboratory Operating Funding	459.6	451.8	469.9

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 1997. 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 1997 are included in the programmatic resource projections accompanying this *Institutional Plan*. However, resources required for initiatives in years beyond FY 1997 are generally not included in those projections. Projected resource requirements for the initiatives include costs associated with protection of the environment and the health and safety of workers and the public.

The Laboratory 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:

- APS Beamlines
- IPNS Enhancement
- Mechanistic Biology
- Advanced Transportation Technology
- Industries of the Future
- Nuclear Energy Security
- Mixed Waste Treatment and Waste Form Development
- D&D Technology Center

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

A. Center for Computational Science and Technology

Argonne has established as a major initiative a Center for Computational Science and Technology (CCST), which focuses on two major elements: (1) establishment of a major new computing facility supporting computational science and integrated collaborative research and (2) R&D to build, integrate, and use the core technology required for distributed computational science and technology.

The CCST will provide a major DOE resource for high-performance computing and infrastructure to support remote electronic collaboration and use of large-scale experimental facilities. Technologies to be developed will enable a new generation of computational science applications that couple massive computations with immersive visualization. At the same time, these technologies will increase the productivity of researchers, particularly by enabling diverse teams to collaborate via high-speed networks without time-consuming travel.

Argonne is the ideal home for such a center. Following its successful creation in 1984 of the Advanced Computing Research Facility, followed

- Center for Computational Science and Technology
- Exotic Beam Facility

by establishment in 1993 of the High-Performance Computing Research Facility to support computational science and engineering, the Laboratory has become a recognized leader in advanced computer technology. In mid 1994 Argonne organized the Computing and Communications Infrastructure Futures Laboratory, installed one of the nation's first Cave Automated Virtual Environments (CAVEs), and demonstrated the CAVE's use in significant scientific and industrial applications.

The large-scale computing facilities supporting the CCST and its users will comprise four major components:

- *Several-hundred-gigaflop parallel compute server*, providing the core computing power for underlying computational science problems
- *Scalable input/output and mass storage facility*, providing a high-capacity, high-bandwidth storage subsystem
- *Immersive virtual-reality environment*, enabling real-time immersive graphics displays
- *Digital media server*, enabling multiple, simultaneous, multimedia data streams (such as video and audio)

The new center will build on specific knowledge gained at Argonne during the past several years and on the latest technology emerging from vendors.

Argonne is also playing a lead role in the exploration of advanced communications technologies, another area essential for implementing an electronic, distributed, collaborative research environment. The Laboratory is providing national leadership for the use of local and wide-area high-speed/high-bandwidth networking. Noteworthy examples are (1) the I-WAY (Information Wide Area Year) project, which focuses on mechanisms to link supercomputers and advanced visualization environments via asynchronous transfer mode, and (2) the LabSpace project, which is exploring electronic virtual laboratories to support remote operation and control of scientific experiments.

The CCST research programs addressing collaborative technologies will include topics such as

- Shared immersive virtual reality linked to supercomputers;
- Desktop-based collaborative environments;
- Multimedia, wide-area, and mass storage server environments;
- High-performance, secure, distributed computing tools; and
- Advanced networking R&D.

As successor to the High-Performance Computing Research Facility, the CCST will build on Argonne's successful program of research on high-performance computing and communications. The CCST projects will often involve cooperation among industrial partners; vendors; R&D programs at DOE laboratories; and large-scale, unique experimental user facilities, such as the Advanced Photon Source (APS).

Computational science and engineering programs using the CCST facility are expected to include

- Materials sciences;
- Chemistry, biology, and physics;
- Fluid dynamics and mechanics;
- Engineering mechanics and dynamics; and
- Large-scale optimization.

An important component of the new center is strong collaboration with leading computing centers (such as the National Center for Supercomputer Applications), national laboratories, and universities. Collaborators will complement Argonne's expertise in networking, visualization, and other advanced systems and will work jointly on computational science and computer science projects.

The CCST will require steady-state annual funding of \$12 million. (See Table IV.1.) This support will have high impact because of very strong interactions with other Argonne capabilities

and activities, particularly the CAVE, the IBM Scalable POWERparallel system, and the LabSpace project. Support will be sought from DOE, the Advanced Research Projects Agency, and vendors such as IBM. No major activities or costs related to the National Environmental Policy Act (NEPA) are anticipated.

Table IV.1 Center for Computational Science and Technology (\$ in millions BA; personnel in FTE)

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	2.5	4.0	4.0	4.0	4.0	4.0	4.0
Capital Equipment	4.0	8.0	8.0	8.0	8.0	8.0	8.0
Construction	-	-	-	-	-	-	-
Total	6.5	12.0	12.0	12.0	12.0	12.0	12.0
Direct Personnel	10.0	20.0	20.0	20.0	20.0	20.0	20.0

B. 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.2. Funding is being sought from the Nuclear Physics (KB-02) program. No major NEPA-related activities or costs are anticipated.

Table IV.2 Exotic Beam Facility
(\$ in millions BA; personnel in FTE)

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	0.1	0.5	1.0	1.7	2.7	6.4	14.5
Capital Equipment	-	-	-	-	3.3	5.6	3.0
Construction	-	-	-	56.0	79.2	24.2	-
Total	0.1	0.5	1.0	57.7	85.2	36.2	17.5
Direct Personnel	0.5	2.0	4.0	7.0	10.0	25.0	50.0

C. APS Beamlines

Fourteen sectors at the APS remain available to be developed for future user research programs. DOE and Argonne give high priority to using this capacity fully and effectively. Four of the 14 sectors have recently 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 protein crystallography beamline focusing on the relationship between structure and function; and a broad-based imaging beamline for applications in medicine, archeology, and materials science. Argonne seeks funding for construction of the undulators and beamline front ends for these four sectors.

Use of the APS will be optimal only when the facility's final ten sectors are fully installed and ready for user service. Argonne is working with DOE to plan development of the ten sectors. The specific technical applications for these beamlines have not yet been decided. The strategy for developing the final ten 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; archeology and archeometallurgy; 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. IPNS Enhancement

Argonne's Intense Pulsed Neutron Source (IPNS) continues to host the most cost-effective user program among DOE's neutron sources, a user program comparable to the best in the world. In FY 1996 more than 200 scientists came to the IPNS to perform approximately 320 experiments. Additional funds provided by the Scientific Facilities Initiative, now part of the IPNS funding base, have permitted significant increases in support for users and a doubling of the amount of instrument time available to users.

