Argonne National Laboratory

INSTITUTIONAL PLAN

FY 2004 – FY 2008

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This October 2003 *Institutional Plan* was originally prepared in the early spring of 2003. It generally describes the activities and plans of Argonne National Laboratory as of that time. Thus, for example, financial data for FY 2003 are mid-year projections. In addition, a few selected revisions to the *Draft Institutional Plan* of May 2003 are included to reflect comments received and major shifts in plans.

Available electronically at this location: http://www.ipd.anl.gov/instplan/

Argonne National Laboratory is operated by The University of Chicago for the United States Department of Energy’s Office of Science.

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I. Laboratory Director's Statement

As a member of the national laboratory system for more than 55 years, Argonne conducts world-class research and development in support of the long-term goals of the Department of Energy (DOE) and its Office of Science, to "position our nation for scientific and economic strength and leadership in the years to come." Our efforts focus on basic science, energy resources, environmental stewardship, and national security.

To enhance our performance in carrying out DOE's missions, Argonne and the University of Chicago — which has operated the Laboratory for its entire history — work closely together to strengthen ties and increase research collaboration between the two institutions.

Argonne manages five major DOE user facilities, and we are working to add to this roster. We work with colleagues from the other national laboratories, academia, and industry to employ these national research tools on the cutting edge of science and technology.

The key to making our discoveries useful is to move them quickly from the laboratory to the marketplace. Our current portfolio of technologies contains 185 available for licensing by private enterprise and includes substantial efforts for the Department of Homeland Security (DHS). Our support for DHS draws on our deep understanding of the nation's technological infrastructure and on application of our technologies to detect, prevent, and retaliate against terrorist attacks.

National User Facilities

Over the decades, Argonne and other members of the national laboratory system have proven highly effective at planning, designing, building, and operating user facilities. These one-of-a-kind research centers serve as engines that help maintain and advance U.S. scientific leadership by attracting the world's best scientists and providing crucial support for national communities of researchers in many fields. The following major national user facilities are currently operated by Argonne for DOE, or are in the planning stages:

- The *Advanced Photon Source* (APS) is our premier user facility. It provides researchers with the nation's brightest x-ray beams for investigations in a broad spectrum of scientific and technological areas, including materials science, structural biology, environmental studies, and applied engineering. Collaborative access teams — comprising investigators from private industry, universities, government, and other institutions — have committed a quarter billion dollars in capital investments for construction of APS beamlines.

- The *Intense Pulsed Neutron Source* (IPNS) is widely known as one of DOE's exemplary user facilities, particularly because the machine and its operators embody the professional values of its national user community and assiduously serve the community's scientific interests. In the 20 years since its inaugural run, the IPNS has become a national model for user facility operations. In recent years, the organization and its staff have committed their expertise to supporting the Spallation Neutron Source (SNS) project — soon to become the nation's premier neutron source — by designing and building instruments for the SNS and by training future SNS users.

- The *Argonne Tandem-Linac Accelerator System* (ATLAS) is the world's first superconducting linear accelerator for heavy ions and the premier accelerator for low-energy nuclear physics research. In addition to supporting an active and productive community of physicists from all over the world, ATLAS plays a key role in our conceptual design for the proposed Rare Isotope Accelerator.

- The *Electron Microscopy Center* (EMC) conducts materials research using advanced microstructural characterization methods and state-of-the-art microscopes. Research by

EMC personnel includes microscopy-based studies of high-temperature superconducting materials, irradiation effects in metals and semiconductors, phase transformations, and the structure and chemistry of thin-film interfaces.

• The *Atmospheric Radiation Measurement (ARM) Climate Research Facility* is DOE's largest research program on global climate change. ARM Program scientists focus on obtaining field measurements and developing models to better understand the processes that control solar and thermal infrared radiative transfer in the atmosphere, especially in clouds and at Earth's surface.

• The *Center for Nanoscale Materials* (CNM), one of five Nanoscale Science Research Centers sponsored by DOE, concentrates on understanding and controlling material properties at the nanometer scale. This area of scientific exploration has tremendous potential to advance science and technology. The CNM already offers advanced facilities and expertise to support independent and collaborative research efforts, and construction of a dedicated building will soon begin adjacent to the APS. The CNM focuses on six primary research themes: bio-inorganic interfaces, complex oxides, nanocarbon, nanomagnetism, nanophotonics, and theory and simulation.

In addition, Argonne will be the site of a Regional Biocontainment Laboratory funded by the National Institutes of Health to study the detection, prevention, and treatment of infectious diseases — particularly agents that could be used for bioterrorism. Argonne is also a primary candidate to host the Protein Production Facility, one of the highest-priority projects of the DOE Office of Science. These two facilities, in conjunction with the APS and CNM, would form one of the world's most complete complexes for microbiological research.

Core Competencies and Major Initiatives

Our major strategic goals are supported by our core competencies, which we constantly strengthen. Chief among our competencies are our world-class engineering and scientific expertise in producing safe, sustainable, proliferation-resistant nuclear energy and our long experience and deep expertise in developing, operating, and advancing the science and technology underpinning accelerator-based user facilities. We also have widely recognized expertise in the materials sciences; chemistry; biology; physics; high-energy and nuclear physics; cross-disciplinary nanoscience and technology; structural biology, functional genomics, and bioinformatics; applied mathematics and computer science; computational science; and environmental science. Our overall goal is to be the best in the world in many areas, a leader in others, and a responsible steward of our facilities.

To complement existing programs, we work closely with DOE and the scientific community — often in a leadership role — to develop new initiatives and scientific facilities to serve national needs. The following five Argonne initiatives represent timely opportunities to significantly enhance U.S. research capabilities in basic research and development and, hence, to advance scientific understanding and engineering achievement across a wide range of disciplines:

• *Nanosciences and Nanotechnology*. Research on nanoscale materials will lead to devices such as computers that are smaller and more efficient and to materials with exciting new properties. Argonne is well positioned to contribute to achieving these national goals and is actively developing regional collaborations to help.

• *Rare Isotope Accelerator* (RIA). DOE has given RIA its highest priority among new construction projects for the physics community. Among 28 new user facilities proposed for all fields, RIA tied for third ranking. By accelerating highly unstable nuclei at the very limits of existence, RIA will open new scientific frontiers. Examination of these isotopes and their reactions will answer important astrophysical questions, such as how stars evolve, how their evolution affects the evolution of galaxies and planets, and how much "ordinary" matter the universe contains. Physicists will study the fundamental nuclear processes by which stars generate energy and create heavy elements; discover new and unexpected phenomena; and develop new approaches to studying nuclear decay, reactions, and structure. In collaboration with Michigan State University and other institutions, we have developed a facility concept for RIA that achieves its physics goals at reasonable cost by incorporating our existing state-of-the-art heavy-ion accelerator, ATLAS.

• *Functional Genomics*. Recent developments in genome-wide DNA sequencing, high-throughput analytical tools, and computing technologies have made feasible the genome-wide analysis of biomolecular function. Such research promises new strategies for altering cellular activities in order to improve human health, environmental management, and economic productivity. It also will help DOE pursue its homeland security mission by deepening understanding of organisms used as biological warfare agents. To address this opportunity, we are developing a major Laboratory initiative to undertake large-scale functional analyses of macromolecules and macromolecular complexes. We are also strengthening our research staff to contribute to this fast-moving field. A partnership between our Biosciences Division and our Mathematics and Computer Science Division will coordinate the efforts of experimentalists and simulation experts to develop exciting new capabilities in bioinformatics and computational cell biology.

• *Petaflops Computing and Computational Science.* We are building on our existing long-term program in mathematics and computer science to support work in the areas of mathematical software, parallel programming tools, advanced visualization systems, grid computing and distributed systems, collaboration technologies, scalable systems software, and performance analysis and modeling. Strong internal and external scientific collaborations tie this computer science research to diverse applications in biology, high-energy physics, climate modeling, computational chemistry, chemical engineering, subsurface modeling, biomedical computing, astrophysics, and other areas. Our initiative aims to accelerate progress in these areas through a Laboratory-wide computational science program, a targeted research and development program, and construction of a large-scale research facility to house a petaflops computing system and supporting programs in collaborative computational science research.

• *Nuclear Energy*. The nation's need for a secure, reliable supply of energy dictates that nuclear energy play a major role in the future. Our researchers are identifying technologies for the economical production of increasing amounts of energy while reducing burdens on the environment. This work includes addressing the problems of spent fuel disposition and nuclear nonproliferation inherent in producing nuclear energy on the required scale. In particular, we are looking at ways to return fuel to the reactor and produce more benign waste forms.

• *Hydrogen Research and Development.* In response to President Bush's national initiative to reverse growing dependence on foreign oil by developing the technology that could make hydrogen a viable and widely used fuel, we have mounted a coordinated effort integrating our state-of-the-art user facilities with our expertise in basic science and technology and in nearer-term technology development and deployment. Central to this program are two objectives that drive progress toward the hydrogen economy: (1) high-performance materials for hydrogen separation and fuel cell membranes and (2) new catalysts that improve hydrogen production and combustion. We are drawing on our broad knowledge of materials science and chemistry to orchestrate comprehensive research programs that coordinate advances across the spectrum from basic science to applications. In these efforts, the unique capabilities of IPNS, APS, and EMC will be particularly valuable, and we will rely on our extensive expertise in nuclear reactor technology to investigate the production of hydrogen from nuclear power.

The state of Illinois has provided extremely valuable support for Argonne's major research initiatives. This outstanding cooperation has fostered a highly favorable environment for accomplishing the Laboratory's missions.

Employer of Choice

The most important measure of an organization is the quality and dedication of its people. Our successes come from our staff. Many have been with Argonne for decades; more than a quarter have 20 or more years of service. Obviously, Argonne is a good place to work. To strengthen our status as an employer of choice, we are pursuing a number of initiatives in our operations. One initiative is a human resources strategy to develop strong leadership, support a creative and diverse workforce, and recruit and develop the talent we need, in an environment totally committed to equal opportunity for everyone. Our development of talent begins at the earliest possible stage, with educational programs and other efforts to convey to students from grade school to the postdoctoral level our love of science and technology and our fascination with the possibilities they offer.

Notable among our operations initiatives are the following:

- Make optimal use of the national talent pool to attract the best qualified new employees from all ethnic and cultural backgrounds.

- Ensure that line managers are responsible for achieving excellent performance over the full range of activities under their purview. Our integrated management approach requires ongoing education and training of all staff.

- Maintain a safe and healthy workplace for our employees, with close attention to protecting the environment for the benefit of both ourselves and our neighbors. A bedrock principle is the empowerment of every employee to object to any impediment to safety or security.

- Make open communications a key part of the Argonne culture, across all levels of management and staff. When communication flows unimpeded in all directions throughout an organization, resulting interactions produce fertile synergies and valuable new ideas. Line management needs this open communication to learn of all available good ideas and to help implement them.

Focus on the Ambitious

Just as DOE's Office of Science has outlined an ambitious agenda for science, so has Argonne. We, too, dream large.

The goals of the Office of Science strategic plan fire our imaginations, and we embrace this exciting quest to advance the cutting edge of science, just as we have since our earliest days.

Hermann A. Grunder

Hermann A. Grunder
Laboratory Director

II. Mission, Roles, and Strategic Goals

Argonne National Laboratory is a major multiprogram laboratory managed and operated for the U.S. Department of Energy (DOE) by the University of Chicago under a performance-based contract.

A. Mission

Argonne's mission is to serve DOE and national security by advancing the frontiers of knowledge, by creating and operating forefront scientific user facilities, and by providing innovative and effective approaches and solutions to energy, environmental, and security challenges to national and global well-being, in the near and long term, as a contributing member of the DOE laboratory system.

We contribute significantly to DOE's mission in science, energy resources, environmental stewardship, and national security, with lead roles in the areas of science, operation of scientific facilities, and energy. In accomplishing our mission, we partner with DOE, other federal laboratories and agencies, the academic community, and the private sector.

B. Vision

Argonne ensures U.S. scientific and technological leadership by creating — in the national interest — new knowledge and technologies that enhance energy security, national security, economic productivity, and quality of life. The Laboratory is a full participant in the implementation of administration priorities set forth by the President's science advisor. In all its programs, Argonne is committed to managing its resources to maximize benefit to the taxpayer, with DOE's critical performance measures as its guide.

Argonne's leadership inspires cooperation to integrate the resources of other laboratories, agencies, and universities to solve the nation's most challenging problems. The Laboratory's scientific research supports every major DOE program. Our management approach is to focus the Laboratory's attention on research that has the greatest promise and highest potential impact for the coming decade. To maximize benefit to the nation, we create alliances with industry that expedite application of new discoveries and technological innovations.

Argonne is pursuing ten visionary *strategic goals* to deliver extraordinary science and technology with significant value to the nation:

1. Develop the technologies and infrastructure needed to produce, store, and distribute hydrogen fuel.

2. Close the nuclear fuel cycle, reducing the cost of nuclear waste disposal by billions of dollars and disposing of weapons-grade plutonium and actinides.

3. Develop advanced nuclear power technologies that are safe, economical, proliferation-resistant, and environmentally sustainable.

4. Plan, design, construct, and operate the Rare Isotope Accelerator (RIA) and make fundamental discoveries in nuclear physics and astrophysics.

5. Construct and operate the Center for Nanoscale Materials and create innovative materials with valuable commercial properties.

6. Lead the Genomes to Life team that focuses on protein production and related proteomics; implement computational biology to build fundamental understanding of living systems.

7. Realize the full potential of scientific simulation to solve mission-related problems, through leading-edge research on systems architecture and software, parallel programming and numerical tools, distributed computing, and computational science applications.

8. Establish a new associate laboratory directorate in national security to deliver technologies and analyses for the Department of Homeland Security, the Department of Defense, and the U.S. intelligence community.

9. Make major contributions to environmental research, taking full advantage of our state-of-the-art facilities and tools.

10. Optimize the operation of our national user facilities to perform research in fundamental science and other areas.

These strategic goals, explained more fully below, are consistent with priorities established in DOE's FY 2004 budget request.

Goal 1: Hydrogen Research and Development

Argonne will help develop the technologies and infrastructure needed to produce, store, and distribute hydrogen fuel for use in fuel cells, vehicles, and electricity generation. The Laboratory will continue to participate in the FreedomCar partnership, in order to accelerate the development of practical, affordable hydrogen cell vehicles. We will perform the engineering and reactor physics required to develop a nuclear plant that co-generates hydrogen and electricity. Argonne materials scientists are leading the national effort to develop breakthrough technologies for new hydrogen fuel cells and for hydrogen production, transport, and storage.

Goal 2: Advanced Nuclear Fuel Cycle

Argonne will develop advanced technologies to treat and transmute spent nuclear fuel. We will design and demonstrate a fast-burner reactor to close the nuclear fuel cycle. This approach will reduce the cost of nuclear waste disposal by billions of dollars, contribute to U.S. energy independence by recycling spent commercial nuclear fuel, and dispose of weapons-grade plutonium and actinides.

Goal 3: Nuclear Energy

Argonne will help develop advanced nuclear power technologies that are safe, economical, proliferation-resistant, and environmentally sustainable. We will help design and test the Next-Generation Nuclear Plant being contemplated by DOE. We will continue to support the fusion energy sciences with research in plasma and reactor physics and engineering.

Goal 4: Nuclear Physics and the Rare Isotope Accelerator

Argonne will build and operate RIA as a forefront user facility, thereby opening new frontiers for research in nuclear physics and astrophysics and extending the Laboratory's tradition of innovation, scientific leadership, and service to facility users. RIA will allow us to obtain critical scientific information about how heavy elements are created and how nuclear properties influence the stars; the properties of short-lived atomic nuclei near their limits of stability; and the nature of nuclear decay, reactions, and structure.

Goal 5: Nanoscience and Nanotechnology

Argonne will enable the rapid characterization of new materials required for the nanoscale revolution by co-locating multiple research disciplines and nanoscience instrumentation at two of its national user facilities: the Advanced Photon Source (APS) and the Intense Pulsed Neutron Source (IPNS). DOE has approved the mission need ("critical decision 0") and the preliminary baseline range ("critical decision 1") for Argonne's Center for Nanoscale Materials. Construction of this state-of-the-art user facility adjacent to the APS begins in 2003. The state of Illinois is funding the building, and DOE is funding the scientific equipment, including a world-class nanoprobe beamline at the APS.

Goal 6: Bioscience

Argonne will develop a proteomics user facility adjoining the APS, which serves as a world-class user facility for forefront research in structural biology and many other areas. We are planning for significant growth in research for DOE's Genomes to Life program. Argonne is the preferred site for a regional biocontainment laboratory that will conduct microbiology research to combat emerging infectious diseases and reduce the threat from bioterrorism. This facility is being proposed to the National Institutes of Health by a consortium led by the University of Chicago.

Goal 7: Advanced Scientific Computing

Argonne will provide the high-performance computational and networking tools that are indispensable for scientific discovery. The Laboratory has had international impact through its leadership in the areas of Grid computing, scalable numerical tools, parallel computing, and advanced visualization. We are a major partner in the development of architectures, applications, software systems, and test beds for petaflops-scale computing. We will continue to support the Scientific Discovery through Advanced Computing program — a multidisciplinary effort involving teams of mathematicians, computer scientists, and application area scientists in the development of a new set of scientific simulation codes that can fully exploit our rapidly expanding computing resources — and will actively participate in the state-of-the-art computing initiatives now being planned by DOE. Moreover, Argonne is strengthening its work on computational science applications, especially in the areas of nanoscience and biology.

Goal 8: National Security

Argonne will help enhance national security by delivering new technologies and threat analyses for the Department of Homeland Security, the Department of Defense, and the U.S. intelligence community. Many Laboratory discoveries and inventions developed in pursuit of our mission are now helping to increase homeland security. Notable technologies include portable systems for detection and field identification of concealed nuclear materials, pathogenic microorganisms, and airborne poisonous chemicals; models to guide infrastructure assurance; and the PROTECT system, which combines detection, communication, and quick-response strategies to protect subways and other enclosed public spaces against chemical and, eventually, biological attacks. Argonne is also exploring the sociological dimensions of terrorist threats by partnering with leading social scientists at the University of Chicago.

Goal 9: Environmental Research

Argonne will provide leadership in key areas of environmental research by integrating fundamental research with reliable impact assessments and innovative technological solutions. We will make major contributions in such areas as the cycling and sequestration of carbon, the causes and consequences of global climate change, atomic-level controls for contaminant sequestration, and potential environmental impacts of a hydrogen fuel economy. This research will take full advantage of the APS and other state-of-the-art facilities and tools available at the Laboratory.

Goal 10: National User Facilities

Argonne is committed to maximizing the scientific and technical productivity of its existing user facilities, especially its three leading national user facilities: the APS and IPNS (discussed above) and the Argonne Tandem-Linac Accelerator System (ATLAS, which would become part of RIA). Meeting this goal involves maintaining the facilities' high reliability and availability while increasing their performance and experimental capabilities. At the APS, for example, we plan upgrades over the next two decades that will increase the productivity of users by roughly 10,000-fold. The benefit will be much more information, obtained much more quickly, to support important scientific activities such as imaging nanoscale devices and solving the atomic structures of the huge biological molecules crucial to understanding diseases. Argonne will remain an international leader in accelerator-based user facilities, through the APS, RIA, connections with high-energy and nuclear physics, and involvement in development of the next generation of x-ray sources after the APS.

C. Scientific and Technical Core Competencies

To achieve our vision, we cultivate distinctive, world-class scientific and technical capabilities and integrate them into a dynamic portfolio of core competencies that serve and anticipate current and emerging national R&D needs in our mission areas. Our current competency portfolio includes the following:

- A complete set of engineering and scientific expertise supporting the design, development, and evaluation of current and advanced nuclear energy systems and proliferation-resistant nuclear fuel cycle technologies, including pyroprocessing.
- Design, construction, and operation of accelerator-based user facilities, along with diverse state-of-the-art capabilities related to acceleration, particle detection, synchrotron radiation techniques, spallation neutron scattering techniques, and the control and manipulation of particle beams and photon beams.
- Fundamental science and engineering expertise in, and at the interfaces between,
  - Materials sciences, chemical sciences, biological sciences, and atomic physics;
  - High energy and nuclear physics;
  - Multidisciplinary nanoscience and nanotechnology;
  - Structural biology, functional genomics, and bioinformatics;
  - Environmental science and technology;
  - Applied mathematics and computer science, including collaborative and virtual environments; and
  - Computational science, including modeling, simulation, systems analysis, and complex adaptive systems.

Our goal in managing our portfolio of core competencies is to be best in the world in selected areas, to be among the leaders in other areas, and to have sufficient breadth and balance to both support users of the facilities we steward and tackle complex multidisciplinary challenges in our mission areas — typically in collaboration or partnership with others.

D. Roles in Accomplishing DOE Missions

Argonne has a contractual responsibility to serve DOE's mission areas, especially its overarching national security mission. In *science* and in *energy*, we have a principal role. Our role in *environmental quality* is as a major contributor. Developments after September 11, 2001, demonstrated how fundamentally our knowledge, technologies, and facilities — even those originally developed for other purposes — serve as a major resource for *national security*.

1. National Security

The recent evolution of threats to U.S. national security has amplified and focused our involvement in DOE's national security mission. Our contributions draw particularly on substantial Laboratory expertise in the nuclear fuel cycle, in chemistry and biology, and in systems analysis and modeling, along with the diverse enabling technologies and sciences underpinning those areas. We also have specialized R&D capabilities contributing to the development of new technologies for detection and attribution, such as highly sensitive instruments and verification technologies to detect radiation and chemical threats or provide biological clues to possible weapons proliferation or actual attacks. Our skills in modeling and decision science are contributing to the security of critical infrastructure at local, regional, national, and global scales. In addition to this scientific and technical expertise, we have experience with other nations in cooperative R&D that will be valuable in supporting DOE goals relating to nonproliferation cooperation, export controls, and materials protection.

Scientific, engineering, and operational capabilities that we have developed over many years for other purposes are more recently yielding results that help to counter the threats of terrorism. In the future, our expertise, facilities, and technologies promise to address a broader range of important goals in national security and homeland defense, across the full spectrum of concerns about threat anticipation, threat mitigation, response, and recovery.

2. Science

For DOE's science mission, we operate major scientific user facilities and have significant experimental and theoretical research programs in nuclear and high-energy physics; in applied mathematics; and in materials, chemical, computer, computational, biological, environmental, and fusion science. In several key fields and subfields important to DOE, our research is among the most cited, and our scientists are international leaders. We take pride in effective collaborations with other DOE laboratories, strong interactions with the academic community, productive R&D partnerships with private industry, and high-quality research experiences provided for hundreds of undergraduate and graduate students each year.

The APS, IPNS, and ATLAS are among DOE's most successful major national scientific user facilities. The APS, the nation's premier hard x-ray synchrotron radiation facility, now serves nearly 5,000 users from universities, corporations, and national laboratories throughout the country, and it routinely reports newsworthy new science. The IPNS continues to provide extraordinarily reliable neutron beams and user support for approximately 400 experiments, while continuing its tradition of leadership in the development of spallation targets, neutron moderators, and neutron scattering instruments. In addition to operating the APS and IPNS, we educate the next generation of users by hosting the National School for Neutron and X-ray Scattering. At ATLAS, unique low-energy heavy-ion beams enable over 100 scientists each year to conduct forefront research in nuclear, atomic, and applied physics. The RIA initiative — recently identified by the nuclear physics community as its highest priority among major new construction projects — derives considerable scientific motivation and much of its technology base from ATLAS.

For several years we have made significant contributions to major subprojects associated with user facilities or detectors located elsewhere. The most visible current example is our participation in the Spallation Neutron Source (SNS). We have leading responsibility for SNS spectrometer systems, and we provide substantial technical support for SNS target systems. Other examples include contributions to the ATLAS detector for the Large Hadron Collider, participation in the Linac Coherent Light Source, and detector fabrication for the MINOS neutrino experiment.

Science at Argonne benefits from access to major facilities and from the Laboratory's integrated approach to complex problems. The grand challenges in modern science, such as nanoscale materials or fundamental understanding of biological processes at the molecular scale, are beyond the reach of isolated experiments. Success requires not only forefront capability but also a suite of experimental and theoretical approaches. Our strength comes from diverse scientific teams that examine a problem from many complementary perspectives. This synergy of many approaches working together generates remarkable scientific power and often leads to the creation of pathbreaking new research facilities. The APS, IPNS, and ATLAS all had their origins in Argonne science.

Four of the major Laboratory initiatives featured in Chapter III of this *Institutional Plan* build on Argonne strengths that serve DOE's science mission, both through performance of forefront research and through service to users. Those four initiatives are the Center for Nanoscale Materials, the Rare Isotope Accelerator, Functional Genomics, and Petaflops Computing and Computational Science. In addition, major components of the initiative Hydrogen Research and Development fall under DOE's science mission.

3. Energy

For its energy mission, Argonne serves with the Idaho National Engineering and Environmental Laboratory as co-lead laboratory for nuclear reactor technology. In addition, we have substantial programs and facilities serving DOE's mission to develop innovative, energy-efficient, cost-effective, and environmentally friendly technologies for electric power, transportation, and industry. Since the 1970s we have cultivated capabilities and programs — and have produced results — that are well aligned with recommendations of the administration's energy policy, as described in the May 2001 *Report of the*

National Energy Policy Development (NEPD) Group. We operate numerous unique energy R&D facilities that are used by researchers from universities and industry.

We have noteworthy expertise and facilities in nuclear reactors, non-reactor nuclear facilities, and nuclear fuel cycle technologies. Over the years, we have developed safe and reliable fast-reactor technologies and have demonstrated the technical basis for a proliferation-resistant closed nuclear fuel cycle, based on pyroprocessing, that can consume weapons-grade plutonium and spent fuel from the nation's current fleet of power reactors. We are ready to contribute solutions that will allow nuclear energy to be a significant component of the nation's energy supply portfolio in both the near and long term — safe, environmentally acceptable, proliferation-resistant, sustainable, and economical. The major Laboratory initiative Advanced Nuclear Fuel Cycle envisions a closed, environmentally sound nuclear fuel cycle that generates electricity — and possibly hydrogen — while reducing inventories of plutonium and the long-term toxicity of the waste generated. We played the key technical role in DOE's development of an R&D road map for "Generation IV" nuclear reactors, and we are now conducting the R&D. We have the capability to contribute importantly to Generation IV technologies, including reactors designed for some combination of electricity generation, waste management, and hydrogen production.

Our broader energy R&D portfolio is built on expertise in superconductivity, fuel cells, fossil fuels and carbon management, renewable energy technologies, energy testing and analysis, and other key technologies. Transportation technology R&D relies on many of these competencies and on unique Laboratory facilities to support DOE's quest to increase the efficiency and productivity of vehicular energy use while limiting environmental impacts.

The breadth of our R&D portfolio in both energy technology and supporting basic science is reflected in the range of contributions that we propose to make in support of the nation's new national hydrogen economy initiative. Our major Laboratory initiative in Hydrogen Research and Development encompasses extensive work on the materials science and chemistry of high-performance structural materials and catalysts, bolstered by use of the APS, IPNS, and other major research facilities; investigation of the production of hydrogen from nuclear power, taking advantage of our extensive expertise in nuclear reactor technology; and exploration of effective systems for utilizing hydrogen in both transportation and stationary applications, capitalizing on experience and facilities developed in earlier partnerships with industrial firms.

4. Environmental Quality

In support of DOE's environmental quality mission, we develop innovative characterization and remediation tools and technologies, create advanced technologies that intrinsically produce little or no pollution and minimize waste generation, clean up land and facilities on the Argonne sites, and conduct thorough and objective environmental analyses. The focus of this work is shifting from effluent control technologies and associated regulation toward resource and waste management, site remediation, long-term stewardship, and global environmental issues. Our strength is our combination of capabilities in bioprocessing, ecology, modeling and measurement of environmental pathways, atmospheric physics and chemistry, environmental assessment, and decision models.

Our work in the environmental quality areas ranges widely. We are responsible for operating all three Cloud and Radiation Testbed facilities of DOE's Atmospheric Radiation Measurement Program. In other work, we are using the APS to pioneer synchrotron-based environmental tools that will deepen microscale understanding of environmental processes. The Laboratory also belongs to the EnviroCAT partnership, which will develop state-of-the-art APS beamlines designed to tackle a broad range of environmental science problems. Elsewhere, the U.S. Department of the Interior has tapped Argonne to develop the environmental impact statement for the Alaska Pipeline.

5. Enabling the Mission through Excellence in Operations

Built into all Argonne programs and support activities is a commitment to operational excellence, to exemplary relations with the public (especially neighbors near the Illinois and Idaho sites), and to development of the diverse science and engineering workforce needed to accomplish DOE missions and assure U.S. prosperity, security, and leadership into the future. In the operations area, our contractual goal is to conduct all work and operate all facilities cost-effectively and with distinction, in a manner that integrates with and supports our missions in science, technology, energy, and environment, while fully protecting workers, facility users, the public, the environment, and national interests.

For most of the past half century, the University of Chicago has, as a public service, managed and operated Argonne under contract to the federal government. As a result, the Laboratory's research environment and performance have maintained a high standard of intellectual excellence and integrity, and the site — despite its age — is among the best maintained in the DOE complex. Currently, the University and the Laboratory are strengthening ties at all levels, from student research to joint appointments, collaborations between individual investigators, and strategic alliances.

E. Strategic Context and Planning Assumptions

Argonne is one of DOE's nine major multiprogram national laboratories, and it is one of ten facilities affiliated with DOE's Office of Science. Like most DOE R&D sites, Argonne is managed and operated by a contractor. We serve all four of DOE's mission areas, and we are internationally recognized for our science, scientific user facilities, and energy R&D. Our track record of performance, our human resources, and our R&D facilities are the assets upon which the Laboratory's strategic plan for the future is built.

Our planning is based on five key assumptions:

- DOE's national laboratories must act increasingly as a synergistic system, with the laboratories managing their collective competencies, increasing their overall cost-effectiveness, and partnering on major initiatives among themselves and with the private and academic sectors.
- Sponsors, regulators, and the public will continue to require that we demonstrate responsible corporate citizenship. This imperative includes being a good and trustworthy neighbor, conducting operations cost-effectively and responsibly, and meeting or exceeding regulatory requirements.
- Argonne must compete on its merits for federal funding, for the "best and brightest" employees, and for the modern infrastructure needed for future success. Important factors in this competition will be scientific and technological excellence, cost-effectiveness, mission contributions, record of performance, and a working environment that enables high performance from a diverse and talented workforce.
- Robust links with universities, industry, federal laboratories, and the general scientific and technical community (within the United States and abroad) are essential if we are to maintain our leadership and fully exploit advances made throughout the world.
- Computing, computational science, and communications and information technology will advance rapidly, will become seamlessly intertwined with experimental science, and will thereby revolutionize many fields of research and applications that are central to the missions of DOE and Argonne.

F. Strategic Objectives

Objective 1. We will continue to perform outstanding science and technology consistent with our mission and will provide results and value to the nation. This objective includes operating world-class scientific user facilities and providing other science- and technology-based tools in a way that maximizes service to users and research productivity, as well as other public *benefits.* Outstanding science and technology are Argonne's *raison d'être.* The Laboratory's history of accomplishment is the basis on which it becomes the performer of choice in its mission areas. In support of this objective, we expand the frontiers of knowledge, develop and test new technologies, and create new areas of inquiry that keep us at the forefront. Thousands of scientists and students from universities, industry, and other laboratories around the country and the world use our unique facilities to conduct their research. Reliable facility operation, meeting or exceeding performance specifications, and high-quality user support are critical. In addition to the APS, IPNS, and ATLAS, we operate or provide other important special research tools, such as major nuclear research facilities, environmental research sites, mathematical libraries, software packages, and decision tools.

We have an obligation to the taxpayer to provide the highest possible mission value with the resources we receive. Under constrained or declining budgets, this goal can only be achieved by nurturing the best, most important programs and phasing out the least important. Only by making such choices can we ensure that the research we undertake achieves the required quality and stature. In the near term, we will emphasize expanding and strengthening the computational components of our R&D, operating user facilities effectively, operating and improving reactors and other nuclear facilities, expanding capabilities for research on nuclear fuel cycle technology, applying diverse expertise to homeland security, exploring promising areas at the interfaces between traditional disciplines, solving problems of national importance, and catalyzing the expeditious transfer of our technologies into beneficial use. Chapter IV provides updated plans for each of our major science and technology areas.

Objective 2. We will develop important new R&D initiatives and scientific facilities that serve emerging national needs consistent with our mission and will implement them cost-effectively and expeditiously to the benefit of DOE and the nation. New initiatives are an engine for change. They attract bright research staff and facility users, and they help direct our programmatic focus onto current and future needs. Each year we feature a few major Laboratory initiatives that promise extraordinary, broad benefits and that build naturally on our mission areas and strengths. This year's portfolio includes the Center for Nanoscale Materials, the Rare Isotope Accelerator, Functional Genomics, Petaflops Computing and Computational Science, Advanced Nuclear Fuel Cycle, and Hydrogen Research and Development. Chapter III summarizes these major Laboratory initiatives.

Objective 3. Argonne and the University of Chicago will strengthen and fully exploit partnerships and alliances to maximize the Laboratory's value and impact — nationally, regionally, and locally. A strong intellectual alliance between the University of Chicago — one of the nation's premier research universities — and Argonne — one of DOE's major multiprogram science laboratories — promises benefits to DOE and to the broadly ranging impacts of both institutions. Argonne and the University are increasingly taking advantage of each other's complementary expertise in areas such as nanoscience, computing and computational science, bioscience, environmental science and impacts, homeland security, and economic modeling of energy systems. The two institutions plan to increase joint recruiting, joint proposals, joint appointments, joint projects, and sharing of facilities and other resources.

Objective 4. The University of Chicago and Argonne will continuously improve the cost-effectiveness, management, and operations of the Laboratory. The University of Chicago is working with DOE to continuously improve and streamline Argonne's administration and operation. Major challenges include recruiting and developing a diverse workforce, modernizing the physical infrastructure, and fully exploiting partnerships. The changes undertaken in this quest will build on best practices gleaned from the private, academic, and public sectors. The result will be an integrated, creative, and high-performing laboratory whose performance significantly exceeds the sum of its parts, because it engages — productively, cost-effectively, safely, securely, and environmentally responsibly — as a contributing member of the DOE laboratory system and as a partner and leader in addressing national needs in science and technology. Chapter V and Supplement 3 in this *Institutional Plan* describe our status and plans in operations areas.

III. Major Laboratory Initiatives

The Laboratory's second strategic objective is stated in Chapter II: "Argonne will develop important new R&D initiatives and scientific facilities that serve emerging national needs consistent with its mission and will implement them cost-effectively and expeditiously to the benefit of DOE and the nation." This chapter provides planning "snapshots" of Argonne's major Laboratory initiatives, for consideration by DOE.[1] The Laboratory's initiatives represent important opportunities to enhance U.S. research capabilities, to serve the broader scientific community, and to advance scientific understanding and engineering achievement across a wide range of disciplines.

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

The six major Argonne initiatives relate most closely to two DOE mission areas, Science and Energy:

- Science
  - Nanosciences and Nanotechnology — Center for Nanoscale Materials
  - Rare Isotope Accelerator
  - Functional Genomics
  - Petaflops Computing and Computational Science
- Energy
  - Advanced Nuclear Fuel Cycle
  - Hydrogen Research and Development

In addition to these six major Laboratory initiatives, we are applying our capabilities to national security. In the next chapter, Section IV.A.3 explains these efforts and presents six programmatic initiatives in the areas of (1) nuclear national security and (2) infrastructure assurance and counterterrorism. These initiatives individually are too specialized and exploratory to be included among the Laboratory's current major initiatives. However, they point toward more extensive future program development in support of DOE's core national security mission, from which flow all of the Department's missions.

A. Science

1. Nanosciences and Nanotechnology — Center for Nanoscale Materials

The National Nanotechnology Initiative is an interagency effort driven by the realization that present-day materials and processes are reaching their limits of performance. Fundamentally new approaches are needed to transcend these limits. The emerging field of nanoscience offers the requisite scientific and technological opportunities. Accordingly, DOE has taken the bold step of establishing five new Nanoscale Science Research Centers at its national laboratories. Argonne's Center for Nanoscale Materials (CNM) was approved in FY 2002 as one of the five.

Our vision is to go beyond present-day semiconductor materials and processing methods to create new functional materials on the nanoscale. Highlights of our plan include focusing on chemical methods to self-assemble nano-structures, to pattern nontraditional electronic

[1] Inclusion of initiatives in this chapter does not necessarily imply approval, or an intention to implement, by DOE. All funds received for initiatives during FY 2003 are included in the resource tables in Chapter VI of this *Institutional Plan*. However, resources required for proposed growth of initiatives in years beyond FY 2003 are generally not included in those projections. Projected resource requirements for all initiatives include costs associated with protection of the environment and the health and safety of workers and the public.

materials, and to create new probes for exploring nanoscale phenomena. Moreover, we aspire to help pioneer the new fields of molecular and magnetic electronics and to help lay the foundations for new sensor technologies in the chemical and biological arenas.

The CNM will serve simultaneously as a forefront research center and as a user facility for the regional and national research communities. Previously, DOE's stewardship of the nation's major materials science user facilities (such as the Advanced Photon Source [APS] and Intense Pulsed Neutron Source [IPNS] at Argonne) focused on the advanced *characterization* of materials. The CNM will be part of a new generation of DOE user facilities, because its primary goal is to *fabricate* advanced nanoscale materials.

The CNM will complement our existing user facilities and enhance their value by creating cutting-edge nanomaterials that require advanced characterization. To maximize this synergy, the new building for the CNM will adjoin the APS, and the CNM will construct a state-of-the-art, hard x-ray nanoprobe beamline at the APS. The new beamline will focus hard (i.e., 10 keV) x-rays down to an unprecedented spot size of 30 nanometers. This capability will enable a variety of imaging, spectroscopic, and diffraction experiments that cannot be performed similarly anywhere else in the world.

A signature new technology of the last half of the 20th century was solid-state electronics. The 21st century is expected to be marked by the creation of connections across the biointerface, and a major focus of the CNM will be creating novel interconnections between soft matter (complex organic and biological molecules) and hard matter (solid-state nanoparticles and patterned systems). Major areas of interest will include the flow of chemical energy and the propagation of light. Our initial work in these areas has been supported by Laboratory Directed R&D funding and, more recently, by funding of proposals we made to the DOE Nanoscale Science, Engineering, and Technology call.

Magnetic nanomaterials hold much promise to advance the future of electronics, despite the fact that magnetic materials are among the oldest of technological materials (starting with the use of lodestones for ships' compasses). Today, magnetic nanomaterials promise to revolutionize computer design. Computers already use magnetic nano-systems in hard disk drives to store and read data, and the data density of such magnetic recording devices is doubling every nine months. In the future, nanomagnetic devices may also be used to control the flow of current in the computer's logic elements, which could enable programmable processors that transcend the fixed architectures of today's circuitry. Such processors could be reconfigured dynamically to optimize performance for the particular task at hand. Currently under industrial development are magnetic random access memories that may ultimately provide nonvolatile electronics, including laptop computers capable of "instant bootup."

Realizing these technological opportunities requires fundamental studies of magnetic materials on the nanoscale. We are positioned to take a leadership role within the DOE system in this challenging area. Work on nanomagnetism at the CNM will create new nanostructures by using chemical methods of self-assembly, as well as lithographic patterning of novel thin-film hybrid systems. Utilizing the spin (magnetism) of the electron, in addition to its charge, is opening the new field of magnetic electronics (spintronics). The mission of the CNM will include spintronics, along with molecular electronics and nanophotonics, in the effort to develop new functionalities at the nanoscale.

The CNM will energize new collaborations and partnerships that broaden the user community throughout the nation, particularly in the Midwest. To foster this user community and stimulate feedback from users, general and specialized workshops have been held, and more are being planned. Research themes already covered include the x-ray nanoprobe, neutrons and nanoscience, and industrial microfabrication. The University of Chicago-Argonne Consortium for Nanoscience Research was launched in 2001. Investigators from both institutions are cooperating to pursue initial research themes that embrace major focal areas for the CNM. The investigators also have begun ambitious planning for intellectual cross-pollination and educational outreach.

An emerging prime interest for the CNM is the role of theory in creating computational algorithms that simulate nanoscale phenomena. Now under way are efforts to define the scope of a research theme within the CNM dubbed the "Virtual Fab Lab." The objective is to use large-scale computational strategies to transform nanofabrication from an art into a science. The concept of the Virtual Fab Lab in the context of the CNM will be the topic of a future workshop, and it creates linkages with the Petaflops Computing and Computational Science initiative described in Section III.A.4.

The excitement of planning science for the CNM is being enhanced by planning for its infrastructure. The state of Illinois has committed funds for construction of the CNM building. M.W. Zander was selected as the architectural and engineering firm to design the building, and its work has begun. Jacob Facilities, Inc., is the construction management firm.

The CNM initiative requires investments in the following three complementary areas:

1. *Personnel.* Our staff includes some of the researchers required for this initiative, and several of our core programs will naturally move in directions complementary to the CNM. Many new staff members with special expertise will be recruited in areas such as self-assembly, lithography, advanced spectroscopies, and imaging. In addition, creation of the Virtual Fab Lab will require critical new staff in the areas of theory and computational nanosciences.

2. *New Tools for Nanofabrication.* Electron lithography and focused-ion-beam lithography are essential tools for fabrication of nanostructures. Also required is equipment for etching, deposition, and other processes. Several of these tools do not exist elsewhere in the Midwest and will strongly attract outside users. Clean rooms and related infrastructure will be developed; nanostructures are much smaller than a speck of dust, and scrupulously clean conditions are needed for their fabrication.

3. *New Tools for Nanocharacterization.* Tools for visualizing nanostructures, especially microscopes (x-ray, electron, scanning probe, and near-field optical), will be further developed at Argonne. The x-ray nanoprobe will be developed to use the brilliance of the APS to probe at the nanoscale. Our Electron Microscopy Center (Section IV.A.1.b) will be enhanced by synergies with the CNM, and the IPNS will attract new users because of new materials created by the CNM.

Resources required for this initiative are summarized in Table III.1. We are working with the state of Illinois to construct the building for the CNM by January 2006. Further funding for instrumentation and research operations is being provided by DOE-Basic Energy Sciences (DOE-BES; KC-02 and KC-03) and also by the state of Illinois and other sources.

Table III.1 Nanosciences and Nanotechnology — Center for Nanoscale Materials ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating[a]	1.5	1.5	6.0	10.0	18.0	18.0	18.0
Capital Equipment	-	10.0	12.0	14.0	-	-	-
Construction[b]	17.0	17.0	-	-	-	-	-
Total	18.5	28.5	18.0	24.0	18.0	18.0	18.0
Direct Personnel	5.0	5.0	24.0	40.0	60.0	60.0	60.0

[a] Not included here is funding for in-house nanoscience research, for which Argonne will compete separately. The magnitude of this additional funding is expected to be similar to that of the initiative's operating funding.

[b] The state of Illinois is funding construction of a building for the CNM.

2. Rare Isotope Accelerator

Present understanding does not allow reliable prediction of the properties of unexplored forms of nuclei having unusual ratios of protons to neutrons. These forms hold the keys to unlocking fundamental questions of matter and the cosmos. Beams of short-lived nuclei (rare isotopes) provide the opportunity to determine the properties and structure of these nuclei and promise answers to these scientific questions:

• How do short-lived nuclei derive their properties from the interactions of their individual constituents, and why do such complex systems exhibit such simple symmetries?

• How are the heavy elements created, and how do nuclear properties influence the characteristics of stars?

• What are the fundamental symmetries of nature, and how can the rare isotopes help us investigate them?

• What new uses of radioactive isotopes can be developed to serve society and the nation?

Exploration at these frontiers will require extension of today's technical capabilities and facilities. This need and its scientific basis have been discussed thoroughly in a number of forums in the past decade, both in the United States and abroad, including the 1999 National Research Council's Committee on Nuclear Physics. Most recently, the compelling scientific opportunities offered by research with rare isotopes led the DOE-National Science Foundation Nuclear Science Advisory Committee (NSAC) in its *2002 Long Range Plan for Nuclear Science* to recommend the Rare Isotope Accelerator (RIA) as the field's highest priority for major new construction and to conclude that RIA is required to ensure U.S. leadership in the areas of nuclear structure and nuclear astrophysics. Most recently, NSAC reaffirmed this priority in its published recommendations supporting the DOE Office of Science strategic plan for major construction projects.

We have developed a facility concept for RIA that will achieve the physics goals set forth by NSAC. The project is currently preparing to complete the initial steps of DOE's major systems acquisition process. Approval of mission need ("critical decision zero") is expected in 2003 or 2004.

Our work on RIA is a collaboration with other U.S. research institutions. Technology development related to RIA is currently under way at ten institutions, including both universities and national laboratories. We are working with the research community to organize the RIA team and prepare a preconceptual design report.

In parallel with consideration of the fundamental science to be pursued, Argonne's design for RIA has aroused significant interest in the technological applications of the rare isotopes to be created. In addition to potential applications to research in materials science, biology, and medicine, RIA has an important national security role identified in the science-based stockpile stewardship program.

Our concept for RIA is based on two accelerators. It uses a flexible approach for the primary production accelerator, which will be a high-power superconducting heavy-ion linac. The heavy-ion driver can deliver beams of any element from hydrogen to uranium, so a variety of production mechanisms can be selected to optimize rare isotope yields. One mechanism, heavy-ion fragmentation, can be used with a magnetic fragment separator and a new kind of fast gas catcher. This mechanism operates independently of the chemical properties of the exotic species being used. Our approach to RIA also capitalizes on the capabilities of Argonne's existing state-of-the-art heavy-ion accelerator — ATLAS (Argonne Tandem-Linac Accelerator System) — as the postaccelerator. ATLAS is 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, where the beam quality requirements are especially stringent.

In the past year we have achieved significant technical advances demonstrating the feasibility of key elements of the RIA design: (1) construction of a full-scale RIA gas-stopping cell and initial tests that demonstrate the required ion extraction efficiency; (2) operation of a half-scale, windowless, flowing-liquid lithium target, to serve as the prototype for heavy-ion fragmentation targets; (3) construction and testing of three new classes of intermediate-velocity superconducting accelerating cavities; (4) construction and testing of a cold model of a new class of hybrid radio frequency quadrupole structure; and (5) detailed simulations of beam dynamics and beam loss for the entire driver accelerator.

Preliminary estimates of effort, time lines, and cost suggest that this major new facility can be constructed at Argonne within the planning window established by DOE, following approximately two years of detailed facility design. Funding (Table III.2) is being sought from the Nuclear Physics (KB-04) program. A major challenge is to increase DOE's total nuclear physics budget sufficiently to allow RIA to proceed. Argonne's plan for RIA calls for substantial completion of capital construction in 2010, with commissioning extending through 2012. This plan achieves the objectives of the RIA project while recognizing the need of DOE's Office of Science to set priorities across its full portfolio of prospective major construction projects.

3. Functional Genomics

Recent developments in genome-scale DNA sequencing, high-throughput analytical tools, and computing technology have made feasible the genome-wide analysis of biomolecular function. Construction of a complete functional map of cellular behavior now appears to be achievable. Functional analysis of the thousands of proteins and other macromolecules needed for a comprehensive analysis of even the simplest prokaryote is a significant technological challenge that will require substantial enhancement of currently available experimental and computational capabilities. The amount of data needed for functional characterization of an organism greatly exceeds the amount required to sequence the genome. Furthermore, unlike genome sequencing, functional analysis requires multiple high-throughput experimental technologies and novel computational approaches. At the deepest level, the biological sciences now stand at the threshold of developing new conceptual structures — facilitated by informatics and large-scale computation — that will transform biology from a science that is almost exclusively experimental to one in which theory plays a key role.

It is widely appreciated that the comprehensive characterization of biomolecular function has huge potential payoffs. It will provide the basis for developing entirely new strategies for modulating cellular activities and engineering novel cellular capabilities. These opportunities can provide the basis for novel solutions to problems associated with the DOE science mission, and they will be particularly important for advancing the DOE national security mission through the study of organisms used as biowarfare agents. More broadly, the resulting capabilities will enable major benefits for environmental management, human health, and general economic productivity.