Long-term plans for the IPNS feature — in addition to continuing operation as a highly productive scientific user facility — development of new instruments for use at the IPNS and at the National Spallation Neutron Source (NSNS) currently being designed at Oak Ridge National Laboratory (ORNL). Under the IPNS Enhancement initiative, submitted to DOE in mid FY 1997, Argonne proposes to improve existing instruments significantly over a period of one to three years. For a total cost of \$6.3 million, the capabilities of most instruments will be more than doubled, and, in addition, a second-generation microvolt spectrometer will be constructed. Argonne is also investigating modest enhancements of the IPNS accelerator, target, and moderator, with the objective of increasing neutron production by 30% to 50%. An additional \$3.8 million of new funding is requested from DOE; the balance of \$2.5 million will come from operating and equipment funds.

On the basis of their long experience and demonstrated capabilities in developing instrumentation, IPNS personnel have been assigned the lead role in plans for developing NSNS instrumentation. The conceptual design report for

the NSNS, scheduled for review at ORNL on June 23-26, 1997, specifies that Argonne will be responsible for designing and constructing instruments and that many of the instruments and instrument components will be developed as prototypes at Argonne, tested on IPNS beamlines, and later constructed at IPNS for delivery to NSNS.

The process of building and using prototype instruments at the IPNS is expected to broaden and strengthen the community of scientific and technical users for the NSNS. IPNS will hold workshops with potential users of neutron scattering from a broad technical community, from such fields as structural biology, materials engineering, and geoscience, in addition to the more traditional fields of condensed-matter physics, materials science, and chemistry. These scientific workshops will aim to identify and foster valuable applications for neutron scattering and to define specifications for NSNS instrumentation.

E. 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 better understand disease processes and basic biochemical mechanisms.

Argonne's Mechanistic Biology initiative comprises three major programs: (1) Computational Biology (based on the application of high-performance computing methods to support the analysis, modeling, and display of molecular structure-function relationships); (2) the Structural Biology Center (SBC) and related basic research in protein crystallography; and (3) Human Genome Sequencing (including basic research on the physical and chemical properties of nucleic acids; research, development, and application of high-throughput, cost-effective technology for

genetic sequencing; and the study of gene expression). These elements and their relationships are described briefly below. Funding for these programs from the DOE Office of Health and Environmental Research (OHER) is expected to be augmented by other sources, starting in FY 1998. Table IV.3 summarizes total resource requirements for the three component programs, including non-OHER support.

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

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	5.7	7.1	7.4	7.4	7.4	7.4	7.4
Capital Equipment	0.3	0.6	0.6	0.6	0.6	0.6	0.6
Construction	-	-	-	-	-	-	-
Total	6.0	7.7	8.0	8.0	8.0	8.0	8.0
Direct Personnel	29.6	32.0	33.0	33.0	33.0	33.0	33.0

^aResource projections include support for the operation of the Structural Biology Center user facility. Starting in FY 1998, estimates include new funding from sources beyond DOE-OHER.

Computational Biology. Argonne's Computational Biology program investigates relationships between sequence, structure, and function in biological macromolecules. Innovative techniques are being developed to establish reliable correlations between nucleic acid or amino acid sequences and the corresponding structures and functions of proteins. Information on protein structures from theory and experiment will be analyzed by using massively parallel computing and novel mathematical models.

The Computational Biology program is also developing new methods for studying the reaction mechanisms of enzymes, in order to analyze more effectively the recognition and catalytic properties of molecules. These studies will provide the basis for progress in areas such as protein folding and design, the relationship of gene sequences to structural components and the functional role of proteins, molecular recognition and drug design, and enzyme catalysis through enzyme engineering.

Computational Biology activities complement and interface with the SBC and the Human Genome program (and also with the Laboratory's

Center for Computational Science and Technology initiative) by providing high-performance computing capabilities and methods that facilitate the extensive data reduction and modeling needed by the other two programs.

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 research, combined with structure-function information from the Computational Biology program 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 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. A parallel sequencing research effort involves a technique called "modular primer walking," which eliminates the need for the synthesis step required in conventional sequencing. The SHOM and modular primer walking techniques promise 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 is establishing new collaborations to apply these techniques in genome-sequencing projects. Opportunities to develop a SHOM research collaboration with one or more industrial partners are also being explored. When it is fully developed, Argonne's microchip technology is expected to have substantial commercial value. The technology is expected 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.

Argonne's R&D on the Human Genome Sequencing component of this initiative will be supported by computational algorithms and analytical methods developed by the Computational Biology component and will contribute information on gene sequences to studies of biomolecular structure-function relationships.

F. Advanced Transportation Technology

Argonne proposes to expand its current research, development, and analysis of advanced transportation technologies for DOE and other federal agencies by establishing a Center for

Advanced Transportation Technology. 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 and reduce the environmental emissions from advanced transportation systems. The initiative comprises three major activities: (1) automobile research, conducted as part of the national Partnership for a New Generation of Vehicles (PNGV); (2) research on heavy-vehicle technology, involving the national laboratories and truck manufacturers; and (3) intelligent transportation systems (ITS). These three areas encompass research on advanced diesel engines, energy storage devices, hybrid vehicles, fuel cells, supercomputing, vehicle recycling, railroad systems, and ITS sensor and data processing technology. Each of these research areas is described briefly below.

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 (NO_x) and particulate matter remains a key technical hurdle, especially as emissions regulations become tighter. Building on its R&D on diesel engines for trucks and locomotives, Argonne has a prominent role in research on the compression-ignition, direct-injected engine, to help PNGV meet its goals. Argonne also has a CRADA with the Association of American Railroads (AAR) to investigate the potential for reducing locomotive emissions through oxygen enrichment. A work-for-others agreement with the Electro-Motive Division (EMD) of General Motors involves researching, designing, and developing subsystems, components, fuel systems, and emission controls for EMD's new generation of locomotive diesel engines. In another project, Caterpillar is supporting an exploration of the potential of a NO_x control device developed by the Laboratory.

Energy Storage Devices. Battery-powered electric vehicles represent a zero-emission alternative to the internal combustion engine. The market for these 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, a

partnership with DOE and the Electric Power Research Institute, to develop advanced batteries for electric vehicles. In 1996, DOE and the domestic automakers signed a four-year extension of the agreement. Under the partnership, Argonne is participating in a team with 3M and Hydro-Quebec to develop a lithium-polymer battery and to test nickel-metal hydride batteries produced by various American manufacturers. Argonne also is working with industry to develop lithium-ion consumer electronics 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. In support of DOE's program to develop hybrid propulsion systems, Argonne is conducting R&D on high-power batteries and undertaking an initiative to develop galvanic ultracapacitors (which, unlike conventional capacitors, can provide much greater energy density while retaining high-power capability). In addition, Argonne is modeling components and simulating 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%. Through the PNGV, government and industry are developing fuel cells for a car potentially capable of 80 miles per gallon. 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 a quick-starting, fast-responding, catalyzed partial-oxidation reformer that converts methanol fuel to a mixture of hydrogen and carbon dioxide appropriate for proton-exchange-membrane fuel cells. The Laboratory is also working to extend this concept

to other fuels, to allow flexibility in the choice of fuels. For PNGV, Argonne also provides fuel cell modeling and system analysis. A fuel cell test facility to be completed in 1997 will independently evaluate fuel cells developed by others under the DOE program.

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 Big Three 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. Reduced time to market should make the U.S. manufacturers more competitive internationally. The focus will be on leading-edge computing systems, such as massively parallel supercomputers; advanced computational engineering software for fluid dynamics and structural mechanics; and rapidly evolving visualization techniques, such as virtual reality.

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 CRADA with the Vehicle Recycling Partnership (involving Ford, General Motors, and Chrysler) and the American Plastics Council, Argonne will be developing technologies for processing waste streams that result from recycling obsolete cars, 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 AAR to help the freight railroad industry address these

needs. In a pilot program with AAR, Argonne is currently studying oxygen-enriched combustion. The Laboratory is also serving as DOE's technical lead in a cooperative government-industry maglev research program. In other work, the Laboratory is continuing to develop and validate computational codes and build small-scale experimental facilities to help the government evaluate and test alternative electromagnetic propulsion systems.

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. Argonne currently participates in the Chicago-based ADVANCE ITS project, the nation's largest demonstration of an intelligent transportation system, and in the activities of the Gary-Chicago-Milwaukee ITS Priority Corridor.

Funding for this research is sought from DOE-Laboratory Technology Research (KU), 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)

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	14.4	17.8	21.4	25.4	28.4	29.0	29.0
Capital Equipment	0.9	1.4	1.9	2.3	2.3	2.3	2.3
Construction	-	-	-	-	-	-	-
Total	15.3	19.2	23.3	27.7	30.7	31.3	31.3
Direct Personnel	72.0	83.0	92.0	102.0	110.0	110.0	110.0

G. 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 proposes a concerted initiative targeting the energy-intensive industries that will conduct research to improve energy efficiency, increase resource recovery and reuse, and generally 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. The 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 two years, the chemicals industry has developed a vision, *Vision 2020*, 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 roadmap development through participation in the CCR process. Particularly relevant 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, and plasma chemical processing. Argonne has achieved a preeminent position in the development of processes to recover and separate high-value plastics from obsolete appliances, auto shredder residue, and post-consumer wastes. The Laboratory has designed and is pilot testing a continuous-cleaning and -drying apparatus for recovered foam. Under construction and scheduled for testing in FY 1997 is a continuous pilot process for separating acrylonitrile-butadiene-styrene (ABS) plastics from high-impact polystyrene (HIPS) with better than 99% efficiency.

In collaboration with Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), National Renewable Energy Laboratory (NREL), and Idaho National Engineering and Environmental Laboratory, Argonne is developing improved processes to convert bio-based materials into chemicals and precursor chemicals that can displace petroleum-derived feedstocks. Argonne has developed a new genetic strain of bacteria that produces succinic acid (a desirable chemical intermediate) at higher concentrations and speed than were previously achieved. Argonne, ORNL, PNNL, and NREL have signed a CRADA with a private company to commercialize this technology. Argonne also has several CRADAs and other agreements with private companies to develop the production of "green solvents" from bio-based high-starch raw materials. Under the proposed initiative, Argonne will work on high-priority problems identified by the industry's vision and roadmap.

Petroleum Refining Industry. Argonne has played a key role in developing a vision for the petroleum refining industry, particularly 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 has helped to organize and lead a "virtual laboratory" for petroleum refining; altogether, 12 national laboratories are cooperating to identify areas of expertise and capabilities that will be valuable for the industry.

Argonne is working with UOP and Chevron to develop an advanced fluid catalytic cracker

designed for the feedstocks that refineries will face in the near future. Rapid commercialization is expected.

To address the critical problem of fouling in refinery operations, Argonne is working with several refiners to test the fouling characteristics of real-world refinery streams; Argonne designed and assembled and is now operating fouling monitors in multiple industrial settings. Argonne is also working on the upgrading of heavy oils, through programs investigating the catalytic conversion of California crudes, the upgrading of residuum, and the use of fluidized beds. Under the proposed initiative, the Laboratory plans to apply its expertise in catalytic, process engineering, and computational fluid dynamics modeling, in collaboration with industry, to address this key problem.

Forest Products Industry. The American Forest and Paper Association (AF&PA) 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.

In collaboration with the Institute of Paper Science and Technology, Argonne is developing an electrodialysis process for removing non-process elements from bleach plant filtrates, so that water can be recycled after bleaching rather than being used once and discharged to a stream. With three other national laboratories, Argonne is also involved in a program to develop optical sensors for continuous measurement of the paper web during paper making. In partnership with the University of Maine and an industrial partner, the Laboratory is working to apply intelligent control systems in the pulp and paper industries, exploiting technology developed earlier for DOE's nuclear reactor program.

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 to develop standardized contract language for cooperative programs involving government

laboratories and the steel industry. The agreement is to be broadened in coming months for nonferrous metals industries such as aluminum.