To help seize these opportunities, we are continuing a major Laboratory initiative to undertake the large-scale functional characterization of genomes and thereby advance the goals of DOE's Genomes to Life program. The Functional Genomics initiative comprises three components: structural genomics, high-throughput molecular biology and biochemistry, and bioinformatics. The structural genomics component will evolve from the crystallographic resources of our Structural Biology Center (SBC) — one of the best facilities in the world for collecting high-resolution data from crystals of macromolecules and macromolecular complexes. Meeting the needs of this initiative will require greater throughput at the SBC, which can be achieved by enhancing existing detectors and upgrading optics and robotics capabilities.

Table III.2 Rare Isotope Accelerator ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12
Costs										
Operating	3.5	14.0	13.0	9.0	4.0	3.0	25.5	40.0	68.0	96.0
Capital Equipment	-	-	-	-	-	-	-	-	-	-
Construction	-	-	24.0	76.0	150.0	183.0	149.0	120.0	78.0	-
Total	3.5	14.0	37.0	85.0	154.0	186.0	174.5	160.0	146.0	96.0
Direct Personnel	10.0	35.0	70.0	120.0	200.0	250.0	250.0	300.0	300.0	300.0

The high-throughput molecular biology and biochemistry component of this initiative will develop through the growth of facilities and capabilities originally created for the Midwest Center for Structural Genomics (MCSG), funded by the National Institutes of Health (NIH). The MCSG has robotic facilities for high-throughput cloning, expression, and purification of proteins. Significant expansion of those robotic facilities will be required for production of proteins at a rate adequate for the Functional Genomics initiative. In summary, our intention is to establish the premier protein production facility in the nation.

The initiative's informatics component will encompass computational structural biology and development of novel genome and proteome databases that support high-throughput experimentation. Integrating the massive amounts of data to be generated by the Functional Genomics initiative with the vast amounts of data accumulating in public databases throughout the world will be a significant challenge in itself.

We have sought input on the development of strategies and procedures for this initiative throughout the research community. In September 2001 we hosted a workshop on the challenges of integrating genome and proteome databases. Additional workshops addressing other aspects of the program are being planned.

Our efforts in functional genomics will take advantage of a number of important existing resources at Argonne and the University of Chicago. The SBC at the APS will be key for the production of high-resolution images of gene products. Such high-resolution images are the best way to link the sequence information generated by genome projects to the functional data that will be generated by the Functional Genomics initiative. Resources at the APS and the IPNS will be used for small-angle scattering studies of macromolecular complexes (molecular machines) that will be identified by protein-protein interaction mapping and generated in high-throughput protein production facilities. Protein chips for the study of protein-protein interactions will be developed in cooperation with our biochip program (see Section IV.A.2.f). Studies of gene expression will be carried out in partnership with biochip facilities at the University of Chicago. Finally, our computer scientists will create a computational environment for information management and for analysis and integration of functional data. Computer simulations are essential to the development of systems biology capabilities. The Functional Genomics initiative will include a major effort to advance the systems biology of prokaryotes by using simulation.

To develop comprehensive functional information on whole organisms, we will both enhance our existing capabilities and establish new capabilities. Existing resources for protein production will be enhanced. Novel resources for high-throughput mapping of protein-protein interactions will be established, as will facilities for identifying high-affinity, high-specificity ligands for all gene products and for the biochemical and biophysical characterization of protein function (e.g., enzyme assays). To house these resources, we have proposed that the state of Illinois fund construction of a new facility providing over 40,000 square feet of laboratory space, including space for high-throughput crystallization facilities. To develop state-of-the-art intermediate-voltage cryoelectron microscopy and associated image processing capabilities, we will partner with the University of Chicago. The facilities developed for this initiative will serve the entire research community. They will provide researchers from universities and industry with a broad range of capabilities needed to study molecular processes in the cell.

Our Functional Genomics initiative is designed to advance the goals of the Genomes to Life program of DOE's Office of Biological and Environmental Research (DOE-BER). The four goals of this program are to (1) identify and characterize the molecular machines of life, (2) characterize gene regulatory networks, (3) characterize the functional repertoire of complex microbial communities in their natural environments at the molecular level, and (4) develop the conceptual framework and the computational capabilities needed to advance understanding of complex biological systems and predict their behavior. Key to this program is a systems biology approach to understanding how molecular machines and other cellular components function together in a living system. Developing capabilities for comprehensive functional characterization of entire genomes is critical to the success of this program.

Elements of our Functional Genomics initiative should attract sponsorship from NIH. Table III.3 describes the overall resources required, including the efforts of computer scientists, environmental scientists, and APS staff, as well as biologists working in the areas of structural and functional genomics. The increase in resources leading up to FY 2005 reflects anticipated expansion of computational and robotics capabilities and NIH funding to support sector development and operation of an experimental station (the GM/CA-CAT) at the APS. These increases will support multiple Argonne research divisions working — in the areas of computation, engineering, and molecular biology — to determine the molecular structure and function of macromolecular complexes. DOE funding will be sought from DOE-BES (Energy Biosciences; KC-03) and from DOE-BER (KP-11), including the latter office's Genomes to Life program.

Table III.3 Functional Genomics ($ in millions BA, personnel in FTE)[a]

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating[b]	14.3	16.5	17.7	18.6	19.5	20.5	21.5
Capital Equipment	1.5	1.3	1.3	1.6	1.6	1.6	1.6
Construction[c]	-	2.0	16.0	16.0	-	-	-
Total	15.8	17.8	19.0	20.2	21.1	22.1	23.1
Direct Personnel	55.2	67.3	69.4	69.4	69.4	69.4	69.4

[a] Resource projections include funding from the National Institute of General Medical Sciences for the MCSG, plus anticipated funding from NIH, DOE-BER, and other organizations.

[b] Includes anticipated funding from NIH and the National Institute of General Medical Sciences for development of the GM/CA-CAT sector at the APS (enclosures, utilities, and undulators and other insertion devices).

[c] Funding of construction has been proposed to the state of Illinois.

4. Petaflops Computing and Computational Science

Our Petaflops Computing and Computational Science initiative builds on Argonne's existing long-term base program in mathematics and computer science, which is supported by DOE's Office of Advanced Scientific Computing. DOE and other agencies support work in the areas of mathematical software, parallel programming tools, advanced visualization systems, grid computing and distributed systems, collaboration technologies, scalable systems software, and performance analysis and modeling. Strong internal and external scientific collaborations tie this computer science research work to diverse applications in biology, high energy physics, climate modeling, computational chemistry, chemical engineering, subsurface modeling, biomedical computing, astrophysics, and other areas. We plan to continue building our base activities in fundamental computer science and mathematics while increasing our computational science efforts by applying advanced computing to leading-edge scientific investigations, both theoretical and experimental.

Our Petaflops Computing and Computational Science initiative aims to accelerate progress in these directions through three major components: (1) a Laboratory-wide computational science program, (2) a targeted R&D program, and (3) a new advanced computation building. Details are as follows:

- The *Laboratory-wide computational science program* will provide expertise and midrange computing resources to the Laboratory. The purpose is to enable all research groups at Argonne to begin to apply state-of-the-art computational methods to their work and to help them prepare to take advantage of emerging large-scale computing opportunities. Current exploratory efforts involve all of our scientific and engineering programs.

- The *targeted R&D program* will lead to deployment of a petascale system (one capable of 10^{15} operations per second) by 2006 and will include development of next-generation modeling capabilities in diverse scientific applications ranging from the life sciences and nanosciences to energy systems and the environment. The program will take advantage of the development of advanced analysis techniques for constructing predictive models of overall systems performance; recent advances in computer-aided design tools for applying an integrated software-hardware co-design approach to large-scale systems; and the expected availability by 2005 of the billion-transistor chips needed to build petascale systems.

- The *new advanced computation building* will support integrated research in mathematics, computer science, computational science and theory, collaborative research with industry, and joint programs with the University of Chicago (e.g., the Computation Institute). The building will include a large-scale computer room capable of housing a petaflops computing system and will incorporate digital collaboration technologies to support distributed meetings and collaboratories.

We have made substantial progress in several areas that support the Petaflops Computing and Computational Science initiative. A newly established collaboration with IBM's advanced architecture group has begun studying design options for specific classes of applications. A collaboration involving Argonne computer scientists and computational biologists and researchers at the University of Chicago aiming to advance large-scale computing in systems biology has begun to analyze model organisms and to design a whole-cell modeling system targeting petascale architectures. Laboratory researchers in computational nanoscience have begun development of an integrated simulation environment that combines models at multiple temporal and spatial scales; the researchers are also developing a virtual fabrication line simulation capability that will complement facilities being deployed in the Center for Nanoscale Materials (see Section III.A.1).

Resources required for the Petaflops Computing and Computational Science initiative are specified in Table III.4. Included are costs for facilities and for a concomitant increase in personnel (systems staff, postdoctoral researchers, scientific programmers, and permanent research staff). Funding will be sought from the Mathematical, Information, and Computational Sciences Division (KJ-01) and from other sponsors within DOE's Office of Science.

Table III.4 Petaflops Computing and Computational Science ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	2.0	4.0	12.0	16.0	24.0	24.0	24.0
Capital Equipment	-	1.0	2.0	4.0	40.0	40.0	40.0
Construction[a]	-	-	-	7.7	7.7	7.7	7.7
Total	2.0	5.0	14.0	27.7	71.7	71.7	71.7
Direct Personnel	10.0	20.0	60.0	80.0	120.0	120.0	120.0

[a] Detailed planning for the advanced computation building will be done in FY03. Calculation of construction costs assumes third-party financing for FY04 and FY05, with leasing to begin in FY06. The calculated leasing cost is based on 240,000 square feet at $28 per square foot, plus overhead at approximately 1.15%.

B. Energy

1. Advanced Nuclear Fuel Cycle

The need to produce increasing amounts of energy and still reduce the burden of energy production on the environment dictates that nuclear energy will have a major role in the future. Nuclear energy on the required scale cannot be realized without addressing problems associated with spent fuel disposition and nuclear nonproliferation. The best way to address those two problems is through an advanced nuclear fuel cycle that returns fuel to the reactor and produces a more benign waste form.

The requirement for an advanced nuclear fuel cycle is recognized in the May 2001 report of the National Energy Policy Development Group: "The United States should reexamine its policies to allow for research, development, and deployment of fuel conditioning methods (such as pyroprocessing) that reduce waste streams and enhance proliferation resistance." This need was also recognized more recently in the May 2002 summit meeting between President Bush and Russian President Putin. The two presidents agreed that their governments see promise in advanced technologies for nuclear reactors and nuclear fuels that would significantly reduce the volume of waste produced by civilian reactors, would be highly proliferation resistant, and could be used to reduce excess stocks of weapons-grade plutonium and other dangerous nuclear materials.

Argonne has been collaborating with DOE-Nuclear Energy, Science and Technology, as well as with other national laboratories, industry, and international partners, to formulate an Advanced Nuclear Fuel Cycle initiative. The initiative's objective is to develop the technology base for a new globally secure, sustainable nuclear regime that will allow nuclear power to become a publicly acceptable, growing part of the energy supply mix in the United States and abroad. Such a regime would also be marked by reduced and stabilized inventories of spent nuclear fuel, secure management of problematic nuclear materials, enhanced proliferation resistance, and restoration of U.S. global leadership in nuclear technology.

Working with international partners, the Advanced Nuclear Fuel Cycle initiative would demonstrate the technologies and nuclear systems needed to establish the desired new nuclear regime. The two key technologies and systems that must be developed and demonstrated are a closed, proliferation-resistant fuel cycle and an advanced fast-neutron-spectrum facility. Argonne proposes to develop and demonstrate a fuel cycle based on pyroprocessing and a fast-spectrum nuclear reactor.

In addition to its work on the pyroprocess fuel cycle and the fast reactor, Argonne is a leader in developing advanced aqueous separation technologies that might also help to close the nuclear fuel cycle. We will assess both pyroprocessing and advanced aqueous options to determine their appropriate roles in meeting the objectives of the Advanced Nuclear Fuel Cycle initiative. Moreover, Argonne plans to continue supporting the development of transmutation system models and assessing transmutation options, including thermal reactors.

Primary support for the Advanced Nuclear Fuel Cycle initiative will be sought from DOE-Nuclear Energy, Science and Technology (AF). Required resources are summarized in Table III.5.

Our Advanced Nuclear Fuel Cycle initiative has four components: (1) oxide fuel reduction and actinide recovery, (2) the demonstration of reactor transmutation, (3) a spent fuel treatment facility, and (4) design studies for a prototype reactor.

Table III.5 Advanced Nuclear Fuel Cycle
($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	27.0	35.0	41.0	49.0	54.0	57.0	59.0
Capital Equipment	5.0	8.0	10.0	8.0	5.0	5.0	5.0
Construction	-	-	-	-	-	-	-
Total	32.0	43.0	51.0	57.0	59.0	62.0	64.0
Direct Personnel	135.0	170.0	190.0	220.0	230.0	230.0	230.0

Oxide Fuel Reduction and Actinide Recovery. Pyroprocessing is now being used on a production basis at Argonne-West to treat spent fuel from the Experimental Breeder Reactor-II (EBR-II). However, the current system cannot process oxide spent fuel, nor can it separate and recover plutonium and higher actinides. Necessary advances are the development and demonstration of (1) a front-end process for reducing oxide fuel to metal suitable as input for electrorefining and (2) a process for recovering plutonium and other actinides for recycling into fast reactor fuel. Also required is completed qualification of the metal and ceramic waste forms for disposal in a repository. Those waste forms contain metals and fission products remaining after the separation and recovery of uranium, plutonium, and other actinides.

Demonstration of Reactor Transmutation. Demonstration of transmutation of actinides in a fast reactor requires fabrication of fuel containing actinides and irradiation of the fuel in a fast reactor to about 10% burnup. Such a demonstration will show that fuel containing actinides can be fabricated successfully in a remote process, that the fuel performs reliably in the reactor, and that the fuel has the necessary inherent safety characteristics. With no fast reactor operating today in the United States, the demonstration will require international collaboration. (Argonne currently supports the fabrication of samples of various actinide-bearing fuels for irradiation in both domestic and international facilities.)

Spent Fuel Treatment Facility. As the third component of this initiative, we propose that a spent fuel treatment facility be designed, constructed, licensed, and operated to treat spent fuel from light-water reactors. This facility would be larger than that employed in demonstrations of separations technologies, nominally in the range of 100-500 metric tons of heavy metal per year. Operation of this facility would further demonstrate the technical and economic viability of fuel recycling, particularly fabrication of new fuel containing recycled actinides and production of waste forms for disposal. In addition, the facility's operation would reduce the amount of spent fuel destined for a geologic repository and would support the deployment of subsequent treatment facilities.

Design Studies for a Prototype Reactor. Finally, we propose to conduct nuclear system R&D and design studies focusing on a medium-sized fast reactor (with a power rating of 300-400 MWe) that incorporates lessons learned about fast-reactor technology from around the world, particularly lessons from Argonne's successful EBR-II program. Past experience in designing and operating fast reactors will be combined with new technologies to design a power plant having optimal capital costs. International collaboration will facilitate the incorporation of worldwide lessons learned, and Argonne will seek partnerships with countries having significant experience with fast reactors and sustained interest in the technology, particularly Japan, France, and Russia.

2. Hydrogen Research and Development

In his 2003 State of the Union address, President Bush announced a major hydrogen initiative. The goal is to reverse America's growing dependence on foreign oil by developing the technology for commercially viable fuel cells that use hydrogen to power cars, trucks, homes, and businesses without directly emitting pollution or greenhouse gases. This national initiative encompasses R&D on, and eventual deployment of, the technologies and infrastructure needed to produce, store, and distribute hydrogen for use in fuel cell vehicles, industrial production, heating, and electricity generation. Combined with the FreedomCAR Partnership, the President's new program is expected to accelerate the development of hydrogen-powered fuel cells and a hydrogen infrastructure. Achieving the President's comprehensive vision for our energy future requires an aggressive, interdisciplinary R&D effort spanning the fields of materials science, chemistry, and engineering. It is broadly appreciated that a hydrogen economy will not be economically competitive until fundamental breakthroughs occur in many areas, including more efficient hydrogen production, far more effective storage at high energy densities, more efficient hydrogen distribution, and more effective ultimate utilization.

In response to this national initiative, Argonne has mounted a coordinated effort that integrates its expertise in basic science and technology and in nearer-term technology development and deployment with its state-of-the-art user facilities. Central to our research program are two cross-cutting objectives that drive progress toward the hydrogen economy: (1) high-performance materials for hydrogen separation and fuel cell membranes and (2) new catalysts that improve hydrogen production and combustion. In pursuit of these objectives, we draw on our broad knowledge of materials science and chemistry to orchestrate comprehensive research programs that coordinate advances across the spectrum from basic science to applications. In particular, our program builds on insights and research directions identified by two recent workshops: (1) the May 2003 Workshop on Hydrogen sponsored by DOE-BES, in which Argonne played a leading role, and (2) the August 2002 Workshop on Hydrogen Storage Materials sponsored by DOE-Energy Efficiency and Renewable Energy, which the Laboratory hosted.

The unique capabilities of Argonne's IPNS, APS, and Electron Microscopy Center will be particularly valuable in our work on high-performance materials and catalysts for the hydrogen economy. To investigate the production of hydrogen from nuclear power, we will rely on Argonne's extensive expertise in nuclear reactor technology. To address hydrogen utilization issues, we will take full advantage of experience and facilities developed through our participation in the FreedomCAR Partnership and in the stationary fuel cell distributed generation program for electric utilities.

We are already one of DOE's leading resources for developing the technologies required for hydrogen production, distribution, storage, and utilization. Key elements of our current programs are funded by DOE through the Offices of Science; Energy Efficiency and Renewable Energy; Fossil Energy; and Nuclear Energy, Science and Technology. Further valuable work is sponsored by industrial collaborators. Current R&D programs are investigating the following areas:

- Hydrogen production
- Hydrogen storage
- Fuel cell development and testing
- Fuel and power systems
- Vehicle simulation and testing
- Economic and technical analysis
- Infrastructure assurance
- Environmental research
- Technology validation projects

Primary support for the Hydrogen Research and Development initiative will be sought from the DOE Offices of Science (KC); Energy Efficiency and Renewable Energy (EE); Fossil Energy (AA); and Nuclear Energy, Science and Technology (AF). Required resources are summarized in Table III.6.

Table III.6 Hydrogen Research and Development
($ in millions BA, personnel in FTEs)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	2.0	5.0	9.0	16.0	24.0	24.0	24.0
Capital Equipment	-	0.5	1.5	3.0	3.0	2.0	1.5
Construction	-	0.2	5.0	5.0	-	-	-
Total	2.0	5.7	15.5	24.0	27.0	26.0	25.5
Direct Personnel	10.0	25.0	45.0	80.0	120.0	120.0	120.0

The Hydrogen Research and Development initiative we now propose has six coordinated components: (1) production, (2) storage, (3) utilization, (4) infrastructure, (5) environmental research, and (6) technology validation.

Hydrogen Production. We will explore a variety of options for efficiently producing hydrogen by using domestic energy resources — fossil, nuclear, and renewable. We will continue to develop fuel processing technology as a near-term means of producing hydrogen from fossil fuels or from renewable fuels such as ethanol. The main transition strategy envisioned involves co-production of electricity and hydrogen from fossil fuels, with stringent environmental controls and carbon sequestration. Much of the required research on fossil fuels will be applicable to our longer-term emphasis on co-generating electricity and hydrogen by nuclear power and to our focus on developing novel low-temperature thermochemical cycles and advanced membranes to use the heat from a nuclear power plant to generate hydrogen from water. By developing the next generation of nuclear reactors ("Generation IV") in conjunction with efficient hydrogen generation technology, we will address the nation's two major energy needs: electricity and transportation fuels. In the meantime we are also working to facilitate the use of existing nuclear power plants to produce hydrogen.

Hydrogen Storage. A major challenge to the success of hydrogen-powered vehicles is the development of lightweight, compact, and safe onboard storage capabilities for adequate quantities of hydrogen. Building on a DOE-sponsored workshop that Argonne hosted in FY 2002, we will explore new and innovative concepts for storing hydrogen. Laboratory-directed research is already investigating two such novel concepts, and other ideas are being considered. Some of this research will benefit importantly from work at Argonne's emerging Center for Nanoscale Materials. We propose to lead a DOE-supported virtual center for research on storage of hydrogen through novel approaches such as chemical hydrides, metal-organic frameworks, and nanoclusters and nanofibers. We also propose to participate in other DOE virtual centers that are to investigate storage using carbon-based materials and advanced hydrides.

Hydrogen Utilization. Our work on hydrogen utilization will build on our extensive, wide-ranging partnerships with nonfederal organizations in areas that will be crucial to developing this aspect of the hydrogen economy. We have conducted research on the FreedomCAR with the automotive industry and its suppliers, helped fuel cell companies in product development, worked with state and local government agencies on alternative fuel demonstrations, and helped electric power companies analyze the technological requirements for load management and transmission.

Infrastructure Development. In collaboration with Canadian partners on the "2050 Study," we are examining long-range supply-and-demand scenarios for transportation fuels. For the Hydrogen Research and Development initiative we propose further technical and economic analyses focusing specifically on issues related to hydrogen distribution. Our expertise in infrastructure assurance will allow us to identify the steps needed to ensure that a national network for hydrogen transmission and distribution is safe and secure.

Environmental Research. Environmental impacts from the transition to a hydrogen economy must be considered. In particular, we will draw on our broad expertise in environmental research to investigate largely unanswered questions regarding effects on the atmosphere and on global warming from leaks and other losses of hydrogen from a national hydrogen infrastructure and vehicles.

Technology Validation. DOE is soliciting partnerships to conduct cost-shared demonstrations of hydrogen-powered vehicles and of hydrogen production and other infrastructure. We will form a regional partnership with vehicle developers, energy suppliers, and vehicle fleet operators for needed hydrogen technology demonstrations. In addition, at Argonne-West we propose to construct and operate a hydrogen technology demonstration facility utilizing nuclear power.

IV. Science and Technology Strategic Plan

This chapter provides an overview of our strategic plan for research in science and technology. For specific Laboratory program areas, the chapter presents summary plans that describe strategies for accomplishing each program's objectives, in the context of relevant issues and obstacles to be overcome.

Overall coordination of our planning with that of the Department of Energy takes advantage of key DOE and administration planning documents, including the following:

- The national energy policy of the Bush administration, May 2001, a first step toward a comprehensive, long-term national strategy that uses leading-edge technology to produce an integrated national energy, environmental, and economic policy (URL: www.energy.gov/HQPress/releases01/maypr/energy_policy.htm).
- The annual budget request submitted by DOE to Congress (URL: www.cfo.doe.gov/budget/04budget/index.htm), including budget justifications for the Office of Science (URL: www.cfo.doe.gov / budget / 04budget / content/science/science1.pdf) and other DOE offices that support Argonne research.
- The strategic plans of DOE and its Office of Science, which were being updated in April 2003.

Cooperation among the DOE laboratories, particularly through direct R&D collaborations, is increasingly extensive. This trend toward a more integrated laboratory system is described from an Argonne perspective in the Appendix.

A. R&D Area Strategic Plans

The balance of this chapter presents summaries of strategic plans for each of 20 planning units that span our major mission areas (see the inset box on the next page). These strategic plan summaries are grouped into (1) fundamental science and national research facilities, (2) energy and environmental technologies, and (3) national security. This grouping encompasses DOE's four mission areas. In addition, a concluding summary plan addresses the crosscutting topic of collaborative R&D partnerships.

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

A number of the R&D area plans that follow include discussions of program-specific initiatives. These discussions complement presentation of Argonne's major Laboratory initiatives in Chapter III.

1. Fundamental Science and National Research Facilities

Our activities in the area of fundamental science and national research facilities are supported predominantly by DOE's Office of Science.

a. Advanced Photon Source

Situation

The Advanced Photon Source (APS) is Argonne's premier user research facility. Its ongoing successful operation is central to continuing our outstanding performance in science and technology. Built and operated for DOE-Basic Energy Sciences (DOE-BES), the APS is delivering on its promise to serve the scientific community and to enhance U.S. productivity in a broad spectrum of scientific and technological areas. Over 4,800 individuals have qualified for badges to use the facility, and in 2002 nearly 2,400 unique users performed work there. International competition in this research area

Argonne's Strategic Plans

1. **Fundamental Science and National Research Facilities**
   a. Advanced Photon Source
   b. Materials Science
   c. Chemical Sciences
   d. Nuclear Physics and the Argonne Tandem-Linac Accelerator System
   e. High-Energy Physics
   f. Mathematics, Computing, and Information Sciences
   g. Intense Pulsed Neutron Source
   h. Biosciences
   i. Environmental Research
   j. Science and Engineering Education and University Programs
2. **Energy and Environmental Technologies**
   a. Advanced Nuclear Technology
   b. Energy and Industrial Technologies
   c. Transportation Technologies
   d. Environmental Treatment Technologies
   e. Energy and Environmental Systems
   f. Biotechnology
3. **National Security**
   a. Nuclear National Security
   b. Infrastructure Assurance and Counterterrorism
   c. Department of Homeland Security
4. **Collaborative R&D Partnerships**

comes primarily from two similar synchrotron radiation centers, the European Synchrotron Radiation Facility in France and SPring-8 in Japan.

The APS began operating in 1996 as a user facility serving the worldwide community of x-ray researchers. Between 1989 and 1996, DOE invested $812 million in construction of the APS and in R&D supporting construction. The resulting world-class photon source today provides the brightest x-ray beams available in the United States, for a wide range of research fields such as materials science, structural biology, environmental studies, and applied engineering. Partner users — investigators from private industry, universities, government, and other institutions — have committed, in addition, more that a quarter billion dollars in capital investments for construction of APS beamlines. As of the summer of 2003, 28 of 34 available sectors were assigned to partner users who had formed collaborative access teams (CATs). (A sector comprises one bending magnet beamline and one insertion device beamline.) Included in these 28 sectors are 7 sectors fully operated by Argonne staff, including 1 by the Structural Biology Center (SBC) CAT and 6 by the X-ray Operations and Research section of the APS.

The SBC CAT, a national user facility for the study of macromolecular crystallography, is operated by Argonne's Biosciences Division and funded by DOE's Office of Biological and Environmental Research. Designed for rapid throughput, SBC CAT enables users to collect data by employing standard crystallographic techniques and multiple-energy anomalous-dispersion phasing techniques.

Two of the six sectors operated by the APS X-ray Operations and Research section began as a joint venture of Argonne's Chemistry and Materials Science Divisions, in partnership with the DOE-BES Geosciences program and Northern Illinois University. Those two sectors have been developed and instrumented for research in materials science, chemical science, atomic physics, solid state physics, and the geosciences.

The other four sectors operated by the APS X-ray Operations and Research section were originally designed and constructed by APS staff. These sectors focus on developing instrumentation and techniques that utilize the unique properties of APS radiation to advance the frontiers of scientific research capabilities. Among the capabilities developed are microbeam techniques, nuclear resonant spectroscopy, high-resolution inelastic x-ray scattering, coherence-based techniques, applications of high-energy x-rays, and the generation and use of polarized x-rays. The microbeam optics developed are providing foundations for the nanoprobe beamline that will be associated with the Center for Nanoscale Materials (CNM; see Section III.A.1), and the inelastic scattering program spawned the development of an entire APS sector devoted to inelastic x-ray scattering.

In addition to these six sectors, APS jointly operates three other sectors (in partnership with their respective CATs), providing funding and staff for operations and user support.

Demand is high for the remaining six unassigned APS sectors. One sector has been requested for structural biology research, and four other sectors have been requested for materials science (including the sectors for inelastic scattering and the nanoprobe beamline) and for environmental science. Decisions regarding assignment of the remaining sectors will be made over the next several years.

The APS provides 5,000 hours of user beam time each year. During 2002 the APS provided users with top-up (constant-current) beams — an operational mode pioneered at the APS and now used at other facilities — during 75% of their scheduled beam time. This achievement increases the number of ampere-hours delivered; facilitates beam stability because of the constancy of the power loading on the storage ring and optical components; and permits ring operation at lower emittance, because beam lifetime is no longer a concern. In 2002 the availability of APS beam time (the percentage of scheduled user beam time actually delivered) reached a new high of more than 97%.

Vision

The APS will continue to operate at current high reliability levels and will remain the preeminent source of hard x-rays for the U.S. research community into the foreseeable future. The facility will serve a wide range of frontier science and technology and will support investigations of importance to both science and national security. To maintain the high reliability of the accelerator and beamlines, we will implement innovative accelerator enhancements that further improve beam characteristics, as well as state-of-the-art technology that improves experimental capabilities. Through productive partnerships we will serve APS users better, thereby creating a rewarding and enriching R&D environment and enhancing the facility's worldwide leadership role.

Mission, Goals, and Objectives

The mission of the APS is to deliver world-class science and technology by operating an outstanding synchrotron radiation research facility accessible to a broad spectrum of researchers.

Overall goals are as follows:

- Operate a highly reliable third-generation source of synchrotron x-ray radiation.
- Foster a productive environment for conducting research.
- Enhance the capabilities available to facility users.
- Assure the safety of facility users and staff, as well as protection of the environment.
- Maintain an organization that provides a rewarding environment fostering professional growth.
- Optimize scientific and technological contributions to DOE and society from research carried out at the APS.

Major objectives for FY 2004 are as follows:

- Maintain the availability of accelerator operations at better than 95%.
- Maintain operating time scheduled for users at 5,000 hours.
- Provide APS users with essential services in the areas of technical support, operations, safety, administration, and general services.

Issues and Strategies

A major challenge for the APS is providing operational support for sectors originally constructed with funding from DOE-BES. To aid in the implementation of this new operational mode, we have developed a new, more flexible model for partnering with APS users. "Partner users" include members of the previous CATs and may also include groups involved in focused projects of smaller scope that make lasting improvements to the facility. (Other users are "general users.") We will continue to evaluate this new user model. In any case, optimizing the scientific productivity of these beamlines will require additional annual resources averaging $1.5 million per sector.

To date, all sectors assigned to partner users have an associated laboratory-office module for operational staff. Five additional prospective partner user groups are in various stages of writing proposals and raising funds, and the majority of those groups are expected to be approved within the next few years. Two are associated with facilities proposed as part of major Laboratory initiatives. First, the nanoprobe beamline will be associated with the CNM (see Section III.A.1); it will provide the capabilities needed to characterize and study nanostructures though a variety of techniques. Second, an additional sector is proposed as a high-throughput macromolecular crystallography beamline associated with Argonne's Functional Genomics initiative (see Section III.A.3). This beamline will focus on biostructures as they relate to structural genomics. Buildings for these proposed centers will be near the APS and will provide laboratory and office support for associated beamline users. However, no laboratory-office module currently exists to support the remaining prospective groups. Funding for the final laboratory-office module is required now so that the building will be available when it is needed for the proposed beamlines. Additional funding will also be needed to upgrade building services (e.g., heating and cooling).

The APS is a high-quality research facility with excellent, experienced staff. Although all of the technical design parameters of its accelerator systems have been achieved, the facility's staff continue to focus on responding to ever-increasing user demands for the best possible operational reliability and availability. To remain at the scientific forefront and maintain the excellence of its in-house research staff, the APS must continue to develop and meet technically challenging research objectives in accelerator physics, insertion device development, beamline design, optics R&D, and other areas.

Initiative: Enhancement of the APS and Development of Future Light Sources

Over the past three decades, the brilliance of x-ray sources has doubled every ten months. Use of coherent flux, which is directly proportional to beam brilliance, has had major unforeseen benefits for work in the life sciences, research on soft condensed matter, and materials science, even though the flux values currently available at the APS are relatively low. To achieve the benefits expected from future experiments at higher brilliance, planning must begin now for a 10- to 100-fold increase in APS beam brilliance.

Over the next 20 years, new and exciting x-ray sources based on energy recovery linacs (ERLs) and free-electron lasers (FELs) will be needed in the United States. These sources are not simple enhancements of third-generation sources. Rather, they are a new breed of sources having new properties and applications. Although some users of today's synchrotron radiation sources may become users of these new facilities, ERLs and FELs will not replace existing sources for most of today's researchers. Therefore, the APS must remain at the cutting edge of third-generation synchrotron radiation technology, where the demand for x-rays will not decrease for the next 20 years or more. At the request of DOE, we recently developed a 20-year upgrade plan for the APS that is organized into four temporally overlapping phases:

- *Phase I*. Complete beamline installations on the remainder of the storage ring and maximize operations at existing beamlines. This phase, which has already begun, is expected to extend over the next eight years.
- *Phase II*. Optimize source characteristics. This phase will overlap Phase I, beginning during FY 2004-FY 2005 and continuing for approximately a decade.
- *Phase III*. Develop the next-generation user facility by improving the efficiency and performance of beamlines and taking advantage of advanced detectors, robotics, and automation. This phase will start in full in approximately eight to ten years.
- *Phase IV*. Implement a major upgrade of the accelerator complex to develop a "super storage ring." Work on this final phase will begin about ten years from now and will last for approximately ten years. To minimize disruption to APS beam time, for which demand will continue, plans call for only one extended shutdown of the APS — for

implementation of a new linac and storage ring.

Phase I. The clearly appropriate focus of the first phase of a 20-year plan for the APS is full use of the storage ring. We expect that construction of about ten new beamlines will begin during FY 2004-FY 2012, taking advantage of the four remaining unassigned sectors (with two beamlines per sector) and the installation of several bending magnet beamlines. These ten new beamlines do not include (1) three sectors dedicated to macromolecular crystallography, where construction is about to begin (funded by non-DOE sources) and (2) the insertion device beamlines for two exciting proposals whose construction has been partially funded by DOE-BES — the inelastic x-ray scattering beamline and the nanoprobe beamline to be associated with the CNM. The average time from conception of a beamline to commissioning and start of user operations is approximately five years, so construction at the remaining available APS sectors is expected to continue through the next decade.

In parallel with construction of new beamlines, we must contend with the aging of existing beamlines. Ten years have passed since the original design of several beamlines. They will need major refurbishments over the next decade to take advantage of recent major advances in optics and instrumentation. Many beamlines can no longer meet the ever-increasing technical requirements of their users, or they simply fall short of optimal performance levels. This problem is compounded because storage ring operating parameters today are much better than the original specifications on which beamline designs were based. Development of state-of-the-art detectors is perhaps most urgent. In many cases, better detectors are already on the critical path to achieving faster data collection. Construction and refurbishment of some aging beamlines will be the responsibility of the APS, either alone or in collaboration with partner users. The proposed science to be performed at those beamlines will drive the new construction and upgrades. The APS will rely heavily on guidance from its Scientific Advisory Committee in determining which beamlines will be built and upgraded.

Future beamlines are expected to fall into two major categories: (1) those used for "routine data collection," which need to be provided as "turn-key" facilities, and (2) cutting-edge beamlines optimized for "experiments," where constant innovation and tweaking are necessary for scientific success. The highly specialized beamlines in the second category are being designed for radiation properties optimized to particular types of research, such as inelastic x-ray scattering, high-energy x-ray scattering, or nanoprobe applications. Therefore, concurrent with development of new beamlines under Phase I, the aggressive source development specified in Phase II is also needed.

Phase II. Given limitations imposed by the current magnetic lattice of the APS storage ring, further reductions in the natural emittance (presently better than the original design specification by a factor of almost three) can be only incremental. Therefore, without major reconstruction of the storage ring, significant increases in beam brilliance must come through the development of optimized insertion devices or increases in circulating beam current. Along with new insertion devices and higher current, compatible front ends and optical components will also be required. Replacement or upgrading of all original front ends will probably be needed to meet the thermal requirements of longer insertion devices and higher currents. The combination of optimized insertion devices, improved optics, and higher beam currents could improve effective brilliance by more than an order of magnitude.

Insertion device development will push toward shorter-period devices capable of higher energies (20-45 keV) with the first harmonic. We believe that the most promising approach to this development involves use of superconducting undulators. Increased brilliance at high photon energies (25 keV and above) will improve inelastic x-ray scattering capabilities and provide an unequaled source of high-brilliance hard x-rays for high-energy elastic scattering.

To improve beam brilliance further, we have begun to explore the possibility of increasing the length of straight sections in the storage ring to accommodate longer or multiple insertion devices. Initial results indicate that modifications of the storage ring lattice in a few places around the ring could increase the clear space for insertion devices to ten meters from the present five meters. Increased brilliance will be particularly important for certain cutting-edge, photon-hungry experiments, such as inelastic scattering, high-resolution imaging, correlation spectroscopy, and time-resolved studies. Longer straight sections would also allow installation of elliptically polarizing undulators optimized from 0.5 to 3 keV. The beam brilliance from these devices would result in a world-class beamline for photoemission and a photoemission electron microscope capable of spatial resolutions of a few nanometers, well suited to studying the magnetic properties of materials. Despite the common idea that high-energy storage rings are associated with the production of hard x-rays, 6-8 GeV is in fact an ideal stored-beam energy for generating elliptically polarized soft x-rays. This fact, combined with the inherently superior stability of higher-energy beams, means that high-energy storage rings have considerable advantage in generating high-quality polarized soft x-ray beams. The APS is likely to remain the only high-energy third-generation storage ring in the United States for the foreseeable future.

In addition to superconducting and polarizing undulators, Phase II will also pursue solenoid-driven undulators. Insertion devices based on solenoids can simultaneously have both variable periods and variable fields (in contrast to present-day devices having fixed periods and variable fields), making them valuable for a host of scientific applications requiring optimization in several different energy ranges.

As noted above, substantial reduction in the natural emittance of the APS is unlikely with its present lattice. However, the effective emittance delivered to users can be improved by enhancing beam stability. Phase II will therefore continue the focus on this effort. Phase II will also focus on reducing the size and duration of perturbations of the stored beam during the top-up process, which will further enhance beam quality.

Phases III and IV. To adequately accommodate the estimated 10,000 researchers who will use the APS during the coming decade, Phase III will improve ease of access, beamline performance, and data collection speed. Automation and robotics for sample alignment have already been implemented on macromolecular crystallography beamlines at the APS and elsewhere. Many physical science beamlines could benefit from implementation of similar techniques. For instance, integration of automated sample changers into powder diffraction beamlines and small-angle-scattering beamlines seems to be a straightforward extension of the sample changers used for macromolecular crystallography. Moreover, automated alignment of optical components and diffractometers could substantially increase scientific productivity of some beamlines (particularly the turn-key beamlines proposed for Phase I); automation should be incorporated into the design of these beamlines from the beginning. We also see a large class of experiments that could be performed effectively via remote access, if we can achieve real-time communication of data, experimental conditions, and beamline control.

Phase IV envisions significant improvements in the accelerator system. As indicated above, maintaining the existing 40-fold symmetry of the storage ring implies that only incremental improvements in particle beam brilliance can be expected. Phase IV calls for a radical change in the storage ring magnetic lattice, from 40-fold symmetry to 80-fold, that will reduce beam emittance by a factor of eight. This eightfold increase in beam brilliance — in combination with the increased brilliance achieved through optimized insertion devices, longer straight sections, and increased current — would put the APS near the limit of brilliance attainable with a storage ring of its dimensions and energy. The resulting super storage ring would significantly benefit the many important brilliance-related techniques, notably x-ray photon correlation spectroscopy, coherent imaging, inelastic scattering, and x-ray nanoprobe microscopes. The obvious advantage of the Phase IV approach to a super storage ring is its continued use of existing beamlines. The novel concepts proposed would create new capabilities that are qualitatively and quantitatively different, and considerable R&D will be required to verify the feasibility of the proposed alterations of the storage ring. Modification of the APS storage ring for reduced emittance would not be implemented until very late in the 20-year plan.

Required resources for the first eight years of the APS upgrade plan are summarized in Table IV.1. Funding will be sought from DOE-BES (KC).

Table IV.1 Enhancement of the APS and Development of Future Light Sources
($ in millions BA, personnel in FTE)

	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12
Costs								
Operating	3.6	5.6	8.0	8.2	9.0	7.5	7.5	7.5
Capital Equipment	16.4	19.4	22.0	24.3	23.5	20.0	20.0	20.0
Construction	-	-	-	-	-	-	-	-
Total	20.0	25.0	30.0	32.5	32.5	27.5	27.5	27.5
Direct Personnel	14.0	23.0	35.0	35.0	39.0	32.0	32.0	32.0

Initiative: Generation and Use of Short-Pulse Radiation from Free-Electron Lasers

In the late 1990s the Basic Energy Sciences Advisory Committee (BESAC) gave first priority to R&D on sources exploiting an 8- to 20-keV x-ray laser. We have joined five partners — Brookhaven, Los Alamos, and Lawrence Livermore National Laboratories; the Stanford Linear Accelerator Center (SLAC); and the University of California at Los Angeles — to develop a proposal for a laser in the required wavelength range. Development of the proposed facility, the Linac Coherent Light Source (LCLS), will make use of the two-mile linear accelerator at SLAC and will take advantage of the distinctive capabilities of each of the partner institutions. We have agreed to develop the integrated undulator systems for the LCLS, which will account for about 20% of the total estimated project cost. This work will be funded separately from APS operations.

The original LCLS Scientific Advisory Committee, led by Gopal Shenoy (Argonne) and Joachim Stohr (Stanford University), gave BESAC a detailed proposal for pioneering experiments in atomic, molecular, plasma, and laser physics; in protein crystallography; and in nanoscale dynamics in condensed matter. Argonne researchers must start now to develop the optics, instrumentation, beamlines, and experimental techniques for the next generation of laser-based x-ray experiments, if they are to lead the use of the LCLS and remain at the forefront of synchrotron radiation research. For example, this unique facility will undoubtedly have major scientific impact in areas such as femtosecond time-resolved studies. The expertise needed for such studies should be developed now, so high priority should be given to a strong program of pump-probe studies using the APS with its current characteristics. Time-resolved studies, currently under way at the APS though in a nascent stage, should be expanded in scope and enhanced to improve temporal resolution, in order to exploit fully the unique science achievable through this largely unexplored field of study. To gain valuable experience in the use of femtosecond x-ray pulses, we are actively participating in the Sub-Picosecond Photon Source project being developed at SLAC, which aims to produce femtosecond electron pulses at the existing two-mile linac. The APS is providing the required insertion device, and APS staff are involved in experimental investigations of uses for those x-rays. First light from the project was obtained in the summer of 2003.

To further explore the physics and scientific applications of short-pulse radiation from FELs, we are developing a proposal for a partner user program to enhance operation and use of the vacuum ultraviolet FEL at the APS. Unlike users of other synchrotron-based facilities, FEL user partners would not use x-rays from a storage ring source. Rather, they would use ultraviolet radiation generated by an FEL on the low-energy undulator test line at the APS. No tunable laser systems existing today can access the wavelength range below roughly 150 nanometers. This very interesting wavelength range is still virtually unexplored by any tunable, high-power femtosecond laser system anywhere in the world.

Required resources are described in Table IV.2. Funding will be sought from DOE-BES (KC).

Table IV.2 Generation and Use of Short-Pulse Radiation from Free-Electron Lasers
($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	-	-	1.8	2.0	1.1	-	-
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	-	-	1.8	2.0	1.1	-	-
Direct Personnel	-	-	4.3	3.8	0.8	-	-

b. Materials Science

Situation

Our research in materials science addresses critical issues underlying the development of new and improved materials that play crucial roles in both the national economy and DOE mission areas. Our work embraces experimental and theoretical studies, as well as computer simulations. Laboratory programs provide the fundamental understanding of novel materials that will underpin tomorrow's technologies. These programs emphasize the broad scale and depth of investigation that are possible within the national laboratories.

Our user facilities for materials research feature prominently in Laboratory research programs. We play a leading role in developing the instrumentation and experimental design needed to apply our facilities to problems at the frontiers of materials science. Our programs stress collaborations with leading scientists at the Laboratory, across the nation, and around the world.

Key materials research areas at Argonne include superconductivity, magnetism, ferroelectricity, ceramic films, metals, carbon, biomaterials, and nanoscale materials science and technology. Crosscutting research themes are emphasized, especially complex oxides, interfaces, and defect production.

Vision

We will foster world-class materials science, forefront instrumentation, and unique user facilities. The combination of individual freedom and teamwork that nurtured past successes will be strengthened. Our contributions to new materials, especially at the nanoscale, will support both DOE and the nation in meeting new scientific, technological, and economic goals.

Objectives

Specific objectives of our research are as follows:

- Develop forefront programs in nanoscale materials science that explore the effects of confinement, proximity, and organization in magnets, superconductors, and ferroelectrics.
- Develop innovative neutron scattering science and apply it to the investigation of materials, in preparation for the advent of the Spallation Neutron Source.
- Understand and exploit the rich diversity of behavior in complex materials, including oxides, polymers, biosynthetic composites, and carbon.
- Develop novel instrumentation that drives the frontier of science at the APS and the Electron Microscopy Center (EMC).

Issues and Strategies

Today is a time of high opportunity in condensed matter and materials physics. National attention on nanoscience has revealed new horizons for creating, understanding, and controlling novel behavior in materials arising from their nanoscale structure. Now within reach are grand challenges in materials fabrication by lithography and self-assembly, as well as in materials characterization using scanning probe microscopy, electron microscopy, focused x-ray scattering, and neutron scattering. Moreover, a complementary national emphasis on biology and medicine reveals many opportunities for adapting the traditional tools and ideas of materials physics to the study of genomes, proteins, and living cells. Qualitatively new materials and functionality can be created at the "hard-soft" interface between biology and condensed matter. All these directions are part of a general trend in materials physics toward increasing complexity. Exploiting this rich diversity of behavior will require new concepts and new approaches to integrating interdisciplinary experiments and theory in a comprehensive research program.

We will take advantage of these unusual opportunities to strengthen our contributions to materials science. Creation of a new CNM (see Section III.A.1) will extend the Laboratory's reach in materials science through development of fabrication facilities, a nanoprobe x-ray beamline at the APS, and new nanoscale characterization instruments. With other national laboratories, we are developing a Transmission Electron Aberration-Corrected Microscope that will bring subnanometer spatial resolution and real-time response to a host of new materials experiments. We are launching new programs in biosynthetic materials and spin-electronic materials and are teaming with other national laboratories to develop Centers of Excellence in Synthesis and Processing, in the areas of granular materials, permanent magnetism, ultrananocrystalline diamond, and ferroelectrics.

We emphasize excellent basic science as the cornerstone of our materials science program. We continuously refresh our program mix by adding new directions as new materials are discovered and research capabilities grow. We stress comprehensive programs that incorporate integrated experimental and theoretical thrusts and exploit advanced scientific instrumentation ranging from benchtop scanning probes to unique x-ray and neutron sources. We regularly attract outstanding international scientists as collaborators in our interdisciplinary programs. Leading theorists are attracted to our new Materials Theory Institute for stays of one week to six months in support of key experimental programs. The resulting extensive professional network is invaluable as a source of intellectual stimulation and also as a source of outstanding candidates for postdoctoral and permanent staff positions.

We have launched an interdisciplinary program for the design, synthesis, and characterization of a new class of nanostructured biocomposite materials that exploit the capabilities of biological molecules to store and transduce energy. The goal is to organize complex biological molecules (e.g., light-harvesting proteins) into artificial host structures where the biological function can be optimized and exploited. An interdisciplinary team of materials scientists, chemists, and biologists will use a novel lipid-based complex fluid and a rigid mesoporous inorganic framework as the host materials for biomolecules. This novel approach to nanostructured biomaterials that exploit biological functions has great scientific interest and enormous technological value. Research results are expected to provide fundamental insight into ways to use soft and hard materials to construct complex architectures that combine the functionality of biomolecules with the novel properties of host materials. This work will also provide fundamental knowledge of (1) nanoscale phenomena occurring at the interfaces between the integrated materials and (2) means to tailor energy transduction processes. Results could lay the groundwork for producing the next generation of materials for use in sensors, optoelectronics, artificial organs, and catalysis. This program will use major Argonne research facilities, including the APS, the EMC, the Intense Pulsed Neutron Source (IPNS), the Advanced Computer Research Facility, and the new CNM (see Section III.A.1). Also available for this work will be the facilities of the Center for Nanofabrication and Molecular Self-Assembly at Northwestern University. These major facilities provide unique capabilities for synthesizing and characterizing new biomaterials, as well as for understanding and tailoring their properties. This program was funded at the end of FY 2002 by DOE-BES through its program Nanoscale Science, Engineering, and Technology Research.