In partnership with Metals Recovery Industries, Inc., Argonne has already developed a process for dezincing galvanized steel. Operations are underway at a pilot plant with annual capacity of 50,000 tons, and establishment of the first commercial demonstration plant is being negotiated.

Secondary aluminum smelters generate salt cake that contains metal, oxides, and salt. If it is not recycled, the salt cake must be deposited as waste in landfills at substantial cost. Argonne is working with aluminum industry associations to develop separation processes and markets for the materials recovered from salt cake, including aluminum and raw materials for production of insulation and firebrick.

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.

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

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	9.3	10.1	11.7	12.4	13.4	13.7	14.0
Capital Equipment	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Construction	-	-	-	-	-	-	-
Total	9.4	10.3	11.9	12.6	13.6	13.9	14.2
Direct Personnel	40.0	46.0	50.0	52.0	53.0	53.0	53.0

H. Nuclear Energy Security

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 will be terminated after 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 108 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. 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 Chernobyl sarcophagus and 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

To achieve these goals Argonne proposes an initial research program, based on INSC, which focuses on key light-water reactor technologies. The following four 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 fuel costs.

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

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

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	7.0	10.5	14.5	14.5	14.5	14.5	14.5
Capital Equipment	-	0.5	0.5	0.5	0.5	0.5	0.5
Construction	-	-	-	-	-	-	-
Total	7.0	11.0	15.0	15.0	15.0	15.0	15.0
Direct Personnel	30.0	45.0	60.0	60.0	60.0	60.0	60.0

I. 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 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 Research and Development (AF), and DOD.

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

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	10.0	12.0	12.0	15.0	18.0	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	18.0
Direct Personnel	40.0	46.0	46.0	60.0	72.0	72.0	72.0

J. D&D Technology Center

The decontamination and decommissioning (D&D) of surplus nuclear facilities — such as nuclear reactors, hot cells, and accelerators — represent a major challenge for DOE, the commercial nuclear industry, and other owners of nuclear facilities. Deregulation of the U.S. electric power industry is bringing D&D to the forefront in economic planning by commercial utilities because of the major liabilities associated with surplus nuclear facilities. In recognition of the magnitude of these problems, Argonne plans to establish a D&D Technology Center to address the needs of DOE, commercial utilities, Nuclear Regulatory Commission licensees, the international community, technology developers, and D&D-integrating contractors. The primary customer will be DOE. Building on current Argonne capabilities, the Center will focus on four D&D areas: operations, technology, technical services, and education.

Operations. Argonne's operations group is responsible for the safe and efficient D&D of surplus nuclear and radiological facilities on the Argonne-East site. In addition to research reactors, these shutdown facilities include nuclear support facilities such as accelerators, hot cells, glove boxes, and waste-handling and storage facilities. D&D for Argonne-East is estimated to be a \$75-80 million program that will take approximately ten years to complete. By the end of FY 1997, 5 of 12 identified projects will have been completed. The 5 completions include 2 research reactors, a spent-fuel examination hot-cell facility, a plutonium glove box facility, and an accelerator facility. These completions, constituting approximately 60% of the total program scope, have helped to create an experienced, highly qualified group of D&D specialists. In addition to completing D&D work at Argonne-East, this group embodies knowledge that will be very valuable beyond Argonne, in the areas of needs assessments, baseline technology evaluations, and field execution.

Technology. Argonne is uniquely positioned to provide valuable services to the DOE complex and the commercial nuclear industry on the basis of its extensive experience gained through on-site operations and the CP-5 Large Scale

Demonstration Project. This experience will be particularly valuable as a guide to the Laboratory's development of innovative new D&D technologies and methodologies and as a means of evaluating those innovations. The goal is to take full advantage of Argonne's strong background in many relevant areas of R&D and the opportunity to demonstrate and deploy the D&D innovations, in order to create a highly integrated process of developing, using, evaluating, and improving D&D that is more productive than fragmented operations at multiple sites. All organizations involved in D&D, including the private sector, will benefit.

Services. Work in technical services at the Center will continue to be based on the development and application of improved risk-based approaches to cleanup and release criteria, regulatory standards, and transportation guidelines for the shipment of radiological wastes generated by D&D. The Center will further refine cost engineering methods for D&D through model development and validation. These refinements will allow much more accurate determinations of the liabilities associated with pending D&D, for the commercial sector as well as for DOE, and will allow identification of opportunities for large savings. More generally, on the basis of its strong foundation in operations and technology, the Center will be well positioned to participate in D&D planning throughout the DOE complex and beyond. Up-to-date knowledge of the full range of applicable D&D technologies will enable the Center to guide the selection and deployment of proven new technologies that reduce costs, shorten schedules, and improve safety. The Center will also specialize in the development and application of cost-effective characterization techniques for identifying the operational and environmental hazards associated with a D&D project, allowing more accurate planning and cost estimation at the project's inception. The Center's expertise in operations and in risk and safety analyses will be used to aid the development of ES&H standards for D&D projects.

Education. Under almost any plausible scenario, the growth in D&D within the DOE complex and the commercial sector will be significant. To help participants cope with this growth, the Center will conduct a variety of education programs and activities. D&D

workshops and courses sponsored by DOE, IAEA (the International Atomic Energy Agency), and other customers will be presented by the Center to educate planners, project managers, engineers, regulators, and other stakeholders. An active exchange program will stimulate new ideas and their beneficial application.

Resources required for this initiative are summarized in Table IV.8. Funding will be sought from DOE-Environmental Management (EW/EX), DOE-Nuclear Energy Research (AF), selected U.S. utilities, and international sponsors.

Table IV.8 D&D Technology Center
(\$ in millions BA; personnel in FTE)

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
Costs							
Operating	4.5	6.0	7.0	7.5	8.0	8.0	8.0
Capital Equipment	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Construction	-	-	-	-	-	-	-
Total	5.0	7.0	8.0	8.5	9.0	9.0	9.0
Direct Personnel	24.0	28.0	32.0	35.0	38.0	38.0	38.0

K. 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 Supplement 1.

Table IV.9 Programmatic Initiatives

Initiative	DOE Program	Page ^a
Energy Research		
Argonne National Atmospheric Observatory	KP-02	9
ATLAS Detector at the LHC	KA-04	11
MINOS Long-Baseline Detector	KA-04	12
Fundamental Chemistry of Radioactive Waste	KC-03	20
Linear Accelerator Upgrade — Ultrafast-Pulse Radiolysis Facility	KC-03	21
Fossil Energy		
Ion Transport Membranes for Production of Synthesis Gas from Natural Gas	AB-05	33
Environment, Safety, and Health		
Assessment and Management of Risk	HC, HD, EW, EX	41

^aSee Supplement 1.

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 are envisioned 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.
- Manage the recruitment, development, and support of the Laboratory's human resources.
- 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 new incentivized, performance-based contract between DOE and the University of Chicago for the management and operation of Argonne 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 has embarked on 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 work force. The Laboratory is developing a new program to integrate employee performance evaluation with a performance-based compensation system. Employee interactions and feedback are being facilitated through new human resources information systems and a broad-based employee opinion survey that will be implemented in FY 1997. Planning for human resources is discussed further in Section V.A.

Effective environmental stewardship and safety and health management are overriding priorities for Argonne. The Laboratory is pursuing continuous improvement in these areas through organizational realignment, new policies and procedures, and enhanced training for operating personnel. Current strategies to increase the effectiveness of ES&H management and improve performance involve moving toward regulation of worker safety under OSHA (the Occupational Safety and Health Administration), strengthening the implementation of an Integrated Safety Management program as part of the Laboratory's work processes, and implementation of a five-year site environmental cleanup plan. Recent successes include shutting down landfill operations, accessing Lake Michigan water, eliminating the burning of high-sulfur coal, progress on a portfolio of major environmental remediation projects, and a partnership with DuPont Corporation to train supervisors in improving worker safety practices. Planning for ES&H is discussed further in Section V.B.

Continuing Laboratory goals are the efficient use and maintenance of an aging physical plant and the provision of efficient new physical structures to accommodate new programs. The last decade has seen construction of the Advanced Photon Source and removal from service of substandard and temporary buildings, as well as significant site enhancement and continuing modernization and life extension for programmatic buildings. Beginning operation in 1997 are a new water supply, new waste treatment facilities, and a new Argonne Science and Technology 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. Strategies are being developed 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.

Argonne exploits state-of-the-art technologies to enhance the efficiency of its information infrastructure for both programmatic and business functions. Among notable recent developments is the Laboratory's move to a distributed computing environment with high-speed networks that support rapidly expanding desktop computing resources. Recently developed administrative systems on client-server platforms achieve improved work flows and productivity through greater access to information on the network. Increasingly, Argonne's strategies for information management focus on interoperability and information sharing through use of an information architecture based on commercially available software and industry standards. The Laboratory is rapidly expanding its repositories of electronic information and its use of electronic communications. Planning for information management is discussed further in Section V.D.

A variety of 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 the Laboratory's initiatives in quality management. Communications and outreach strategies are in place to enhance openness, mutual understanding, and trust among Argonne, DOE, and their stakeholders.

Formation of Partnership 2000, a collaboration of senior managers for Argonne and DOE-Chicago Operations, is a strategic initiative for improving business and operations practices through enhanced communication and interaction. A recently organized Community Leaders Roundtable is strengthening relations with stakeholders from neighboring areas. DOE's move to a performance-based contract with the University of Chicago for operation of Argonne

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 work force 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. The HR staff understand the complexity and legal implications of federal and state legislation and provide special training for Laboratory managers when required.

In June 1995 the University of Chicago signed a new contract to operate Argonne for DOE. The contract includes a Total Compensation Cost Containment Pilot Program, under which the Laboratory has greater flexibility to establish pay and benefits for its employees, and DOE oversight is to be less restrictive. Each year the Laboratory is obligated to reduce compensation levels by at least 1% of actual compensation in the prior year. Successful attainment of this obligation allows distribution of payments from an employee bonus pool.

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. The performance-based contract under which the Laboratory now operates has created the opportunity to establish incentive compensation on the basis of attainment of specified performance goals. To seize this opportunity, the Laboratory is revising its performance management system to

- Incorporate best practices,
- Identify exceptional contributions, and
- Identify high-potential employees.

All components of compensation — base pay, merit increases, incentive compensation (bonuses), and promotion-related increases — 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.

Driven by the new prime contract for operation of Argonne by the University of Chicago, containing employee compensation costs has become a key element of HR management strategy. The Laboratory has taken an aggressive front-end-loaded approach toward meeting cost containment goals. Significant changes in retirement incentives, leave policies, and various fringe benefits were implemented during FY 1996 to achieve savings that will carry forward toward meeting goals in FY 1997 and beyond.

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 new 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 work force, 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 *ad hoc* meetings 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. An extensive reassessment of professional development and other training needs of employees will be undertaken. Training on the subject of employee relations, especially the many laws affecting the employee-employer relationship, is underway. To further support employee performance development, the Laboratory is considering a mentoring program under which younger 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 plans to take 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. To publicize its commitment in these areas, the Laboratory will seek recognition as one of "America's Healthiest Companies" from 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.

B. Environment, Safety, and Health

Situation

In recent years, DOE has strongly emphasized programs in the area of ES&H. Current health and safety statistics indicate that Argonne is a safe place to work, among the best of DOE's research facilities. Argonne integrates responsibility for ES&H planning into all Laboratory activities.

Under the new performance-based contract between DOE and the University of Chicago for operation of Argonne, the Laboratory is required to conduct a self-assessment of its performance in ES&H. The self-assessment focuses primarily on performance measures, but consideration is given also to significant accomplishments, opportunities for improvement, and actions taken. In FY 1996, DOE's assessment of the Laboratory's overall performance in ES&H agreed with the Laboratory's self-assessment, resulting in an overall rating of "excellent," the second highest category achievable.

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, reactor sites and hot-

cell facilities are being decontaminated and decommissioned as part of a systematic program to deal with formerly used radiological facilities. Nuclear materials have been removed from the Experimental Breeder Reactor-II, the Experimental Boiling Water Reactor, the JANUS reactor, and below-grade storage area 317; nuclear materials have been largely removed from several hot cells in Building 200.