User Facility: Electron Microscopy Center

Situation

Argonne's EMC provides transmission and scanning electron microscopy for high-spatial-resolution imaging, microanalysis, and *in situ* research. The EMC includes the Intermediate Voltage Electron Microscope (IVEM)-Tandem, which is employed for a variety of *in situ* studies, especially for dynamic recording and structural characterization of the effects of ion irradiation. The IVEM-Tandem is the only facility in the Americas with this specialized capability, and it is used by the international community. Qualified users access the IVEM-Tandem by submitting written proposals that are peer reviewed. For nonproprietary research there are no use charges. EMC users — including researchers from universities, other national laboratories, and industry — conduct studies ranging from imaging of electron-sensitive soft materials to *in situ* observations of phenomena at elevated and cryogenic temperatures in pure metals and alloys, semiconductors, and ceramics.

Other advanced instrumentation in the EMC includes a state-of-the-art transmission electron microscope (TEM) with a field emission gun, excellent analytical capabilities, and the capability to perform holographic and Lorentz imaging. A high-resolution scanning electron microscope (SEM) with a field emission source provides a broad range of capabilities in surface analysis. We are in the process of acquiring new instrumentation using focused-ion-beam techniques for manipulating and modifying samples on the nanoscale. The EMC continues to drive important developments in its field. We are currently pursuing an aberration-corrected TEM that will provide unprecedented capabilities for *in situ* experiments and will be ideally suited to comprehensive diffraction and spectroscopy studies of single nanoparticles in controlled magnetic environments.

Vision

The EMC will develop new techniques and methods and state-of-the-art TEM and SEM instrumentation, including capabilities for *in situ* studies. The materials research supported will provide important new insights for major technologies in such areas as micromagnetics, irradiation effects in high-temperature superconductors, solid-state amorphization reactions, and analysis and control of nanostructures.

Issues and Strategies

Our IVEM-Tandem facility provides ion beam capability for *in situ* studies and in this role remains a special resource for the national research community. The EMC is developing a new program to improve *in situ* experimentation based on novel designs for holders and samples. These advances will serve as an important foundation for a major new initiative in aberration correction for electron microscopy. At the same time, the EMC will develop new methods and capabilities for imaging and diffraction of single nanoparticles, especially position-sensitive diffraction.

A major issue in the current EMC experimental space is high levels of vibrational, electromagnetic, and thermal noise that reduce the effectiveness of the facility's electron microscopes. The most advanced microscopes cannot operate at their designed specifications because of the mechanical vibration of the floor. Vibration and other noise problems are inherent in a building constructed in the mid 1960s and designed for other uses. Required noise isolation will become much more stringent for the aberration-corrected microscopes to be developed under the initiative described below. This level of noise isolation can be achieved only in a new, state-of-the-art building designed to have quiet floors, electromagnetically shielded rooms, and precise temperature control. Ideally, such a dedicated noise-free building would be located near complementary facilities such as the Center for Nanoscale Materials. Experimental samples fabricated in the Center for Nanoscale Materials could then be characterized conveniently by using the electron microscopy.

Initiative: National Transmission Electron Achromatic Microscope

Thanks to advances in aberration correction and quantitative-transmission electron microscopy, a new generation of electron microscopes can be built that are capable of sub-angstrom image resolution and sub-electron-volt spectroscopic resolution and that have space adequate for a variety of important experiments on advanced materials. To take advantage of these new technologies, the EMC is participating in the proposed Transmission Electron Aberration-Corrected Microscope (TEAM) project. The required instrument development will be carried out cooperatively at DOE's four national centers for electron beam microcharacterization, with each center contributing a complementary specialized facility based on a common platform.

The revolutionary combination of space and resolution envisioned for TEAM instruments will allow the electron microscope to be converted into a true experimental materials science laboratory. Scientific benefits to be expected include the first three-dimensional atomic imaging of defect structures; the first atomic structure determination of a glass; microscopic understanding of magnetism and ferroelectricity in nanostructures; visualization of dislocation interactions in nanostructures under controlled stress; development of interface science to the level of surface science; understanding of grain boundary motion under stress in nanocrystals; understanding of chemical reactions on highly curved, small catalyst particles; and imaging of defects in the oxygen sublattice of complex oxides. More generally, advances in electron beam micro-characterization associated with the development of TEAM will be crucial for proper implementation of the planned national thrust in nanotechnology. The TEAM project will also help to revitalize the critically important electron optics industry in the United States.

Following an international workshop held at Argonne in FY 2000 and a second workshop held at Berkeley Lab in FY 2002, the EMC is receiving preliminary funding to develop the new electron-optic designs necessary to incorporate aberration correction in electron microscopes. This work will include a broader program in aberration correction for charged-particle optics. The focus will be a novel design that enables excellent control of the magnetic environment around the sample, a requisite for studying magnetism at the atomic scale. These efforts will contribute importantly to Argonne's growing research in nanoscience.

Funding will be sought from the DOE-BES Materials Science program (KC-02). Partnerships with industry and universities that have already been developed will be an important component of this new Argonne initiative.

c. Chemical Sciences

Situation

Chemistry is an Argonne core capability. World-class research programs and staff with cutting-edge expertise study fundamental scientific questions critical to DOE's mission. Our research provides the foundations for addressing issues of energy independence, environmental sustainability, and national security, and it will underpin new technologies for energy efficiency, energy conversion, combustion, nanotechnology, cleanup and disposal of radioactive and nonradioactive waste, and catalysis.

Vision

We will enhance our status as a leading performer in chemical science research by sustaining our preeminence in established research focus areas, by seeking new initiatives, and by forging new collaborations based on our core competencies to pursue new multidisciplinary research challenges.

Objectives

Our chemical science program will grow around our core competencies — in physical chemistry, chemical dynamics, and chemical energy sciences — to focus aggressively on important new research areas by developing closer ties within the chemical sciences program and with other programs at Argonne and the University of Chicago. Our objective is to foster cross-disciplinary collaborations that will provide revolutionary approaches to difficult problems in chemical science. Major long-range objectives of Argonne's core research in the chemical sciences are as follows:

- Investigate issues related to interfacial dynamics and to gas- and condensed-phase chemistry, in order to broaden our expertise both in experimentation and in theory and computation, with the goal of understanding chemical reactivity in all forms.
- Examine the chemical and physical properties of nanoscale materials — including gas-phase clusters, colloids in solution, hybrid bioinorganic systems, and nanomaterial on or in bulk phases — through studies combining experimentation and theory.
- Improve understanding of the fundamental fast-transient physicochemical phenomena that occur when radiation interacts with matter, in the context of
  - Photochemical energy conversion in natural photosynthetic systems and comparisons with photochemistry in synthetic systems,
  - Charge dynamics and transport in the condensed phase, and
  - Gas-phase photoionization and x-ray interactions with atoms and molecules.
- Develop expertise and facilities to investigate the fundamental chemical and physical properties of actinides.

Essential to achieving these objectives are the development and use of special tools and facilities, including the following:

- Specialized capabilities at the APS, including transient x-ray spectroscopies (x-ray absorption and scattering); hard x-ray physics (atomic, molecular, and optical); and the Actinide Facility for experiments involving samples that contain such elements
- Novel electron and x-ray generators
- Time-domain, multifrequency capabilities for electron paramagnetic resonance
- Transient optical spectroscopies
- Scalable software for theoretical chemistry simulations, optimized to run on large centralized parallel computer platforms at Argonne and elsewhere

Issues and Strategies

Our core chemical sciences research programs integrate special expertise with unique tools and facilities. The recent developments described below are establishing new directions in chemical sciences research that are consistent with DOE's energy mission. In addition to support from DOE-BES, we will explore a broad range of further funding sources for studies in these new directions.

In this context, important recent developments include the following:

- We are investigating new ideas about hydrogen production and storage on the basis of our recent discoveries in such diverse areas as synthesis of template-derived carbon nanofibers, the reduction power of irradiated metal oxide colloids, and bonding patterns in organic-inorganic hybrids. (See the major Laboratory initiative Hydrogen Research and Development in Section III.B.2.)
- Our developing capabilities for synthesizing nanoparticles can address fundamental questions about reactivity and promise novel approaches to organized assembly. We are also developing tools to study electronic structure in confined spaces; to observe the migration of charge, photons, and spin; and to understand the high efficiency and selectivity of catalysis on the molecular scale.
- We are gaining valuable experience in areas of research at the inorganic-biochemical interface; state-of-the-art time-resolved x-ray capabilities on molecular and kinetic time scales; completion of the first phase of the tabletop terawatt laser for ultrafast pulse radiolysis; and rapidly expanding computational chemistry power on local and remote parallel facilities. The resulting synergistic capabilities are providing critical mass to address issues in complexity and in collective phenomena, including particle aggregation and disaggregation in inorganic systems and protein dynamics in biological systems.

The chemical science goals in the major Laboratory initiative Center for Nanoscale Materials (Section III.A.1) derive directly from Argonne's core expertise in areas including (1) the assembly of nanostructures from gas-phase clusters or fluidic phases, focusing on understanding the forces that drive aggregation and developing experimental and theoretical methods for controlling the assembly of nanostructures; (2) controlled reactivity in hybrid nanostructures, focusing on understanding and controlling photochemical, catalytic, and biological reactivity in bioinorganic hybrids and mesoporous structures at the nanoscale (an area in which the project Nano-Engineering the Biomolecule-Inorganic Interface for Integrated Photochemistry and Catalysis has been funded); and (3) information transfer between nanodomains, focusing on understanding the principles by which the communication between nanoscale devices (sending and receiving) can be organized and controlled. Our expertise in transient spectroscopies, x-ray synchrotron science, photochemistry, and theory, coupled with emerging expertise in scanning-probe microscopy, will be critical for understanding these phenomena. We have initiated a program in nanophotonics for these studies.

Our integrated program in the fundamental chemistry of radioactive waste is partly supported by the DOE Environmental Management Science Program. We are uniquely qualified to undertake this program through our core capabilities in chemical separations science, heavy-element chemistry, radiation chemistry, and theoretical chemistry, as well as through our facilities for research with radioactive materials (including the Actinide Facility at the APS and our nuclear magnetic resonance (NMR) facility designed for studying radioactive materials). This program of experimental and theoretical research responds to a national need for greater fundamental knowledge of the chemistry underpinning technologies for the cleanup and disposal of radioactive waste.

We have developed two research programs in the chemical sciences in response to DOE's Nuclear Energy Research Initiative (NERI). Both were awarded funding in 2002. One program focuses on (1) an innovative, single-material, minimum-volume approach to the selective sorption of most metal ion radionuclides from aqueous waste solutions and (2) the subsequent creation of a final nuclear waste form that is suitable for long-term storage or burial. In the other NERI research program, we are collaborating with the University of Wisconsin to study radiation-induced corrosion relevant to designing next-generation reactors. Higher energy efficiency can be achieved by operating pressurized-water reactors at pressures and temperatures well beyond those necessary for the formation of supercritical water. This work will consider the possibility of radiolytic water decomposition under such conditions.

We are partnering with Northwestern University in the Institute for Environmental Catalysis. This partnership takes advantage of our expertise in magnetic resonance, pulse radiolysis, synchrotron research at the APS, and heterogeneous catalysis. In a second institute, we are a partner with Ohio State University in research on the role of environmental molecular interfaces in the chemical and biological reactivity of pollutants. This collaboration will leverage our expertise in solid-state NMR, high-field electron paramagnetic resonance, and surface science. In a third partnership, we have joined the University of Notre Dame in studies on actinide chemistry that exploit our facilities and expertise in radionuclide chemistry.

We have developed a new program in computational chemistry in response to DOE's Scientific Discovery through Advanced Computing initiative. Conducted in collaboration with Sandia National Laboratories and several universities, the program focuses on software for calculating and applying reaction kinetics and dynamics. This effort exploits our expertise in chemical dynamics, theoretical chemistry, and computer science and is part of the multi-laboratory initiative Chemical Science Discovery through Advanced Computing: A Multi-Scale Collaboration. A second part of this program will develop the foundation for statistical methods and algorithms that provide internally consistent tables of active thermodynamic values.

d. Nuclear Physics and the Argonne Tandem-Linac Accelerator System

Situation

Review committees have consistently identified Argonne as one of the world's centers of excellence in nuclear physics research. Our leadership role in planning the Rare Isotope Accelerator, the next-generation nuclear physics accelerator, will continue this tradition. The Argonne program has many strengths, including (1) low-energy heavy-ion physics, which is largely performed at the Argonne Tandem-Linac Accelerator System (ATLAS) facility (discussed below); (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; (3) the study of relativistic heavy-ion collision dynamics by using beams from Brookhaven's newly commissioned RHIC (Relativistic Heavy Ion Collider); and (4) nuclear theory, which focuses on developing fundamental understanding of hadronic and nuclear structure, reactions, and dynamics.

Vision

Our 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

Our 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 of their stability: at high excitation energies, in exotic shapes, at rapid rotation, and with extreme proton-to-neutron ratios. Producing and detecting previously unknown isotopes and studying their structures can benefit greatly from secondary (radioactive) beams, which can provide access to regions of nuclei not currently accessible with stable beams. This approach will also allow laboratory study of key reactions in astrophysics and in the creation of the elements — reactions that occur in astrophysical settings and involve short-lived nuclei. To this end, we are proposing a national Rare Isotope Accelerator that will be based largely on novel superconducting accelerator technology originally developed at the Laboratory and used for ATLAS. (See Section III.A.2.)

Our 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. Argonne researchers are playing a leading role in the research program at TJNAF, emphasizing the use of a general-purpose magnetic spectrometer we constructed at the facility. At DESY the Argonne group emphasizes use of a dual-radiator ring-imaging Cerenkov detector in the Hermes experiment to study the spin structure of the proton. In addition, we are developing new technologies in laser atom trapping of noble gas atoms for sensitive trace isotope analyses and for tests of fundamental symmetries.

Our work in nuclear theory addresses the dynamics, structure, and reactions of (1) quark and gluon degrees of freedom in hadrons and (2) meson, nucleon, and nucleon resonance degrees of freedom in nuclei and nuclear matter. Using Argonne's massively parallel Chiba City and Jazz computer systems and the National Energy Research Scientific Computing Center IBM SP, the Laboratory's nuclear theory group has set world standards for calculations of nuclear many-body problems addressing fundamental questions in nuclear structure and nuclear astrophysics. The Argonne theory program provides important guidance for current and future experimental programs at ATLAS, TJNAF, and RHIC.

User Facility: Argonne Tandem-Linac Accelerator System

Situation

A DOE-designated national accelerator facility for research in nuclear physics, ATLAS 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. We 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 enhanced frequently. We will be investigating technical and research issues relating to acceleration of beams of short-lived nuclei, as a basis for proposing development of a Rare Isotope Accelerator based on ATLAS. (See Section III.A.2.)

e. High-Energy Physics

Situation

We perform cutting-edge research on the physics of elementary particles and develop 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. Our program includes four large 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.

Our 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 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, we will provide scientific leadership and will design and assemble major components of the required experimental systems. We will choose studies in theoretical physics for relevance to our experimental program or for general potential to advance understanding of interactions between elementary particles. Collaboration with universities will be emphasized.

Objectives

Major objectives of our work in high-energy physics are as follows:

- Maximize the output and impact of new physics generated from Argonne's experiments.
- Complete the demonstration of the Argonne Wakefield Accelerator and exploit the facility for further experiments in advanced acceleration technology.
- Advance the technology of detectors for high-energy physics by improving existing detector devices and inventing new ones.
- Improve theories of particle physics and expand understanding of experimental consequences.

Issues and Strategies

Experiments in high-energy physics 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, our work in high-energy physics is increasingly conducted at foreign accelerators, as well as at those in the United States. Data taking in the ZEUS experiment at the German DESY laboratory began in 1992, and ZEUS continues to provide unique data from high-energy electron-proton collisions. In 2001, a major luminosity upgrade was completed for ZEUS and related experiments, permitting a new focus on extreme values of kinematic variables where rates are low. Currently under way is fabrication work on a detector for the Large Hadron Collider (LHC), which is being constructed at the CERN Laboratory in Switzerland. Our 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 has a formal agreement with CERN that details the scope of U.S. participation in the LHC and the level of funding to be provided by DOE and the National Science Foundation. Some work on the ATLAS detector has shifted to preinstallation and installation activities that should be completed in 2005. The detector is expected to begin taking data in 2007.

We will be carefully considering expansions or new directions for many of our programs in high-energy physics, in order to preserve their effectiveness in the next decade. Our researchers are playing leading roles in the MINOS (Main Injector Neutrino Oscillation Study) experiment, a long-baseline study of neutrino oscillation, employing a neutrino beam from the new Fermilab main injector. MINOS is now in the installation phase. The "far" detector is underground, adjacent to the current Soudan 2 detector in Minnesota. We have built the major active components of the "near" detector (scintillator modules and electronics) and will be centrally involved in its installation and commissioning. First data from the detector are expected in FY 2005. A major upgrade of the Collider Detector at Fermilab began taking data with the upgraded Fermilab Tevatron in 2002. Our 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, we are discussing possible collaborations and alliances with researchers at other institutions.

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. Calorimeter fabrication began in FY 1999 and was completed at the end of 2002. Work on the calorimeter has shifted to a process involving preassembly and then installation of the detector at the CERN Laboratory. We are also currently contributing to the design and prototyping of the trigger for ATLAS. System components will be built, tested, and commissioned during the coming five years. Development of the computing system for the ATLAS detector began as a new task in FY 2000 and became fully integrated with other U.S. work on ATLAS during that year. In collaboration with other U.S. and foreign ATLAS institutions, we are taking the lead role in developing core data management software, as well as calorimeter-specific software.

In theoretical high-energy physics, funding limitations have prevented us from adding junior researchers at appropriate intervals. With DOE, we will explore means of adding one or more early career theorists, particularly in the area of neutrino physics.

Discussed below as a programmatic initiative is proposed R&D toward a linear electron-positron collider and an associated detector.

Initiative: Linear Collider Accelerator and Detector Technology

In January 2002 a subpanel of the DOE-National Science Foundation High Energy Physics Advisory Panel gave highest priority to construction of a linear electron-positron collider in the energy range 500-1,000 GeV. This collider will complement the LHC by having sensitivity to a similar energy and mass range for new phenomena but qualitatively different measurement and identification abilities.

Success in building and exploiting this new collider depends on resolving a number of design issues and choosing between two major accelerator technology alternatives, based on either warm or superconducting radio frequency cavities. Substantial R&D is also needed on the detector for the new collider, in order to optimize its ability to reconstruct events with the required precision. We plan R&D on both the accelerator and the detector. For the accelerator, we will use our world-class expertise in photocathode guns and electron beam optics. For the detector, we propose a new hadronic calorimeter technology based on resistive-plate chambers, which will be used with the energy flow approach to calorimetry being explored with the ZEUS detector.

Resources required for our work on this initiative are summarized in Table IV.3. Funding is sought from the DOE High Energy Physics Program (KA-04).

Table IV.3 Linear Collider Accelerator and Detector Technology ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	0.5	0.8	1.0	1.5	2.0	2.5	3.0
Capital Equipment	0.2	0.3	0.3	1.0	1.3	1.5	2.0
Construction	-	-	-	-	-	-	-
Total	0.7	1.1	1.3	2.5	3.3	4.0	5.0
Direct Personnel	2.0	4.0	5.0	8.0	11.0	13.0	15.0

f. Mathematics, Computing, and Information Sciences

Situation

In the 1980s and early 1990s more than 20 U.S. companies were producing supercomputers designed for scientific and technical applications. In recent years, however, that situation has changed. Scientific computing has become increasingly dependent on hardware designed and optimized for commercial applications. The performance of the Earth Simulator in Japan exposed the seriousness of this problem.

Typical scientific applications can extract only 5-10% of the power of supercomputers essentially built from commercial web and data servers. By contrast, the Earth Simulator makes 30-50% of its power accessible to most scientific calculations. By combining 40 trillion operations per second with optimization for scientific computing, the Earth Simulator gives its users a clear advantage over other researchers.

Regaining the U.S. lead in scientific computing will require dramatic advances in hardware, algorithms, systems software, and related enabling technologies. The hardware challenge alone is formidable. Current technologies, such as clusters and parallel vector processing, appear to be incapable of scaling effectively to the petaflops regime. Innovative computer architectures, such as virtual-vector and system-on-a-chip technologies, therefore must be explored. Critical to this effort will be sustained partnerships in which computer vendors interact directly with computer scientists and scientific applications teams throughout the prototyping, testing, and design of the new architectures.

Petaflops computing will also require a new software infrastructure. Simple enhancements to existing software will not suffice. Researchers will need to explore innovative strategies, such as linked development of systems software and compilers. Moreover, novel interfaces must be developed to integrate petaflops computing into emerging national computational grids, and high-level tools will be needed to enable users to move applications quickly and seamlessly from the workstation to a large-scale facility. A further major challenge will be the development of systems integration strategies to enable scaling of the system from teraflops to petaflops, while still using the same hardware and software elements.

Vision and Goals

We believe that it is possible, within a decade, to provide scientific computing in the United States with sustained performance increased by orders of magnitude. Key to realizing this vision is the development of world-class supercomputing and networking resources, complemented by world-class algorithms, tools, and software. Argonne, in collaboration with Berkeley Lab, is exploring a comprehensive new strategy that will couple scientific applications to the development of computer architectures. The goal is to open a sustainable path to petaflops-level performance and beyond.

Objectives

We have established the following specific objectives for achieving a world-class computing capability:

- Work with DOE to formulate a national strategy aimed at creating new computer designs that achieve maximum sustained performance on scientific applications.
- Form partnerships with applications developers, computer scientists, and hardware vendors, not simply to evaluate architectures, but to *drive* the design of new architectures by exploring design tradeoffs and testing early prototypes.
- Address key challenges to high-performance computing, including scalable input and output, fault-tolerant software, memory hierarchy management, performance analysis, and numerical and communication libraries.
- Spearhead development of the grid tools, middleware, and services needed for large-scale collaborative problem solving.
- Accelerate development and deployment of the ultrascale networks needed to complement the advanced architectures.

Issues and Strategies

Argonne researchers in the computing sciences are at the forefront of U.S. scientific computing. They lead efforts to develop new paradigms and technologies. For example, in collaboration with Berkeley Lab, we recently proposed to DOE a new program to accelerate scientific computing in the United States by implementing a radical new paradigm of collaborative development with computer vendors.

Of particular interest is the Blue Gene architecture, which potentially could scale far beyond current systems and enable researchers to attack key scientific problems in diverse disciplines. A software simulator is available now, and the vendor could provide a hardware simulator in late 2003 or early 2004; a full system of approximately 100,000 processors, capable of sustained petaflops computing speed, could be available by 2007-2008. To move forward, the vendor requires three major collaborators by the end of 2003. We are aggressively considering the possibility of participating.

In another important area of research — distributed computing systems — coupling workstations and parallel computers, large databases, virtual-reality devices, and other resources worldwide promises tremendous advances in scientific problem solving. Our deployment of the Globus Toolkit™ has made Argonne the center of distributed systems research worldwide. We are now exploring ways of extending this technology to areas of computational science such as a Proteomics Data Grid and a Biotechnology Data Grid. We are also taking the lead role in developing grid technology for many of the projects funded by the federal Scientific Discovery through Advanced Computing program, including the DOE Science Grid, the Earth Systems Grid, the Plasma Physics Collaboratory, and the Particle Physics Data Grid.

As a complement to these efforts in advanced computing, we have developed a major initiative in petaflops computing and computational science (see Section III.A.4). Central to this initiative is the development and deployment of a petascale experimental research facility that targets critical scientific problems. Argonne researchers have established a test bed and are exploring new technologies, such as cluster-on-a-chip, to enable computers to scale to systems capable of trillions of operations per second. The petascale facility primarily targets applications in the biosciences and nanosciences.