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 the Comprehensive Environmental Response, Compensation, and Liability Act, the Resource Conservation and Recovery Act, and the Hazardous Waste Management Act. Environmental monitoring improvements have been made, and a remedial action baseline risk assessment is being developed to establish final characterization requirements for environmental remediation activities at the site. A sodium treatment facility has begun operation.

Goals

In the area of safety, Argonne's goal is nothing less than continuous pursuit of the objective of zero injuries. Goals for health and the environment are defined similarly: pursuit of zero adverse impacts. These goals are to be pursued through the effective integration of safety management principles and functions into the Laboratory's work processes and through the active, knowledgeable, and mutually supportive participation of every individual on-site.

Strategies

An important component of Argonne's ES&H program is monitoring progress toward excellence in ES&H performance by using pertinent indicators in addition to 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 are at least above the performance levels achieved by other DOE contractors.

External Regulation. Argonne's commitment to continued improvement in ES&H performance was highlighted when the Laboratory volunteered in FY 1996 for a pilot exercise with the Occupational Safety and Health Administration (OSHA), designed as input to DOE's planning for a possible transition to external regulation of the Department's facilities. The pilot, which consisted of program evaluation and some limited inspection by OSHA, featured development of a performance evaluation profile. The resulting profile rating indicated that the safety program at Argonne-East would qualify for partnership status with OSHA. The Laboratory plans to pursue with DOE the options that may be available in that context.

DOE has stated its intention, in line with the recommendations of an independent review of DOE's regulatory structure and practices by the National Academy of Public Administration, to transfer occupational safety regulation at DOE facilities from DOE to OSHA. This strategy is based in part on the OSHA pilot exercise discussed above, which generally concluded that the hazards at a laboratory such as Argonne-East are typical of hazards already regulated by OSHA. Accordingly, the Laboratory is planning a detailed review and assessment of the upgrades to its physical plant that would be necessary to meet OSHA requirements fully. The only upgrades identified to date that may require budgetary adjustment involve fire protection (life-safety egress, alarm systems, sprinklers, etc.). The Laboratory is discussing with DOE the legal and contractual implications of a transition to OSHA regulation. As DOE and OSHA plans become better defined, Argonne will prepare a detailed transition plan.

Other ES&H Issues. Argonne is continuing to streamline and improve its safety and health training programs, particularly through establishment of training that is computer based and "just in time." Argonne also continues to work toward minimizing the number of its nuclear facilities and thereby reducing associated regulatory costs.

DOE-Environmental Management. At Argonne-East, waste management initiatives include new facilities to meet current requirements for handling and storing wastes, upgrading water treatment facilities to ensure compliance with the NPDES (National Pollutant Discharge Elimination System) permit and other regulations, and implementing a waste minimization and pollution prevention program. Argonne has prepared a proposed site treatment plan for mixed wastes, as required by the Federal Facilities Compliance Act.

Decontamination and decommissioning (D&D) of the CP-5 project is achieving remediation of a large-scale "environmental legacy" facility at Argonne-East. The remediation, DOE's first large-scale demonstration project for new D&D technologies, is being performed in concert with industry. D&D of the JANUS reactor in Building 202 began in January 1997 and is expected to be completed in FY 1997. D&D of the Experimental Boiling Water Reactor was completed in February 1996, and the facility has been converted for interim storage of transuranic waste.

In addition to new wastewater systems and waste storage capabilities, Argonne is undertaking three initiatives that support the strategic goals of DOE-Environmental Management.

- *Five-Year Cleanup Plan for Argonne-East.* Argonne has prepared a plan to complete both remediation and D&D for remaining release sites in Illinois by FY 2001, at a cost of \$57 million. Relative to the previous baseline estimate, this plan saves nearly \$100 million and reduces the project's duration from ten years to five years. If the plan is funded at requested levels, Argonne-East would be the first major multiprogram laboratory site to complete its environmental restoration program.
- *Field Characterization for Waste Area Group 9.* The U.S. Environmental Protection Agency, the state of Idaho, and DOE have agreed on a conceptual schedule for accelerating the comprehensive remedial investigation and feasibility study for Waste Area Group 9 at Argonne-West. This approach will significantly reduce the cost and

duration of the project. In operational units 9-01, 9-03, and 9-04, the Laboratory is performing field characterization in preparation for environmental cleanup. This characterization is the first major activity aimed at improving the speed and cost of the remedial investigation and feasibility study for Waste Area Group 9. Argonne plans to pursue a remedial investigation work plan that was developed in FY 1996, in order to fill gaps remaining after earlier sampling and information gathering.

- *Waste Sodium Facility.* At Argonne-West, a major facility for pacifying surplus and waste sodium, including radioactive sodium, is being put into operation. The facility's first campaign will be to pacify and prepare for disposal sodium that has been in storage since the Fermi-I reactor was shut down some three decades ago.

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 the Idaho National Engineering and Environmental Laboratory, about 35 miles west of Idaho Falls, Idaho, is devoted mainly to R&D on nuclear technologies and nuclear environmental management.

Argonne-East contains over 4.7 million square feet of floor space, which includes 94,000 square feet of leased external commercial space. The estimated current plant replacement value is approximately \$1.6 billion. Argonne-West contains 407,000 square feet of floor space, with an estimated replacement value of \$355 million. Space at Argonne-East, which accommodates roughly 6,100 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 needs, 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 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, eliminate substandard facilities, and 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.

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, to increase ES&H acceptability, to save energy, and to replace obsolete building systems that require excessive maintenance.

Argonne-East uses a Condition Assessment Survey to evaluate the baseline condition of all facilities regularly and employs 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 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 (GPP), General Plant Equipment (GPE), Multiprogram Energy Laboratory — Facilities Support (MEL-FS), and Environmental Management (EM). This funding allows the Laboratory to address its most urgent needs to upgrade its physical plant, meet environmental standards, and decontaminate facilities. Particularly needed are additional funds for general purpose equipment and plant rehabilitation, 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. Acceptance of DOE's proposal that Congress appropriate complete funding for major construction projects at initiation could reduce the inefficiencies caused by funding inflexibility.

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 efficiency and conservation are priorities; a number of strategies are being pursued to further reduce energy consumption and associated costs, including energy savings performance contracting.

Argonne-East plans replacement facilities to increase the efficiency of its receiving, storage, distribution, and shipping of materials and goods, for both intra-site shipments and those crossing the Laboratory's boundaries, and also to facilitate the 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 these activities and the associated infrastructure, they are supported as part of research programs or through Laboratory indirect funds. Information is managed at Argonne both as an integral aspect of each research program and as an institutional resource.

Within each research program at Argonne, scientific and technical information is acquired, created, and communicated in a customized fashion fitted to the objectives of the programs. This decentralized approach recognizes that the life cycle management of programmatic information must be tightly interwoven with the underlying research in order to meet fully the expectations of the Laboratory's sponsors. Laboratory programs are also major users of scientific and technical information generated elsewhere, as well as users of internal administrative data relating to the Laboratory's business operations. Effective information management is also crucial for support organizations.

Argonne provides publication support services for both paper and electronic distribution of R&D and operational information. Central service organizations also implement and operate Laboratory-wide electronic information infrastructures via a spectrum of systems and services for systems analysis, telecommunications, and computing.

Argonne maintains policy and planning bodies and an information technology infrastructure dedicated to achieving cost-effective information management to meet programmatic and operational goals. Strategic planning, funding, and coordinated management for the Laboratory's information infrastructure and systems are addressed collaboratively by review and implementation teams. An *Administrative Computing Strategic Plan* is published annually.

Argonne participates in national initiatives in networking and telecommunications through leadership and collaboration on 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), CICNet (a midwestern regional network), and MREN (a high-speed test network in the Chicago metropolitan area). These external networks interface with local Argonne networks via ATM (asynchronous transfer mode), FDDI (fiber distributed data interface) firewall, and on-site Ethernet firewall networks, positioning 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 be designed and operated to support excellence and efficiency in the Laboratory's R&D programs and operations, by providing for efficient exchange of text, data, video, sound, and graphics. 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 fully the potential of the Laboratory's state-of-the-art information systems.

Goals

The overarching 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 goals that evolved in the strategic planning process call for Laboratory operations organizations to

- Maintain a state-of-the-art, standards-based communications and computer networking infrastructure, and also coordinate services that support internal as well as external information exchange;
- Conduct education programs that upgrade the computer literacy and skills of Laboratory employees;
- Maintain strong core competencies in emerging information technologies that enable timely and efficient deployment of the systems needed to meet mission-critical needs; and
- Explore the application of emerging information technologies through aggressive use of demonstrations and pilot projects.

Strategies

Argonne's near-term strategies for information management focus on two primary issues: (1) the need for secure, high-performance telecommunications and networking infrastructure and (2) the need for high-performance information management 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 total 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. 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, to assure compatibility and maximum flexibility in meeting future needs. Included in these plans is the eventual replacement of the Laboratory's central telephone switch by merging its functionality with the advanced network switching technologies being deployed to address overall telecommunications needs in an integrated way, a trend already apparent in the commercial communications industry.

Argonne-East's networking facilities include a 100-megabit-per-second FDDI backbone operating on a fiber-optic cable plant. Argonne has identified the FDDI and ATM standards as an important basis for future high-speed sitewide networks. The current cable plant will allow deployment of these standard technologies to support bandwidths into the gigabit-per-second range through use of SONET. Test beds based on appropriate standards, already in place at the Laboratory, ensure interoperability for Argonne with other DOE sites and with commercial service providers. In support of DOE's Information

Architecture Initiative, Argonne actively participates in DOE standards committees and task groups.

Argonne is working with the National Energy Research Supercomputer Center (NERSC) 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 ATM local area network environments linked across dedicated commercial interconnections in preparation for the advanced fast-packet-switching services to be offered generally throughout the ESnet wide area network in the near future. 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.

In the area of information management systems and services, the Laboratory recently completed a major conversion of its key operational and administrative data systems from an IBM mainframe environment to a state-of-the-art, distributed client-server environment consisting of multiple SQL- (structured query language)-compliant applications on UNIX servers. The Laboratory now is streamlining, refining, and automating business processes to realize fully the efficiencies that these systems offer and is developing new mechanisms that improve access to data supporting R&D and business decisions. Initiatives are underway to implement digital signature authorization, thereby allowing fully electronic commerce in selected business areas. Upgrades based on commercial products were required to accommodate needs in the year 2000 and beyond. The only remaining legacy system is currently being replaced with a commercial product that provides increased functionality and performance, as well as compatibility with the year 2000. All of the Laboratory's business systems will now be compatible and interoperable.

A key near-term strategy for simplifying the user interface to operations and administrative information is an expanded use of World Wide Web interfaces to our 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."

Argonne R&D programs are increasingly publishing their results primarily in digital form, in varied traditional and multimedia formats on both CD-ROMs and networked servers. The Laboratory's support organizations will continue to exploit the most effective electronic media available for 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 that help to achieve the highest possible quality in its work, to maximize efficiency and productivity, and to 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, measures and metrics are used for tracking, benchmarking, assessing performance, and identifying 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, which comes in part from Motorola Corporation, 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.

As part of its quality management initiative, Argonne initially launched five pilot process improvement teams. Positive results led to additional teams, thereby further institutionalizing the process improvement team approach. In FY 1996 notable continuing improvements were achieved in facilities engineering, where the fraction of service request projects behind schedule was further reduced; in human resources, where job posting and transfer application processes were streamlined; in plant facilities and services, where quality improvement teams reviewed processes in the areas of secretarial software standardization, utility metering, and carpenter shop safety standards; in procurement, where the average cycle time for subcontracting actions was reduced from 75 calendar days to 38; and in hazardous waste management, where improved packaging for disposal was developed.

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 planned for lodging, management of recreational facilities, and records management. Improvements are being planned in the Laboratory's operation of vehicles, with increased efficiency allowing reductions in their number. 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 other related business functions. As part of this process, electronic signature authorization is being implemented. Laboratory travel policies are being made more cost-effective.

Partnership 2000 was organized in early 1997 as a joint strategic initiative of Argonne and the DOE-Chicago Operations Office to further improve business and operations practices through enhanced communication and collaboration among senior officials. Further objectives are removal of bureaucratic obstacles to improving policies and practices and joint strategizing and decision making to address selected problems.