We have also established the Laboratory Computing Project to promote the widespread use of high-performance computing technologies for scientific research across the Laboratory. As part of this project, Argonne recently funded a teraflop-class computing cluster. This system was chosen because it is highly reliable and easily reconfigured, two features essential for heavy production. Early tests by nuclear physicists and astrophysicists have shown that the new system can achieve high performance on challenging computational science problems.

g. 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: in both FY 2001 and FY 2002, 240-250 scientists conducted a total of approximately 400 experiments. The total number of participant scientists in 2002 was 680. Moreover, the IPNS is DOE's most cost-effective neutron source. Its high scientific productivity and cost-effectiveness have been noted frequently by national and international committees. In February 2001 that evaluation was reinforced by DOE's Basic Energy Sciences Advisory Committee (BESAC), which strongly recommended increasing annual IPNS funding by $9 million in order to (1) improve the accelerator, targets, moderators, and available instruments and (2) expand the facility's research program. The IPNS currently provides 13 neutron scattering instruments, as well as facilities for studying radiation effects. The IPNS operated for 27 weeks in FY 2002, and it is scheduled to operate for 26 weeks in FY 2003.

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. Staff will help qualified users conduct world-class condensed matter research that addresses a wide range of questions important to both science and technology. Through enhancements, the IPNS will maintain leading-edge capabilities in neutron scattering. Through expanded collaboration with other Argonne facilities, such as the APS and the Center for Nanoscale Materials (CNM) (see Section III.A.1), the IPNS will further increase its scientific productivity.

Issues and Strategies

The IPNS has historically been severely oversubscribed, understaffed, and underfunded. The additional $4 million in IPNS operating funds included in DOE's Scientific Facilities Initiative beginning in FY 1996 now allows 26-27 weeks of operation per year, with a full complement of instruments serving users. A 16% increase in FY 2002 operating funds from DOE, along with an anticipated 7% increase in FY 2003, will enable us to begin work toward enhancing instruments. Improved instruments are expected to attract about 40% more users each year (340 rather than 240).

Neutron scattering in the United States will be in a state of flux for the next decade. Currently, two DOE facilities and a facility of the National Institute of Standards and Technology (NIST) provide neutrons to the user community: the IPNS, the Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory, and the NIST Center for Neutron Research in Gaithersburg, Maryland. A major upgrade of the High Flux Isotope Reactor facility at Oak Ridge National Laboratory is currently under way, and construction of the 1.4-MW world-class Spallation Neutron Source (SNS), also at Oak Ridge, is scheduled for completion in FY 2006, with full user access scheduled for FY 2008. Consequently, over the next five years the IPNS will evolve from a major national source of neutrons for U.S. users to a medium-sized regional facility. In this environment, the role of the IPNS will be increasingly coupled to the APS and the CNM.

The role of the IPNS over the next decade in serving neutron scattering researchers and the broader scientific community is best described in terms of short- and long-term strategies.

Short-Term Strategies (Next Three Years). The IPNS role in the early transition period is to promote growth in the U.S. neutron user community and to support the SNS project to ensure the successful commissioning of that world-class facility. We also must begin positioning the IPNS for highly productive research after the SNS starts operations. These goals can be achieved through the following actions:

- Improve IPNS instruments so as to build the facility's user base (from 240 to 340) and train new neutron users more effectively.
- Contribute to the SNS project where appropriate, in the areas of target, moderator, and accelerator systems and user programs.
- Conceptualize SNS instrumentation capable of serving frontier scientific experiments in the coming decades.
- Leverage the full range of capabilities available at the CNM, the APS, and the IPNS in order to serve facility users better.
- Create joint staff appointments between the IPNS and the APS, the CNM, and the University of Chicago.

Long-Term Strategies (Beyond Three Years). Just before SNS operations begin, the IPNS role will be to begin development of the next generation of SNS instrumentation and to operate the IPNS with upgraded instrumentation that better supports the neutron scattering community. Closer ties with the APS and the CNM will facilitate more effective utilization of neutrons and photons to investigate fundamental issues in science and technology. We will also begin work on a new neutron source at Argonne to help support DOE's nanoscience initiative. These goals can be achieved through the following actions:

- Continue to operate the IPNS highly effectively (at 95% reliability).
- Give priority to development of IPNS instruments that will be capable of world-class science after SNS startup.
- Spearhead the design and construction of up to four SNS instruments. Commission and operate selected neutron scattering instruments at the SNS by using the concept of instrument development teams developed by the SNS.
- Further strengthen scientific ties to complementary U.S. facilities, starting with the APS and the CNM at Argonne. Establish further joint staff appointments with those Laboratory facilities.
- Develop designs for a new neutron source focused on serving nanoscience initiatives.

- Collaborate with other North American neutron centers in developing software and methods that support remote data access and control of experiments via the Internet.

Initiative: IPNS Enhancement

Under the IPNS Enhancement initiative, we propose to improve existing IPNS instruments significantly (increasing data rates by factors ranging from 2 to 32) and to increase the number of weeks of operation to enable an expanded user community to gain experience at a pulsed source in preparation for using the SNS. These additional operations and scientific capabilities were detailed in a plan presented to the November 2000 meeting of the BESAC subpanel reviewing operations at LANSCE and IPNS. In February 2001 our plan became the first of the subpanel recommendations approved by BESAC.

The performance of all IPNS instruments can be increased significantly through various enhancements, such as more detectors, better data acquisition systems, neutron guides, and new ancillary equipment. Implementation of these enhancements over the next four years will improve data rates by factors as great as 32, allowing many IPNS instruments to be competitive with those at the world's best pulsed neutron source, ISIS in the United Kingdom.

h. Biosciences

Situation

High-throughput DNA sequencing is providing a vast database of DNA information and, by inference, information about protein sequences across all kingdoms of life. The availability of these data means that biology has reached a turning point at which complete enumeration of the genes used by any organism is within easy reach. The challenge now is to interpret this information to construct a detailed, coherent, complete view of living organisms and to use this view to develop methods for manipulating and engineering biomolecular systems and predicting their responses to environmental stimuli. The key to such detailed control of biomolecular systems lies in a complete mapping of the activities of the gene products of a cell that cooperate to perform all cellular processes. The information required to characterize these processes is embedded in the spatiotemporal distribution of gene products and metabolites across multiple length scales.

In coming years, progress in the biological sciences will depend increasingly on interdisciplinary interactions with computational, physical, chemical, and materials scientists. Implementation of high-throughput techniques for biochemical and biophysical characterization of biomolecular systems will make it possible to address experimental challenges that are now unbroachable. Huge volumes of data will be required. Cataloging and preserving those data and then extracting maximum information will present a significant challenge in database design and maintenance. In the longer run, integrating the data into a complete view of cellular (and, ultimately, organismal) behavior will require novel approaches to simulating complex systems. Computation will come to dominate the biological sciences in the 21st century. This approach to genome-scale analysis of biological function, now widely referred to as systems biology, involves the fusion of functional genomics with high-end computational simulations of the molecular behavior within biomolecular systems.

Vision and Goals

We will move toward a leadership position in postgenomic biology by creating a model program for the comprehensive functional analysis of genomes. The Functional Genomics initiative (see Section III.A.3) will take advantage of our strong programs in the physical, chemical, materials, and computational sciences to build, along with biosciences, a uniquely interdisciplinary program for postgenomic biology. Partnership with computational scientists will develop a systems biology capability that will be well positioned for the comprehensive analysis of the behavior of microorganisms that are relevant to DOE's science mission.

Experimental facilities at the APS and world-class computational resources will be integral parts of our program for genome-wide structural and functional characterization of organisms — a program that will be centered around our quickly growing effort in structural and functional genomics. Revolutionary approaches to currently intractable problems will be explored in collaboration with Argonne physicists, chemists, and engineers. Programs in bioinformatics, nanobiotechnology, and combinatorial biology will engage scientists at both the Laboratory and the University of Chicago. The goal is a focused program aimed at developing and using high-throughput experimental and cutting-edge computational capabilities for the complete functional characterization of whole genomes.

Objectives

Our Functional Genomics initiative will grow around our current structural and functional genomics programs by taking advantage of both resources supporting the current program and other resources at the APS and across the Laboratory. The initiative will greatly strengthen cross-disciplinary interactions aimed at creating revolutionary approaches to currently intractable problems.

Our major objectives in biosciences are focused on the major Laboratory initiative Functional Genomics (Section III.A.3), elements of which include the following ongoing and novel efforts:

- *Structural Genomics.* Develop a scientific program aimed at deepening understanding of the relationship between protein structure and function — a program centered on current efforts to characterize to atomic resolution the three-dimensional structure of all gene products and to use that structural information to develop better understanding of the function of each gene product.
- *High-Throughput Protein Production and Crystallization.* Our current use of robotics for high-throughput expression of proteins will provide milligram quantities of hundreds of proteins for functional analysis. In parallel with crystallization efforts, these proteins will be analyzed by using functional proteomics, combinatorics, and x-ray solution scattering. The robotics expertise of our scientists will be exploited to develop techniques for high-throughput biochemical and biophysical analyses. Upgraded robotics capabilities for the rapid and efficient production of diffraction-grade crystals of biological macromolecules will eliminate the most severe bottleneck in our structural genomics work.
- *Revolutionary Approaches to Membrane Protein Crystallization.* The 30% of proteins that are integral components of cellular membranes cannot be investigated with the techniques that are successful in crystallizing other proteins. In collaboration with physical and chemical scientists, we will explore revolutionary approaches to the crystallization and biochemical analysis of these proteins.
- *Program for Combinatorial Biology.* Mapping of protein-protein and protein-ligand interactions is one of the most powerful methods for the functional analysis of macromolecules. A comprehensive program in combinatorial biology is being developed to take advantage of the huge potential of this approach for the functional analysis of whole genomes. Furthermore, a program for the high-throughput production of affinity tags will be developed to aid in the purification and functional analysis of gene products. This program will use vast libraries of proteins and peptides displayed on the surfaces of viruses and bacteria and will screen these libraries for desired functionalities.
- *Program in Nanobiotechnology.* Our materials scientists and biologists will cooperate to develop a new program in nanobiotechnology that will explore the creation of bio-inspired nanostructures and bio-compatible materials, as well as the structural analysis of complex biological materials.

Issues and Strategies

We are uniquely positioned to take advantage of the extraordinary opportunities developing in postgenomic biology. Through multidisciplinary collaborations among scientists across the Laboratory and at the University of Chicago, we will seek leadership in newly defined areas of the biological sciences and will explore revolutionary approaches to a number of currently intractable problems in structural and cellular biology.

The core of our bioscience efforts is work in structural genomics to establish high-throughput macromolecular crystallography and its use for enumerating all existing protein structural motifs. This work has motivated initiatives in high-throughput crystallization of macromolecules and high-throughput expression of proteins in bacterial hosts. Building on our existing robotics expertise, these initiatives will provide a further base for developing robotics for rapid biochemical and biophysical assays of protein structure and function. Our existing structural genomics efforts are tightly focused on crystallographic studies, and augmentation in the indicated directions is a priority.

In general, development of new interdisciplinary interactions across the Laboratory and with the University of Chicago will drive our planned initiatives in the biosciences, where DOE and the National Institutes of Health (NIH) will be major funding sources. The Functional Genomics initiative (Section III.A.3) directly addresses the goals of DOE's Genomes to Life program. In addition, important funding from the state of Illinois is being sought to enhance the planned program in high-throughput protein production and crystallization. A key complementary strategy is development of cooperative agreements with biotechnology companies for joint development of novel methodologies.

Our initiatives in the biosciences will build from four parallel and complementary efforts in macromolecular crystallography that are currently being pursued: (1) the capabilities of the existing DOE-funded Structural Biology Center are being enhanced significantly through support from NIH. The Midwest Center for Structural Genomics receives from NIH approximately $5 million per year for development of high-throughput macromolecular crystallography. (2) In partnership with this effort, we are also working with NIH to develop a second APS sector for macromolecular crystallography. (See Section S1.C for discussion of these NIH-supported efforts.) (3) To facilitate this work, a laboratory complex for biostructure research has been constructed at the APS with joint DOE and NIH funding (see Section IV.A.1.a). (4) We are also working with the state of Illinois on plans to construct an Accelerated Protein Production and Crystallization Facility at the APS, which is to include development of an additional APS sector for structural genomics and macromolecular crystallography. Close partnerships among these four efforts will enable significant economies of scale, facilitating rapid improvement in the understanding of structure and function in proteins.

We are building our Functional Genomics initiative around these significant efforts in structural and functional genomics and crystallography. Research on genome-wide analysis of the structure, assembly, and operation of gene products is greatly expedited by the use of large-scale, high-throughput capabilities for analyzing intermolecular interactions and other biochemical and biophysical parameters of macromolecular complexes. This initiative will establish the resources needed for comprehensive studies of biomolecular machines, interface this effort with our ongoing work in structural genomics, and use the resulting capabilities to characterize the molecular machines critical to cellular processes in all organisms.

i. Environmental Research

Situation

Environmental research at Argonne comprises three intersecting thematic areas reflecting the unique role that Argonne and the other national laboratories play in accomplishing DOE's missions. Argonne's basic research strengths in atmospheric, molecular, and terrestrial sciences are complemented by our successful operation of environmental research user facilities and by our development of new methods and technologies for applied and basic environmental studies. Our multidisciplinary research approach, active collaborations with academic partners, and the ability to assemble and operate complex laboratory and field-based user facilities have allowed us to enhance our own research and foster the work of the broad environmental research community.

Vision

We expect to be a leading institution for assembling the flexible, interdisciplinary teams required to address the nation's high-priority environmental problems. Our work will aim at integrating state-of-the-art advances within disciplines — in such diverse areas as structural biology, atmospheric chemistry, functional genomics, climate science, global carbon cycling, and environmental molecular science — with cross-disciplinary system-level studies to improve understanding of how humans and other living things interact with and respond to their environments.

Mission, Goals, and Objectives

The primary mission of Argonne's environmental research program is to perform and facilitate world-class research in the areas most important for addressing high-priority environmental problems critical to the interests of DOE and the nation.

Our overall goals are as follows:

- Optimize the efficiency and enhance the capabilities of the Climate Research Facilities of the Atmospheric Radiation Measurement (ARM) Program (supported by DOE's Office of Biological and Environmental Research [DOE-BER]).
- Extend environmental research activities at Fermilab, at the Atmospheric Boundary Layer Experiments (ABLE) site, at the ARM Climate Research Facilities, and at other field sites to serve diverse user communities investigating air-surface exchange, boundary layer dynamics, carbon cycling, climate science, ecosystem processes, and nutrient dynamics across a range of spatial scales.
- Develop synchrotron-based capabilities that use the high-brilliance x-rays of the APS for molecular-level investigations of environmental systems and atomic-scale studies of mineral-fluid interfaces.
- Establish cross-disciplinary interactions with other Laboratory researchers in the areas of computational science, functional genomics, materials science, and nanoscience, in order to pursue solutions to significant new environmental challenges.
- Expand our interactions and collaborations with the University of Chicago and other academic partners in the areas of atmospheric science and molecular environmental science.
- Optimize the productivity of scientists conducting research at the interfaces between the scientific disciplines relevant to addressing environmental issues.
- Increase the size of our base scientific program.

Among our specific objectives for FY 2004 are the following:

- Redirect our existing strengths in atmospheric chemistry and physics toward new research on the climatic effects of atmospheric aerosols.
- Complete formation of the multi-institutional EnviroCAT consortium and secure approval from the APS Science Advisory Board for a new APS sector devoted to environmental science.
- Define a staff position and offer it to an environmental microbiologist who can contribute to our current work in terrestrial ecology, molecular science, and bioremediation and also can apply new discoveries in functional genomics to enhance understanding of environmental processes on real-world scales.
- Consolidate and extend our participation in the joint Argonne–University of Chicago Center for Environmental Sciences by establishing an Urban Atmospheric Observatory focused on the effects of urbanization on regional climate variability and human health.

Issues and Strategies

The major challenges facing Argonne's environmental research program are to maintain a distinguishing institutional identity and to continue to serve as a uniquely valuable resource to DOE. Competition from universities and industry for qualified staff and new research programs, along with loss of DOE base funding for environmental science, has exacerbated the difficulty of recruiting and retaining a first-class professional workforce. It has also led to a dated research infrastructure in some areas and increased pressure to pursue research opportunities that may be peripheral to the Laboratory's primary scientific interests.

We nevertheless remain convinced that Argonne and the other national laboratories will continue to play an important and unique role in addressing the nation's environmental research needs. The future of environmental research at the national laboratories lies in increased emphasis on basic and applied research conducted by multidisciplinary teams that can fully exploit major research facilities and other unique capabilities. Our general strategy, therefore, is to leverage our existing strengths by reaching across traditional disciplines to integrate environmental research that ranges in scale and hierarchical organization from the molecular to the regional.

Climate Change. Among DOE's priorities in climate change research are (1) understanding the factors affecting Earth's radiant energy balance, primarily through the ARM Program; (2) through the DOE-BER Climate Change Prediction Program (CCPP), accurately predicting regional and global climate change induced by increasing atmospheric concentrations of greenhouse gases; and (3) through the Terrestrial Carbon Processes (TCP) program, quantifying the sources and sinks of energy-related greenhouse gases.

Although we manage the ARM facilities and the ABLE site for the ARM Program and are leading the transition of those sites to national user facility status (as ARM Climate Research Facilities), our scientific research in the ARM Program is not supported commensurately. DOE-BER recently redirected its Atmospheric Science Program toward study of the radiative effects of atmospheric aerosols, offering us a new opportunity to increase our scientific work in this important area of atmospheric research. Improving understanding of atmospheric aerosols is therefore one of the major thrusts of the Laboratory's Challenges in Environmental Science initiative, described in more detail below. This initiative proposes to bring together Argonne's atmospheric scientists, chemists, and materials scientists in an interdisciplinary effort to develop a predictive understanding of the contribution of aerosols to Earth's radiation balance. By coordinating theory, laboratory, field, and modeling work across these disciplines, we will seek new knowledge relating aerosol formation, transformation, and transport to radiative processes that occur on urban, regional, and global scales. This work will intimately involve Argonne computer scientists who have already made substantial contributions to the CCPP. Because performance improvements gained by applying advanced computing are worthwhile only to the extent that real-world processes are represented accurately in the models, we propose to establish firmer connections between scientists studying the atmosphere and those working in the computer laboratory.

Our TCP work is tightly linked to our ongoing research in soil ecology, which aims specifically at understanding carbon cycling in soils and, through the DOE-BER Carbon Sequestration in Terrestrial Ecosystems consortium, at quantifying the potential for carbon sequestration in soils representing different ecosystems. By using combinations of field studies and carefully selected supplemental laboratory experiments, scientists in our terrestrial ecology program have pioneered understanding of the complex below-ground ecosystem. Our objective now is to link our work with new DOE-BER programs in functional genomics by taking advantage of new technologies and facilities for the study of basic biogeochemical processes. We see the opportunity to use genomic methods to design and develop environmental "transponders" that could be valuable tools for understanding the responses of whole ecosystems to global environmental change. This work is also linked to our research in environmental remediation and basic biogeochemical cycling, which is described below.

Global changes are caused by multiple factors, so it is unproductive to study carbon cycling in isolation. We therefore plan to draw on our experience in terrestrial ecosystem research and our expertise in atmospheric sciences to develop a companion program aimed at nitrogen cycling. (This work is also part of our Challenges in Environmental Science initiative.) The first objective is to develop an effective methodology for investigating interactions of the carbon and nitrogen cycles in the field. We expect this research area to grow substantially as better techniques for studying atmospheric and terrestrial processes evolve, and we plan to be among the leading institutions working at conceptual interfaces between disciplines and at physical interfaces between atmospheric and terrestrial systems.

Environmental Remediation. The primary goal of our work in synchrotron-based environmental science is to increase atomic- and molecular-level understanding of structures and processes in environmental systems. One set of studies considers mineral-fluid interactions and the mechanisms by which contaminant elements become bound to mineral surfaces. Another set of studies focuses 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 build on our recognized achievements in molecular radiation and environmental science, and they involve several new internal and external collaborations. Expanding our capabilities for this work is a key component of the Challenges in Environmental Science initiative.

Initiative: Challenges in Environmental Science

Argonne's research in many areas has significant potential for beneficial application in environmental science. Through multidisciplinary teams we propose to address two nationally recognized environmental "grand challenge" phenomena that are especially compatible with our expertise and facilities: (1) biogeochemical cycling, particularly cycling of iron and nitrogen, and (2) atmospheric particulates and aerosols. We also plan to develop a new facility for synchrotron environmental science to enable other aspects of the initiative.

In the area of *biogeochemical cycling,* central goals are to (1) quantify the rates of transfer of compounds to and from storage reservoirs and (2) determine the mechanisms controlling these transfers. The most important challenges are to understand how Earth's major biogeochemical cycles are perturbed by human activities; to predict the impact of these perturbations on local, regional, and global scales; and to determine how these cycles could be restored to more natural states. Argonne teams will focus on primary and secondary interactions among the multiple elements of these problems and on associated positive and negative feedbacks. Studies will range from the atomic level to bench scale to field scale.

Atmospheric particulates and aerosols, both natural and anthropogenic, are inextricably linked to energy production and use. Such particles have significant detrimental effects on human health, play a major role in acid rain formation, and have direct and indirect radiative forcing effects that are comparable in magnitude to the effects of greenhouse gases but are opposite in direction. The characteristics, distribution, and transport of such particles over long distances affect issues ranging from national security (e.g., the transport of harmful spores) to general air quality (e.g., atmospheric chemical interactions). Our research will determine how atmospheric particles are formed, their roles in global and regional climate systems, and their relevance to chronic and acute respiratory diseases. Approaches based on materials science, chemistry, and physics are particularly appropriate for these studies.

To meet the growing need for additional capabilities in *synchrotron environmental science*, we have formed a partnership with the University of Notre Dame and the U.S. Environmental Protection Agency to establish a new APS collaborative access team devoted to environmental research. This "EnviroCAT" aims to provide dedicated, state-of-the-art facilities optimized for research on a broad range of environmental science problems. EnviroCAT will focus on developing a multifaceted microbeam facility and a microtomography facility that use, respectively, insertion device beamlines and bending magnet beamlines. The APS program review board has approved the EnviroCAT letter of intent, and a formal proposal was submitted and reviewed in January 2003. In FY 2004 we expect that work to develop initial design criteria will begin and that discussions with potential institutional partners will result in additional formal research partnerships.

Proposed work on *biogeochemical cycling* and *atmospheric particulates and aerosols* fits within the scope of the initiative in climate change of the U.S. Global Change Research Program, which is a likely near-term source of funding. Other programs that would benefit from our pioneering approach to multidisciplinary integrated research are the DOE-BER Genomes to Life program and

DOE's environmental remediation studies, such as those of the Natural and Accelerated Bioremediation Research program and the Environmental Management Science Program. These efforts will draw on the new Joint Argonne–University of Chicago Center for Environmental Science, a formal collaboration to investigate significant environmental issues. Other potential federal sponsors are the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the National Science Foundation (through collaborations with university partners), and the Department of Defense.

Required resources are summarized in Table IV.4. Also reflected in the table are resources envisioned for work in *synchrotron environmental science* and for developing EnviroCAT (including construction). As indicated above, support will be sought from DOE-BER (KP), other federal agencies, and private sources.

Table IV.4 Challenges in Environmental Science
($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	0.6	2.0	3.6	5.6	8.0	10.0	10.0
Capital Equipment	-	2.5	2.5	2.5	2.0	2.0	2.0
Construction	-	8.5	4.0	4.0	-	-	-
Total	0.6	13.0	10.1	12.1	10.0	12.0	12.0
Direct Personnel	3.0	5.0	9.0	14.0	20.0	25.0	25.0

j. Science and Engineering Education and University Programs

Situation

Through the years, Argonne has consistently maintained very active and wide-ranging interactions with the academic community. These 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 our scientific and technical areas. The activities are supported by the Laboratory, through work for non-DOE sponsors, and by DOE.

Our science and engineering education programs serve faculty and students at both the university and precollege levels. Core programs at the university level provide opportunities for research participation by outstanding undergraduates and faculty, as well as opportunities for thesis research by graduate students. We have become more active in unique graduate programs involving several strategic areas of interest to DOE. These programs include long-term internships and short-term training in a wide range of our research areas. The quality and value of these programs attract applicants from throughout the country.