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 groups and individuals 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, video kiosks, 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 been working closely with DOE-Chicago Operations and its Argonne Group on a series of monthly meetings with representatives of communities neighboring Argonne-East. This "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. Argonne's 50th anniversary celebration in 1996 featured a number of major community outreach activities.

A comprehensive employee survey conducted in 1996 is guiding planning to enhance Argonne's internal communications. Already underway is an expanded Laboratory intranet including employee manuals and even an interactive suggestion box. Current initiatives to enhance external communications and outreach include construction of a new Argonne Science and Technology Information Center with exhibits depicting Argonne's history of accomplishment, current R&D programs, and environmental management activities. When the Center opens in the fall of 1997, it 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 to the general science news media, by using state-of-the-art techniques such as on-demand electronic mail and faxes. 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 new prime contract between DOE and the University of Chicago for the management and operation of Argonne, effective through September 1999, requires systematic measurement of the Laboratory's performance. After completion of the first year under this contract on September 30, 1996, Argonne sees strong evidence that performance evaluation motivates and facilitates continuous improvement in support operations much more effectively than the earlier compliance-based approach. 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, in addition to performance evaluation, encompasses strategic planning, budget formulation, and budget execution throughout the Department.

a. Scientific and Technical Programs

Argonne's science and technology programs received an overall performance rating of "outstanding" (the highest possible) in FY 1996, the first year of the new performance-based contract. Separate performance ratings were provided by the five DOE program offices whose work at Argonne receives more than \$5 million in annual funding: Energy Research; Nuclear Energy, Science and Technology; Non-proliferation and National Security; Energy Efficiency and Renewable Energy; and Environmental Management. The five individual ratings were weighted by funding level to determine the Laboratory's overall rating in science and technology.

In each of the five program areas, separate ratings were given for science performance and for technology performance, by using as criteria the two sets of goals and success indicators for science and technology provided in the prime contract for operation of Argonne. The science rating and the technology rating in each program were averaged to produce an overall rating. The distinctive set of goals and success indicators used to evaluate science differs appropriately from the set 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, in consultation with DOE program managers. The reviews are valuable guides for individual research programs and for Laboratory management.

DOE and the University are piloting a new way of performing assessments in some of the science and technology areas that are evaluated by both DOE-Headquarters program officials and the University peer review committees. Although the reviews will continue to be independent, general presentations by Argonne programs will be held jointly.

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 first year under the new prime contract, the University of Chicago delivered to DOE a narrative and quantitative self-assessment of Laboratory support operations based on results for 82 contractual performance measures. (DOE and Argonne have jointly agreed on 60 performance measures for FY 1997.) These results provided the major basis for DOE's annual appraisal of support operations: an overall rating of "excellent," narrowly missing the highest category. Nine of the 15 functional areas were rated "outstanding," five were rated "excellent," and one was rated "good." 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 Argonne Overhead Management (AOM) 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. The AOM process involves a systematic, detailed, bottom-up methodology for establishing functional area budgets by using modified zero-based concepts. Through this process, the Laboratory has been able to reduce its overhead cost ratio from 22.4% in FY 1994 to 20.3% in FY 1996. The ratio is expected to increase slightly to 20.4% in FY 1997. However, increased efforts now being applied to reducing the cost of overhead and technical support services target further reductions of the ratio over the next three years, to 17.2%. A new contract performance measure for FY 1997 will directly rate the Laboratory's success in achieving this objective.

As part of the new prime contract, Argonne is obligated to contain compensation costs each year to achieve savings of at least 1% relative to the preceding year. DOE has validated Argonne's

compensation cost savings of \$12.6 million for FY 1996, which exceeds by far the FY 1996 target of \$3.2 million and reflects the fact that many of the Laboratory's cost savings initiatives are front-end loaded. The savings surplus will carry forward to help meet compensation cost containment goals for future years.

Article 30 of the prime contract provides further incentives for Argonne to achieve operational cost savings, either in labor costs or in the purchase of materials and supplies. DOE validated and approved achievement of \$1.44 million in Article 30 cost savings for FY 1996. These savings were accomplished through value engineering of the new waste storage facility, excavation of lime sludge for agricultural reuse, metal recycling, outsourcing of payroll processing, more efficient scheduling in the removal of nonregulated waste, and restructuring of custodial work processes.

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 \$141 million over the five years from FY 1996 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 work force and to accommodate expected reductions through increasing efficiency and effectiveness in overhead and technical support services. An overall goal of about 10% reduction in administration, business, operations, and technical support is being planned for FY 1998, with additional reductions targeted

for the two years following. This strategy will generate further improvements in a research-to-support ratio that is already highly favorable. Moreover, the percent of technical labor within the Laboratory's research divisions will be increased similarly through current efforts to reduce division overhead. The Laboratory's favorable average cost per researcher, already among the lowest for a DOE multiprogram laboratory, is targeted to decline steadily over the next three years, reaching a level in FY 2000 that is more than 5% lower than in FY 1997 and 10% lower than in the baseline year of FY 1994, measured in constant dollars.

Table V.1 Productivity Metrics

	Actual Values				Objectives		
	FY94	FY95	FY96	FY97 ^a	FY98	FY99	FY00
Research-to-Support (Labor Dollar) Ratio ^b	2.10	2.20	2.20	2.40	2.80	2.90	3.20
Technical Labor on Research (%) ^c	86.0	84.6	85.0	85.0	85.0	85.0	86.0
Average Operating Cost per Research FTE ^d	137.5	134.0	131.3	131.0	128.0	126.0	124.0

^aAnticipated actual values for FY 1997.

^bResearch labor dollars divided by support labor dollars.

^cTechnical labor dollars divided by research labor dollars, multiplied by 100.

^dThousands of FY 1994 dollars per year per FTE.

ARGONNE NATIONAL LABORATORY

ORGANIZATION CHART

Location	9700 South Cass Avenue Argonne, Illinois 60439
Operations Office	Chicago
Contract Number	W-31-109-Eng-38

Approved

Dean E Eastman

Director

August 1, 1997

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