As part of our education program, we serve the Department of State as the host institution for U.S. participation in training programs of the International Atomic Energy Agency (IAEA). In FY 2002, our role expanded to include placement of IAEA fellows in R&D environments throughout the country. As in earlier years, we have continued to develop and conduct courses in peaceful applications of nuclear technology and also to provide technical support to the Department of State and the IAEA.

Vision

We will enrich science education in the United States through activities that involve local communities, as well as students and faculty at all levels from throughout the nation. We will work closely with DOE and other federal agencies to promote peaceful applications of nuclear technology through collaboration with the IAEA and other international organizations.

Objectives

Our primary near-term objectives in support of science education and training are as follows:

- Continue to attract a large, diverse pool of highly qualified undergraduate students to research participation programs.
- Establish our educational user facility as a valuable and widely used resource providing hands-on laboratory experience for science teachers from the region and throughout the

country; enhance classroom activities through use of the Internet.

- Foster student interest in science education and science careers through a variety of outreach efforts.
- Fruitfully integrate graduate students, postdoctoral fellows, and faculty into Laboratory research programs through internships and training activities.
- Provide training programs and technical assistance to a variety of international organizations.

Issues and Strategies

For our university-level programs, we plan special efforts to develop supplementary activities that will broaden the science horizons of undergraduates and provide training and research opportunities for graduate students. Programs for high school students and teachers will focus primarily on hands-on laboratory work using Argonne facilities and distance learning capabilities dedicated to educational activities. In addition, we will continue to develop programs exploiting computer technology to enhance classroom science education. Important workshops and conferences, such as the annual Women in Science conference, will continue. International programs will focus on unique Argonne research and training capabilities.

Maintaining a sound funding base is the most important issue currently facing our educational programs. Support for participants through the Office of Science has included limited infrastructure support. DOE offices with educational and training needs have been asked to consider the advantages of focusing those activities at Argonne. Our research divisions plan to continue their strong support for the core educational programs of research participation and thesis research at the undergraduate, graduate, and faculty levels. Support for the operating costs of programs for precollege teachers will be sought from the state of Illinois, agencies of the federal government, and the private sector. Laboratory overhead will support the minimal infrastructure required to manage and administer these programs.

2. Energy and Environmental Technologies

Argonne research programs serving the two DOE mission areas of energy and environmental quality are intertwined; this section includes area plans related to both.

a. Advanced Nuclear Technology

Situation

The May 2001 report of the National Energy Policy Development (NEPD) Group chaired by Vice President Cheney summarized its endorsement of nuclear power as follows: “The NEPD Group recommends that the President support the expansion of nuclear energy in the United States as a major component of our national energy policy.” The NEPD Group further recommended reconsideration of next-generation advanced-fuel-cycle technologies: “In the context of developing advanced nuclear fuel cycles and next generation technologies for nuclear energy, the United States should reexamine its policies to allow for research, development, and deployment of fuel conditioning methods (such as pyroprocessing) that reduce waste streams and enhance proliferation resistance.”

In view of these and other recommendations of the NEPD Group, we plan to accelerate our efforts to advance nuclear technology, in order to ensure that nuclear energy can fulfill its promise as a sustainable, clean, safe, long-term energy source, free of carbon dioxide emissions. To this end, we propose in Section III.B.1 the major Laboratory initiative Advanced Nuclear Fuel Cycle. At the conclusion of this area plan, we also propose expansion of our existing R&D on nuclear technology, which supports current nuclear technologies, as well as those of the near future and the longer-term future.

For more than a half century, we have been a world leader in the development of nuclear energy. Our staff has extensive expertise in the full range of disciplines associated with nuclear reactor technology, and a full complement of experimental facilities is in place, representing many hundreds of millions of dollars of national assets. Currently, our nuclear technology R&D focuses primarily on (1) the Advanced Fuel Cycle

Initiative, which aims to close the nuclear fuel cycle with new technology that is environmentally sound, proliferation resistant, and economical; (2) the Generation IV R&D program, whose objective is a new generation of nuclear reactors for deployment before 2030; (3) the Nuclear Energy Research Initiative (NERI), which involves work on innovative reactor concepts and on nuclear science and technology; and (4) operation of the International Nuclear Safety Center, which improves the safety of nuclear reactors worldwide through collaborative R&D programs and in-depth safety analysis, with primary attention to Soviet-designed reactors and the countries operating those reactors.

In partnership with the Idaho National Engineering and Environmental Laboratory (INEEL), we serve as lead laboratory for Nuclear Reactor Technology for the DOE Office of Nuclear Energy, Science and Technology (DOE-NE). In July 2002 the Secretary of Energy designated Argonne-West and INEEL as technical leads for the Advanced Fuel Cycle Initiative and the Generation IV program.

Goals

The goals of our nuclear technology program are to develop and demonstrate innovative nuclear reactor systems and associated fuel cycles that will ensure that nuclear energy can fulfill its promise as a sustainable, long-term, emission-free source of energy; to aggressively pursue solutions for the important technical issues associated with the use of nuclear energy, both domestically and internationally; to help DOE identify and implement technology development programs that will increase the contribution of nuclear energy to a sustainable global energy supply and to the production of hydrogen and fresh water; and to maintain a set of technical capabilities in nuclear science and technology — including both expertise and infrastructure — sufficiently broad and deep to address a full range of national needs.

Strategies

Key strategies for our nuclear technology programs include the following:

• Undertake the major Laboratory initiative Advanced Nuclear Fuel Cycle, including nuclear system R&D and design studies carried out in concert with the Generation IV program and the demonstration of an advanced fuel cycle. (See Section III.B.1.)

• Establish a major Laboratory initiative to investigate the production of hydrogen by nuclear energy. (See Hydrogen Research and Development in Section III.B.2.)

• Develop a space nuclear reactor initiative that responds to the expressed interest in fission reactors for space missions of the National Aeronautics and Space Administration.

• Continue to participate in the NERI, NEPD, and Generation IV programs; apply Argonne's nuclear expertise and unique facilities to current, near-term, and longer-term future nuclear technologies; and apply our expertise to critical issues affecting the continued safe and efficient operation of existing nuclear power plants.

• In partnership with INEEL, serve as lead laboratory for reactor technology for DOE-NE.

• Within our areas of special expertise, participate in advanced technology R&D programs such as the Advanced Fuel Cycle Initiative and nuclear security programs.

Argonne plans a number of important new directions for its work in nuclear R&D that will support the above strategies:

• *Transient Testing at TREAT*. We have begun work to reactivate the Transient Reactor Test Facility (TREAT) in order to carry out various experiments requiring a reactor capable of producing controlled transients. Though TREAT can be restarted, potential future testing missions will require additional resources. These missions might include testing the safety of fuel containing recycled actinides, testing the safety of advanced fuel concepts that might arise from the Generation IV program, or testing current or new fuel designs for commercial light-water reactors.

• *Advanced Fuels Development*. We propose to develop advanced fuels for power reactors, research reactors, and test reactors. Programs such as NERI and Generation IV have fostered discussion of various system configurations, but a common feature is a new fuel design. Of particular interest are metal and metal matrix dispersion fuels. Guided by system studies and technology road maps, we will pursue these fuel development options and others.

• *Materials Development for Nuclear Power*. Materials R&D is important for supporting the current fleet of operating nuclear power plants, as well as for developing future innovative nuclear systems. Future nuclear power plants are likely to operate at higher temperatures and have unique corrosion environments, so advanced structural materials will be necessary. We will undertake both fundamental and applied work to (1) investigate improvements in the performance and production of materials potentially applicable to nuclear power, (2) establish the capability to use modern production and analytical techniques, (3) screen new materials for likely performance in a nuclear environment, and (4) perform prototypic testing of promising advanced materials. Research aimed at both near-term and longer-term applications is proposed.

• *Post-Operation Evaluation of EBR-II Materials and Components*. A complete knowledge of the condition of Experimental Breeder Reactor-II (EBR-II) materials and components will facilitate future reactor decommissioning, life extension for current reactors, and the design of advanced reactors. In order that these valuable data not be lost, we propose significantly expanded examination of EBR-II materials and components.

• *Severe-Accident Management Technology*. Severe-accident research addresses the question of what could be done at a nuclear power plant if a core melt accident were to occur. Argonne's facilities for conducting severe-accident experiments have been designated an international reactor safety R&D facility by the Organization for Economic Cooperation and Development (OECD). A new research program investigating interactions between concrete and a molten reactor core is now under way. We seek continued funding for this program, whose costs are shared with international partners under OECD auspices. (See Section S1.E.5.)

• *Advanced Modeling and Simulation for Nuclear Applications*. We propose expanded work in advanced modeling and simulation for nuclear technologies. The first part of this work focuses on developing and implementing numerical methods on state-of-the-art parallel computers and workstation clusters, so that today's computing technology can be applied to improving nuclear reactor analysis. The second part focuses on machine reasoning, automated pattern recognition, and system modeling based on learned input-output relationships.

• *Space Nuclear Power*. DOE's work on radioisotope power systems includes the development, assembly, testing, and supply of systems for application to the exploration of deep space and to national security. At Argonne-West we recently began contributing to this program by performing final assembly and testing for radioisotope thermoelectric generators. This new activity takes important advantage of our core competencies in nuclear research and strongly complements existing Argonne programs. Future related work could include R&D on advanced radioisotope power systems and on fission systems for propulsion in deep space.

b. Energy and Industrial Technologies

Situation

We develop innovative, efficient, cost-effective nonnuclear energy technologies and industrial technologies. Emphasis is on advanced transportation (discussed separately in Section IV.A.2.c), "industries of the future" identified by DOE, superconductivity, and fossil fuels and carbon management. The Energy and Industrial Technologies program also coordinates the Laboratory's development of partnerships with private companies in these areas.

Industries of the Future. Process industries convert raw materials into ingredients useful for fabrication and assembly in the automotive, electronics, aerospace, construction, and similar industries. The process industries account for approximately a third of U.S. energy consumption, at an energy cost of about $100 billion each year. 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.

Superconductivity. The electric power industry today faces 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 technologies for the transmission and distribution of electric energy that are efficient and robust, and greater interconnectedness necessitates 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 technologies are being pursued by DOE and by increasing numbers of electric power utilities and their suppliers as a promising response to many of these challenges.

Fossil Fuels and Carbon Management. A prudent carbon management strategy for the utility, industrial, and transportation sectors could significantly decrease net emissions of carbon dioxide and other greenhouse gases. An early, economical opportunity for greater sequestration may be provided by the capture of carbon dioxide at large point sources such as power plants, followed by use for enhanced oil recovery and production of methane from coal beds. Sectors of the economy that consume large quantities of fossil fuels are already adopting more energy-efficient technologies. Strategies for the economical use of less-carbon-intensive fuels in existing plants and fleets may be an important bridge to more advanced technologies. However, a full assessment of policy options will require better understanding of carbon transformations "from cradle to grave," throughout current and proposed energy cycles. Our research initiatives support DOE strategies to improve the efficiency of fossil energy technologies and to assist the utility, industrial, and transportation sectors in reducing greenhouse gas emission rates in other ways as well.

Partnering. Responding to the administration goal of improving the productivity of U.S. industry through appropriate use of national technical resources, we are developing a broad range of partnerships with industrial firms on the basis of our leadership in many areas of science and technology. Argonne's midwestern location in the nation's industrial heartland provides exceptional regional opportunities. Partnerships with industry play an important role in shaping many Laboratory R&D programs.

Vision

We 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 our mission in science and technology, we will continue to develop effective relationships with industry to maximize the commercial applications and benefits to the nation from our R&D.

Goals and Objectives

To implement this vision, Argonne's goals include the following:

- Exploit and expand our facilities, capabilities, and core competencies, which integrate science and technology and interest both the scientific and industrial communities.
- Establish strategic partnerships with key industrial firms, large and small, in areas where applying our technical strengths is most likely to lead to valuable commercial successes.

- Implement effective regional outreach, capitalizing on our midwestern location.

Many U.S. industries are working with the federal government to ensure that federally sponsored R&D provides maximum benefits to the nation. We have established the important research objectives summarized below and are pursuing them in close partnership with industry.

Industries of the Future

- Expand Argonne research benefiting the chemical industry, particularly research in the areas of recovery and reuse of polymers, development of chemicals from alternative feedstocks, separative bioreactors, catalysis, and plasma-chemical engineering.

- Work with an industrial equipment supplier and a paper industry manufacturer to develop the multiport dryer technique, already demonstrated through proof of concept, into a prototype demonstration unit.

- Maintain the momentum of current research on metals recycling; expand work on instrumentation, materials, and fabrication technologies for the steel, aluminum, glass, and metal casting industries.

- Target key technical hurdles where unique Argonne capabilities and facilities can be used to advantage; for example, use the APS and the IPNS for critical materials studies that will enable the development of inert metal anodes for aluminum smelting.

- Advance the development of nearly frictionless, nontoxic carbon and nano-crystalline diamond coatings for moving parts (such as oilless bearings, spacecraft mechanisms, rolling and sliding gear systems, and bearings for ultrahigh-vacuum instruments like x-ray tubes), while contributing more broadly to tribology.

- Expand our research benefiting the glass industry by means of multiphase computational fluid dynamics modeling of glass furnaces; develop new techniques for recycling glass with minimal effect on product quality.

Superconductivity

- Maintain core work on the development of superconductors that is sufficiently broad to sustain rapid technical development and foster extensive interactions with industrial companies and universities.

- Continue our contributions to the development of the second generation of high-temperature superconductors, building on earlier successes with powder-in-tube technology.

- Work with the manufacturers of high-temperature superconducting wire (such as American Superconductor Corporation, IGC-SuperPower, and Universal Energy Systems, Inc.) to help advance manufacturing processes.

- Collaborate with system manufacturers (such as Boeing, IGC-SuperPower, and S&C Electric Company) to develop and demonstrate energy-efficient products for the electric power industry, such as flywheels for energy storage, fault current limiters, and transmission cables.

- Collaborate with other national laboratories and industrial partners to develop textured buffer layers — such as MgO, YSZ, Y_2O_3, and CeO_2 — for yttrium-based superconductor films.

Fossil Fuels and Carbon Management

- Expand and help coordinate the development of technologies that are cost-effective and highly efficient, emit smaller net amounts of greenhouse gases, and reduce environmental impacts in the utility, industrial, and transportation sectors; establish emissions inventories for promising technologies and form industrial partnerships to pursue technology development.

- Advance petroleum refining technology by developing (1) catalysts for upgrading heavy crudes, residuum, and distillates and (2) catalytic processing to produce ultraclean low-sulfur transportation fuels through heteroatom removal.

- Investigate opportunities for sequestering carbon dioxide derived from advanced fossil fuel energy systems and from retrofitting technology to the large number of existing long-lived electric generation plants.
- Improve understanding of terrestrial and oceanic responses to natural and anthropogenic changes in atmospheric concentrations of greenhouse gases.
- Develop a center for research on biogeochemical cycling of elements.
- Expand R&D on noncarbonaceous hydrogen production. (See the major Laboratory initiative Hydrogen Research and Development in Section III.B.2.)
- Extend Laboratory breakthroughs in ceramic membrane technologies to advance the development of economical processes for separating oxygen from air and hydrogen from mixed gases (which are critical technologies in, respectively, the use of remote natural gas and the efficient refinery production of clean transportation fuels).

Issues and Strategies

Industry. Through the auspices of the DOE Office of Industrial Technologies, we are working closely with the following industry associations to apply our 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, SECAT LLC
- Metal casting: Cast Metal Coalition
- Glass: Glass Manufacturers Industry Council

In other work, one of our initiatives aims to develop less costly biotechnological methods of producing valuable products from agricultural materials. See the discussion of Biobased Products in Section IV.A.2.f.

Superconductivity. 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 projected increases in 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. Our program of basic science in the field is one of the strongest in the world. Close cooperation continues with the Laboratory's applied superconductivity program, which has produced many notable achievements. We plan 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. We also are contributing to the development of a flywheel incorporating superconducting bearings. We will expand the range of utility applications on which we work, particularly by taking advantage of new ideas for fault-current limiters, transmission cables, 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.

Fossil Fuels and Carbon Management. Support for DOE research related to carbon management is growing. A consortium of major petroleum companies is working with the DOE Office of Fossil Energy to plan field demonstrations of technologies for the economical sequestration of carbon dioxide. The President's FY 2004 budget request includes additional funding for R&D in this area and for regional sequestration initiatives.

Partnering. Congressional appropriations have continued to reduce funding explicitly available for participation by DOE in industrial partnerships. Our industrial partnerships have been severely constrained by this lack of support. The President's FY 2004 budget request includes termination of the multilaboratory partnership in oil and gas exploration and development.

To maximize the likelihood of establishing effective industrial partnerships in the most promising areas of technology, we seek opportunities to include other national laboratories and universities in productive strategic collaborations based on our scientific and technical capabilities and our core competencies. We have already established a vigorous regional outreach program whose broad goal is to help manufacturers in the Midwest. We measure the success of our industrial partnerships by considering the significance and impact of the work accomplished and of the ultimate successful commercialization of new technologies.

c. Transportation Technologies

Situation

The world's transportation system depends critically on petroleum. Oil-derived fuels supply 96% of the energy used to move people and goods. Demand for these fuels continues to grow rapidly, rising by 75% in the United States since the oil crises of the 1970s. Worldwide, the demand for transportation fuels is expected to increase dramatically, especially as developing economies grow. As a result, the world is rapidly approaching the time when a permanent decline in oil production from conventional sources will begin. The Energy Information Administration forecasts that conventional oil production could begin to decline between 2010 and 2040. As the relative price of transportation fuels rises, vehicles with greater energy efficiency will become increasingly important.

Two major research programs led by DOE are designed to reduce oil demand by developing vehicles with greater energy efficiency. These programs are the FreedomCAR and Fuel Initiative (for light-duty vehicles) and the 21st Century Truck Program (for heavy-duty vehicles). Successful development of vehicles that are dramatically more efficient, along with development of alternative fuels, would reduce oil imports, increase energy security, and reduce environmental impacts.

Our Transportation Technology R&D Center is one of DOE's leading research facilities dedicated to addressing the nation's transportation energy problems. Located in the heart of the Midwest, near the nation's manufacturers of automobiles, trucks, and locomotives, we work closely with both manufacturers and suppliers to develop cost-effective technologies that improve fuel efficiency and reduce environmental impacts. As part of this effort, we maintain a web site that describes the research facilities and capabilities of our Transportation Technologies program (URL: www.transportation.anl.gov).

Vision

Transportation and energy infrastructure will always be critical to U.S. national security. Our Transportation Technology R&D Center will become the premiere provider of needed knowledge about advanced transportation technology and its application, for the nation's industrial, academic, and government research communities.

Goals and Objectives

Our Transportation Technology R&D Center will support the nation's needs for R&D on transportation technology. This goal will be accomplished through basic research, through technology development, and through the creation of partnerships with industry, academia, and other federal or national laboratories that promote energy self-sufficiency and improve energy- and transportation-related technologies serving the national interest.

Specific objectives include the following:

- Work with the FreedomCAR program and Fuel Initiative (spearheaded by the DOE Office of Energy Efficiency and Renewable Energy, in partnership with Ford, General Motors, and DaimlerChrysler) to
  - Ensure reliable systems for future fuel cell powertrains, with costs comparable to those of conventional systems (internal combustion engine with automatic transmission) and

- Enable the transition to a hydrogen economy, ensure widespread availability of hydrogen fuels, and retain the functional characteristics of current vehicles. (See the major Laboratory initiative Hydrogen Research and Development in Section III.B.2.)

• Work with DOE and truck engine manufacturers to improve the efficiency and reduce the emissions of advanced diesel technology for use in vehicles of all sizes, as well as to assess the health risks associated with different fuels and engines.

• Develop new technology with a private-sector partner — General Motors Electro-Motive Division — to meet federal locomotive emissions requirements and still achieve high efficiency.

• Work with DOE to develop advanced off-highway and railroad technologies, on the basis of opportunities identified in consultation with industry stakeholders.

Issues and Strategies

Our transportation research, domestic and international, focuses on the following areas where we have recognized expertise and unique facilities:

• *Vehicle Systems*. New vehicle systems promise to overcome the main limitations of conventional electric vehicles, namely range and recharging rate. Hybrid vehicles typically employ a small combustion engine with a battery or ultracapacitor. The result is the performance of a conventional vehicle but greater efficiency and decreased emissions. Our Advanced Powertrain Research Facility validates DOE-funded components with data on performance and emissions. The Laboratory's vehicle systems models can then simulate actual vehicle systems performance and emissions.

• *Fuel Cells*. Fuel cells convert chemical energy directly into electrical energy, cleanly and efficiently. Fuel-cell-powered vehicles could nearly double the energy efficiency of today's conventional vehicles and reduce emissions by 99%. We have developed a partial-oxidation reformer that converts gasoline to hydrogen-rich gas for use in fuel cells based on polymer electrolyte membranes. Our Fuel Cell Test Facility is capable of testing fuel cells up to 50 kW in size. We are also developing solid oxide fuel cells for transportation use.

• *Energy Storage Devices*. In response to stringent environmental regulations, we are developing advanced batteries for electric vehicles. In particular, we are working through the U.S. Advanced Battery Consortium to develop commercially viable high-power lithium-ion storage batteries. This work ranges from research on materials for improved anodes and cathodes to development of novel, low-cost packaging. Our Battery Test Facility performs independent evaluations of batteries developed worldwide.

• *Emissions Control*. By focusing on fuel injector systems and sensors, we plan to develop technologies that simultaneously reduce emissions of particulates and nitrogen oxides from gasoline and diesel engines of all sizes. Until recently, the optically dense regions of the fuel spray from injector systems have been very difficult to image. However, insights gained by using the world's brightest x-rays, provided by the APS, promise improved understanding of combustion and soot formation, leading to the development of cleaner and more efficient engines.

• *High-Performance Computing*. We have supported the transportation industry in the design and testing of new concepts for aerodynamics, thermal management, and safety features. Major efforts in this area involve analyzing underhood cooling and crashworthiness.

• *Recycling*. Obsolete motor vehicles contain plastics, chlorofluorocarbons, rubber, glass, and heavy metals that today are generally not recyclable and must be put into a landfill. Working closely with the auto industry, we are developing economical processes for converting vehicle waste streams into recycled products.

• *Advanced Materials*. Our advanced materials program includes the development of nearly frictionless carbon coatings to reduce the friction and wear caused by sliding and rotating vehicle components. The program also includes the development of new technologies for sensors, rapid prototyping, nondestructive evaluation of ceramic parts, compact heat exchangers, and nanofluids for coolants. Each of these materials technologies promises to improve both the performance and fuel efficiency of vehicles. Use of the APS is expected to assist in the development of catalysts and other new transportation materials.

d. Environmental Treatment Technologies

Separate plans are presented below for three areas of environmental treatment technologies at Argonne: (1) EBR-II spent fuel pyroprocessing, (2) radioactive and mixed waste treatment, and (3) decontamination and decommissioning (D&D).

i. EBR-II Spent Fuel Pyroprocessing

Situation

For nearly four decades, research, development, and demonstration associated with liquid metal fast breeder reactors were conducted at EBR-II, located about 40 miles west of Idaho Falls, Idaho; the Enrico Fermi Atomic Power Plant (Fermi-1) in Monroe, Michigan; and the Fast Flux Test Facility at the Hanford Site in Richland, Washington. These activities generated approximately 60 metric tons of sodium-bonded spent nuclear fuel. DOE is now responsible for safe management and disposition of this spent fuel.

Sodium-bonded spent nuclear fuel must be treated differently from other spent fuel because of the presence of metallic sodium (a highly reactive material), metallic uranium and plutonium (also potentially reactive), and, in some cases, highly enriched uranium. Metallic sodium in particular presents challenges for the management and ultimate disposal of spent nuclear fuel, because the element reacts with water to produce explosive hydrogen gas, as well as corrosive sodium hydroxide that is likely to be unacceptable for geologic disposal.

Argonne's pyroprocess for treating metallic spent nuclear fuel uses electrorefining, a type of technology often used by industry to produce pure metals from impure feedstocks. Application of our pyroprocess has been demonstrated for the stainless-steel-clad uranium alloy fuel and blanket assemblies from EBR-II. A modified process could be used to treat oxide, nitride, and carbide sodium-bonded spent nuclear fuel.

Application of pyroprocessing to EBR-II spent fuel involves several steps. The fuel is first chopped, placed in molten salt, and electrorefined. After electrorefining, the molten salt, fission products, sodium, and transuranics (including plutonium) are removed from the electrorefiner, mixed with the ion exchange agent zeolite, and heated so that the salt becomes sorbed into the zeolite structure. Glass powder is then added to the zeolite mixture and consolidated to produce high-level radioactive waste in the form of a ceramic. The uranium from the electrorefiner is removed, melted, and processed in a furnace to produce low-enrichment or depleted uranium ingots. The stainless steel cladding hulls and the insoluble fission products are melted in a casting furnace to produce high-level radioactive waste in metallic form.

A three-year demonstration of treating EBR-II spent nuclear fuel was completed in 1999. A subcommittee of the National Research Council judged that the demonstration met all success criteria. DOE then selected pyroprocessing (also known as electrometallurgical treatment) for the complete inventory of EBR-II sodium-bonded fuel, work now under way at Argonne-West.

Vision

Through treatment of EBR-II and other sodium-bonded spent fuel, we will demonstrate that pyroprocessing technology is a cost-effective option that provides a viable approach to managing spent nuclear fuel.

Issues and Strategies

In September 2000 we initiated treatment operations with EBR-II fuel. Processing rates were increased from the demonstration rates to a total of 600 kilograms per year. As funding becomes available for additional staffing and technology advancement, the processing goal for the following year will be increased. The capacity rate of 5 metric tons per year is to be reached after processing improvements are implemented and staffing is increased.

An important issue associated with treatment of EBR-II spent fuel is continued development of the pyroprocess treatment technology in order to achieve the throughput rates required for economical operation. Although the basic technology has been demonstrated, product losses and waste streams should be reduced, new equipment should be produced, and batch size should be optimized. The cost of continued technology development will be a significant fraction of total costs during the first several years of operation.

Waste form development and qualification will extend well into the schedule for treating EBR-II spent fuel, 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 that will extend several more years. Nevertheless, tests with surrogate fission products and limited tests with actual radioactive waste forms have provided sufficient data to establish the viability of the new waste forms.

ii. Radioactive and Mixed Waste Treatment

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). Included in the DOE-EM plan is application of new technologies that have reached various stages of development with support from the DOE-EM Office of Science and Technology.

We have demonstrated significant core capabilities in advanced environmental technologies, built on our broad competencies in nuclear technology and environmental science and technology; our existing nuclear facilities; and our extensive understanding of — and experience in resolving — complex environmental problems at sites of DOE, Department of Defense (DOD), other federal agencies, and U.S. industry. Integration of capabilities in environmental research, technology development and deployment, comprehensive assessment, and remediation applications is the basis for our continuing development of advanced environmental technologies tailored specifically to particular facilities and waste streams for many different types of customers.

To support DOE's Central Characterization Program, Argonne-West will perform solid core sampling of contact-handled transuranic materials (homogeneous solids or soils and gravels). Beginning in the spring of 2003, this work is being done in the Waste Characterization Area of the Hot Fuel Examination Facility (HFEF). In the DOE complex, about 700 drums are estimated to require core sampling. The work will be completed in approximately five years.

We plan to construct the Remote Treatment Facility (RTF) at Argonne-West to provide the infrastructure needed to carry out three missions important to DOE, the state of Idaho, and the national nuclear complex: (1) near-term management of wastes resulting from nuclear research conducted in earlier years at Argonne-West and INEEL, (2) R&D to achieve nuclear energy and national security goals, and (3) R&D to achieve environmental technology goals. Special needs in each of these three areas require that DOE operate facilities dedicated to the development, testing, and implementation of technologies and processes involving the remote handling of highly radioactive materials and the use of intense radiation sources. We will operate the RTF both to meet local waste management needs and to serve as a national user facility for the development and testing of remote technologies. The RTF will augment the existing HFEF at Argonne-West. Development of the RTF will include an addition to the present HFEF and integration of existing HFEF support capabilities, such as analytic chemistry laboratories, into RTF operations.

The mission need for the RTF has been confirmed by DOE-NE. As a result, inclusion of funding for RTF design and construction is expected in DOE's FY 2005 budget request.

Vision

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

Objectives

Our work on advanced environmental technologies has the following central objectives:

- Develop technologies and facilities for treating mixed waste and nuclear materials.
- Develop superior waste forms and methods of testing and validating techniques for predicting performance.
- Develop innovative environmental technologies that exploit the state of the art in separation science, chemical interactions, and advanced materials.
- Integrate scientific research with field engineering experience and methodologies in order to develop cost-effective solutions to environmental problems.

These Argonne objectives clearly help to address the following two "gaps" identified in DOE's September 2000 R&D portfolio analysis for its Environmental Quality mission area: (1) dispose of transuranic, low-level, mixed low-level, and hazardous waste (gap number 8) and (2) manage nuclear material (gap number 6).

Issues and Strategies

Development of advanced technologies for mixed waste treatment is a logical extension of our broad background in reactor technology. In mixed waste treatment, we plan 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 Radioactive Scrap and Waste Facility. These wastes require additional characterization, segregation, treatment, and repackaging.

The RTF will be designed to segregate, characterize, treat, and repackage remotely handled materials. The essential features of the RTF are an air atmosphere hot cell with 13 workstations, a hot repair area with access to the hot cell, waste cask handling capabilities, and a cell for nondestructive analysis. Equipment to be installed in the RTF includes a liner disassembly station, an automated waste sorting station, a sodium removal station, an induction furnace, and a waste repackaging station. Direct linkage with the HFEF will be through a cask tunnel. The cask transfer system will be capable of dealing with many types of casks, including the commercial nuclear fuel casks that are licensed for remotely handled transuranic waste. Waste packages that are not compatible with casks will enter the RTF cell through the hot repair area.

Development of stabilized waste forms is very important for solving problems associated with high-level and mixed waste. During the last decade, we have performed a wide range of R&D contributing to waste form development, including long-term and accelerated testing of high-level waste glasses and technical support to the Yucca Mountain Project, development of room-temperature setting 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 phosphate mineralization of actinides achieved by the measured addition of precipitating anions. We will continue to support DOE programs such as the high-level waste repository and the Waste Isolation Pilot Plant. In addition, technical support will be provided to DOE field offices and to the site contractors at major sites charged with cleanup and waste management, such as Savannah River, Fernald, Rocky Flats, INEEL, and Hanford.

We will continue to support DOE-EM R&D aimed at long-term disposal of waste forms. 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.

iii. D&D

Situation

Decontamination and decommissioning of production and research reactors and nuclear manufacturing facilities represents a major challenge for DOE and the commercial nuclear industry. 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 material.

We are 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 Argonne can be applied to D&D, including advanced cutting technologies (such as lasers, water jets, and plasma arcs), telerobotic systems, effluent control technologies (such as filters for aerosols and dissolved contaminants), instrumentation, decontamination methods (both chemical and mechanical), and risk assessment methods.

We are building our 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. We have experience with the D&D of many types of nuclear facilities, including reactors, hot cells, and facilities containing glove boxes. The most significant of our reactor D&D projects involved the CP-5 Research Reactor and the Experimental Boiling Water Reactor. We also have a long history of developing and deploying both nuclear and nonnuclear technologies, and we have played a leading role in this country's first D&D technology demonstration program at a working D&D site. The CP-5 Large Scale Demonstration and Deployment Project was judged one of DOE's "Top 100 Achievements of the Century." We have been instrumental in developing risk-based analyses for recycle and release criteria and for transportation. Our RESRAD (RESidual RADioactivity) family of computer codes is widely used by regulators to aid in evaluating compliance, through estimation of doses and related risks to human health and the environment that result from exposure to radioactivity and chemically contaminated materials. We have also developed cost engineering models that have been used to validate cost estimates throughout the DOE complex. We are active in several international organizations involved in D&D and have initiated information exchange programs with the IAEA, Japan, Russia, and Argentina.

Vision

To optimize the cost-effectiveness and safety of D&D operations, our D&D technology program will continue to advance the development, demonstration, and deployment of cost-saving D&D technologies and to develop and execute analyses of risk, safety, environmental impacts, and costs for DOE, other federal agencies, regulators, and the commercial sector. The program will also continue its contributions to D&D education through training, workshops, and personnel exchanges.

Objectives

The main objectives of our D&D technology program are the following:

- Provide substantive information on the use and value of D&D technologies for all categories of end users.
- Coordinate the research, development, demonstration, and evaluation of D&D technologies in order to achieve cost-effective D&D for the DOE complex.
- Provide technical services and support in the areas of risk, safety, and cost analysis, as well as in planning and technology deployment.
- 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.
- Work with the DOE Environmental Management Science Program to encourage basic research in areas that will benefit D&D technology.

Issues and Strategies

Key to the development of our D&D technology program is formation of strategic alliances among national laboratories, utilities, universities, D&D contractors, and technology developers and providers. We will continue to pursue appropriate alliances with nuclear utilities and D&D contractors, as well as with the Nuclear Energy Institute and the Electric Power Research Institute. In all our D&D technology efforts, we work closely with DOE-Chicago Operations. Internationally, we will take advantage of our 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 our D&D technology program. External factors include scheduling of D&D by DOE and utilities, effects of utility deregulation, and the availability of low-cost disposal sites for low-level nuclear waste. Internal factors include close integration of our diverse capabilities in technology and advanced technical services. Equally important is the formation of partnerships and strategic alliances with organizations outside the Laboratory.

e. Energy and Environmental Systems

Situation

Long-term energy resources and environmental impacts from energy consumption remain controversial public concerns complicated by economic importance and contradictory public perceptions. Informed decision making in this area requires accurate, clearly presented analyses based on a very wide range of technical information. Federal policy analysis is further complicated because responsibilities relating to energy and the environment are spread widely across federal agencies. No single agency has a mandate to examine the full range of relevant issues.

For decades, we have created technically and economically efficient solutions for energy and environmental problems by applying scientific methods in the development and assessment of new and modified technologies and processes. Our successes in this area stem from our capacity to assemble interdisciplinary teams of specialists and to integrate diverse technical resources in order to address difficult problems through focused study and exploitation of unique facilities. A particular Argonne strength is our capability for merging decision analysis, risk assessment, information sciences, and economic evaluations with the engineering specialties and the physical, biological, and social sciences.

Energy and environmental problems create these challenging national needs:

- The rapidly growing complexity of the energy system and related environmental issues such as water resources necessitate a multidisciplinary, integrated approach to solutions.
- Solutions to environmental problems must be both cost-effective and acceptable to the public.
- The growing information glut facing all decision makers requires the development of better ways to capture, merge, and display critical information.
- Such policy areas as climate change, pollution remediation, and resource management increasingly require global analysis and international coordination.
- There is growing evidence that restructuring of the U.S. electric system requires new approaches to reliability, environmental protection, and preparation for disruptions. At the same time, new environmental regulations require the development and adoption of advanced procedures and technologies.
- The benefits of increasing the production of fossil fuels on U.S. public and private lands must be balanced against the need to protect environmental quality.
- Analysis of hydrogen as a basis for future energy systems will require a highly multidisciplinary approach. (See the major Laboratory initiative Hydrogen Research and Development in Section III.B.2.)

Vision

Argonne will provide national and international leadership in the creation of innovative and cost-effective solutions to energy and environmental problems, through the development of next-generation technologies; through the application of state-of-the-art techniques in assessment, risk analysis, and decision analysis; and through the transfer of those technologies to the private sector and other researchers.

Objectives

Key objectives of our program in Energy and Environmental Systems include the following:

- In order to improve the analysis and assessment of advanced energy systems, develop models, methodologies, and techniques that give decision makers more accurate information about the changing structure of the energy system.
- Develop integrated environmental assessments, risk analyses, modeling techniques, and innovative information systems — by using approaches such as advanced visualization, advanced data management techniques, and spatial and geographic information systems — that benefit federal managers, policy makers, and private-sector businesses facing new regulatory requirements.
- Apply these energy and environmental tools, techniques, and methodologies to issues of national concern; transfer the tools to other researchers and to private-sector energy organizations for improved decision making.
- To improve the cleanup and subsequent long-term stewardship of Cold War legacy waste sites, make available more widely — to DOE, federal, and private-sector sites — the benefits of Argonne's unique capabilities in information management; in tools for assessing the changing structure of energy systems; and in methods of site characterization, remediation, and restoration.
- Expand our international activities that address global climate change and environmental protection.

Issues and Strategies

Our strategies for achieving our objectives in Energy and Environmental Systems include the following:

- Take advantage of Argonne's strengths in high-performance computing and multidisciplinary domains to investigate the application of advanced techniques — such as complex adaptive systems analysis and agent-based simulation — and provide better decision making information in the rapidly changing, highly complex, nonlinear arena of energy and environmental policy.
- Combine innovative decision tools with field techniques to create applied environmental methodologies that are more effective. For example, tailor more cost-effective approaches to site cleanup and long-term stewardship through better site sampling strategies, better monitoring methodologies, and more flexible decision-making practices based on rapid acquisition and evaluation of accurate field data.
- Address emerging technical issues associated with long-term environmental stewardship at DOE and other federal facilities, especially sites requiring extensive cleanup. (See discussion of the initiative Science and Technology for Environmental Stewardship at the end of this area plan.)
- Collaborate with urban community groups to increase the stock of energy-efficient buildings, including housing and schools; to return abandoned sites to use; and to design and implement next-generation modes of urban transportation. These efforts will include integration of Argonne techniques, technologies, tools, and training to foster the creation of more high-wage jobs, to ease urban blight, and to support the renovation of urban infrastructure.
- Explore additional opportunities to apply our special capabilities beyond DOE, to benefit the Departments of Defense, Agriculture, and the Interior; the Nuclear Regulatory Commission; other federal agencies; state and municipal governments; nongovernmental organizations; and the private sector.

• With international organizations and appropriate foreign governmental organizations, expand activities involving the analysis of international issues concerning energy and environmental systems — including global electric system restructuring, transnational energy system interconnections, global climate change, sustainable development, hazardous waste generation, and ecosystem management.

In summary, we have considerable strength in most scientific and technical areas related to energy and the environment. We are well organized to integrate our multidisciplinary capabilities in research, development, and demonstration of new technologies. Recognition of these capabilities has allowed us to develop solutions to a wide variety of real-world problems and to further strengthen our relationships with sponsors. Current challenges include developing innovative methodologies for analyzing energy and environmental problems (such as global climate change, restructuring of the electricity market, and the hydrogen economy) that cannot be addressed adequately with conventional techniques; identifying appropriate opportunities for beneficial external collaboration; and extending the breadth and depth of the Laboratory's capabilities.

Initiative: Science and Technology for Environmental Stewardship

The DOE R&D portfolio analysis for the Environmental Quality mission area in September 2000 identified long-term environmental stewardship as one of four highest-priority technical "gap" categories. In response to this need, we propose a program of research, development, and analysis to address emerging technical issues associated with the environmental stewardship of lands and facilities for which DOE and other federal agencies are responsible.

The concept of environmental stewardship encompasses the mechanisms — physical and institutional controls, information management, environmental monitoring, risk assessment, and other means — needed to ensure, in both the short term and the long term, protection of people and the environment. Government is responsible for stewardship of the lands it manages and for the environmental consequences of its activities. Planning for effective stewardship includes evaluating impacts from the use of rights-of-way on federal lands (such as the Trans-Alaska Pipeline system); assessing the effects of extracting energy and other resources; and developing effective methods of managing residual contamination left following cleanups at government facilities.

This initiative in Science and Technology for Environmental Stewardship takes advantage of our substantial capabilities and experience in characterization, in analysis and engineering for processes and systems, and in integrated management, including risk assessment. The initiative will emphasize (1) decision making related to risk to human health and ecosystems and (2) monitoring to obtain feedback for updating previous decisions. Such risk assessment requires integration of results from multiple analyses, models, and monitoring. Associated decision making processes often involve disparate stewards, regulators, and the public. Informed decision making depends critically on effective integration and dissemination of relevant information. To create an improved technical basis for stewardship, we will investigate the deployment of technologies and approaches we have developed by using advanced techniques of computing and communications.

Resources that can be applied beneficially to this initiative are described in Table IV.5. Funding will be sought initially from DOE-EM (EW, EX); DOE-Environment, Safety and Health (HC); DOE-Science (KP-12, KP-13); and the new DOE Office of Legacy Management.

Table IV.5 Science and Technology for Environmental Stewardship ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	9.7	10.0	13.0	15.0	17.0	19.0	19.5
Capital Equipment	0.3	0.4	0.5	0.5	0.5	0.5	0.5
Construction	-	-	-	-	-	-	-
Total	10.0	10.4	13.5	15.5	17.5	19.5	20.0
Direct Personnel	30.0	32.0	39.0	40.0	41.0	42.0	43.0

f. Biotechnology

Situation

Biotechnology research at Argonne is a multidisciplinary, cross-cutting activity that integrates a variety of disciplines and unique research facilities. We are one of DOE's leading resources for developing the technologies of biological microchips and biobased chemicals. Key elements of our program are sponsored by DOE, DOD, and private-sector industrial collaborators. Near-term plans include further strengthening of capabilities in biocatalytic and downstream processing, in bioinformatics, and in the development of automated systems for gene cloning and expression.

Objectives

Key objectives of our biotechnology program include the following:

- Develop integrated systems for the automated acquisition and processing of environmental samples and the use of downstream detection (e.g., biochips) for analyzing complex samples.
- Evaluate biochemicals for control of cellular malignancies.
- Develop advanced emergency resuscitation technologies, improved artificial intelligence for medical diagnostics, and new prosthetic materials and coatings.
- Develop environmentally advantageous bioprocessing technologies (notably integrated biocatalysis and separations) for application to biological and chemical feedstocks.
- Develop technologies to monitor, remove, detoxify, and recover heavy metals, organic compounds, and bacteria in the environment.

Issues and Strategies

In addition to national security, our programs in biotechnology focus on three promising areas having high national priority:

- *Medical Applications.* Programs emphasize development of advanced biochips for analyzing genetic information, studying cancer and biochemicals to guide pharmaceutical development, and developing advanced devices and procedures for emergency resuscitation.
- *Industrial Processes*. Programs include the development of separations and their integration with biocatalysis to produce environmentally advantageous products (e.g., polymer-grade monomers and "green" solvents such as succinic acid, acetic acid, lactic acid, and ethyl lactate) through bioprocessing of chemical feedstocks (e.g., syngas) or biobased feedstocks (e.g., lignocellulose or corn). Also considered are biobased batteries and biohydrogen production in new types of separative bioreactors.
- *Environmental Protection.* Programs include investigation of environmentally acceptable methods for treating microbial corrosion in pipelines; field demonstrations of phytoremediation methods; and development of photocatalysts for the removal, detoxification, and recovery of heavy metals and organic compounds in aqueous waste streams. We are also developing, with former weapons scientists from the former Soviet Union and U.S. partner companies, nonproliferation programs in areas such as biocorrosion and phytoremediation.

Initiative: Integrated Biodetection Systems

Our established biochip program is invigorated by the development of both defense and nondefense applications that use biochips to detect nucleic acids, peptides, and proteins. Current spinoff initiatives focus on five key areas:

- Integrated biodetection systems
- Nucleic acid chips
- Protein chips
- Polymerase chain reaction (PCR) chips
- Metabolic chips

Our patent portfolio covers three-dimensional biochips and associated technologies. This gel pad configuration allows each pad to function as a test tube for protein reactions, PCR, and other processes. Our biochip program is closely linked to our biodefense work for DOD and NIH and to work for DOE's Genomes to Life program, as well as to work on environmental applications and biomedical diagnostics. Resources required for this initiative are summarized in Table IV.6. The funding increase for FY 2004 is sought from DOE, other federal agencies, and the private sector.

Table IV.6 Integrated Biodetection Systems ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	2.4	3.0	3.5	3.5	3.5	3.5	3.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	2.4	3.0	3.5	3.5	3.5	3.5	3.5
Direct Personnel	6.0	6.5	7.0	7.0	7.0	7.0	7.0

Initiative: Biobased Products

Our biobased products program, like our biochip technology program, is an established activity that often spins off initiatives as novel potential applications are identified. Current components of the Biobased Products initiative range from the development of additional uses for corn as a chemical feedstock to the development of advanced membrane processes that lower the cost of downstream processing and purification. We are also developing a separative bioreactor that could transform separations for organic acids and other chemicals from the current costly multi-step process to a single efficient step. Nanoscience and structural biology are being applied to address fundamental issues in biocatalysis and processing, particularly issues that affect product cost. Resources required for this initiative are summarized in Table IV.7. Funding is sought from DOE-Energy Efficiency and Renewable Energy (ED), DOE-Fossil Energy (AA), other federal agencies, and industrial partners.

Table IV.7 Biobased Products ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Direct Personnel	4.0	4.0	4.0	4.0	4.0	4.0	4.0

3. National Security

As stated by Secretary Abraham, national security is the overarching mission of DOE. It is also one of the four traditional underlying mission areas of the Department.

a. Nuclear National Security

Situation

Our current work on nuclear national security aims to reduce threats posed by nuclear and radiological materials. At the end of the Cold War, the principal threat to U.S. national security changed from large-scale nuclear war to asymmetric conflicts and terrorism by subnational groups. Our earlier focus on technical means of verifying treaty compliance has shifted toward developing ways to limit the spread of weapons of mass destruction and also radiological weapons that can cause widespread disruption and impose large costs.

Among the most pressing problems facing the United States is the breakdown of systems for controlling nuclear materials in Russia and the independent states that resulted from the dissolution of the former Soviet Union (FSU). The United States, with several other countries, is providing technical assistance to help FSU nations improve their control systems. A further major concern is radiological materials located throughout the world, for which only limited controls are now in place. In this case as well, the United States is one of several countries providing technical assistance to improve security and controls.

Our nuclear national security program, with an annual budget totaling approximately $20 million, includes several significant components:

- The Reduced Enrichment for Research and Test Reactors (RERTR) program, which develops new fuels, targets, and analysis methods to enable research reactors throughout the world to substitute low-enrichment uranium for the highly enriched uranium in their fuel and targets.

• The Material Protection Control and Accounting (MPC&A) program, which assists nuclear facilities in Russia and the independent FSU countries. Assistance is offered through surveying the current status of protection and accounting for nuclear materials, making recommendations for improvements, and coordinating upgrade plans and their implementation. This program includes training courses, offered both at Argonne and abroad, that enable foreign specialists to effectively utilize new security and accounting systems.

• The Verification Technology program, which develops sensitive and selective instruments to detect radiation and chemical and biological effluents that might indicate clandestine proliferation.

• The Nuclear Export Control program, which provides technical assistance to the National Nuclear Security Administration (NNSA). This assistance includes (1) assessments of proliferation risk associated with proposed exports of nuclear and nuclear-related dual-use material, equipment, and technologies and (2) establishment and improvement of effective systems of export control in the independent FSU countries, supplier countries, and countries through which relevant materials and equipment are transported.

• Transportation and final storage of nuclear materials from the BN-350 breeder reactor in Kazakhstan, which implements U.S. non-proliferation goals by improving the security of the plutonium from the reactor’s spent fuel and blanket assemblies.

• Irreversible shutdown of the BN-350 breeder reactor, which serves U.S. nonproliferation goals by ensuring that the reactor can never again produce nuclear materials suitable for weapons. This program utilizes a unique organizational approach in which integrated design teams are established between various Kazakhstan organizations and Argonne in order to resolve issues that arise.

• The joint U.S.-Russian materials disposition program, which targets the disposal of excess weapons plutonium by reactor irradiation. As part of this effort, the BN-600 fast reactor is being converted to a configuration that burns plutonium.

• The Highly Enriched Uranium Transparency program, which monitors the blending down of highly enriched uranium from dismantled Russian nuclear weapons to produce low-enrichment uranium for eventual use as commercial reactor fuel in the United States, thereby encouraging compliance with international treaty obligations and reducing the threat of nuclear proliferation.

• The Initiatives for Proliferation Prevention (IPP) and the Nuclear Cities Initiative (NCI), which engage former nuclear, biological, and chemical weapons workers in Russia, Ukraine, and Kazakhstan in developing peaceful new civilian occupations. This effort involves collaboration with U.S. companies working under cooperative R&D agreements with Argonne scientists. (The NCI helps only workers in Russian closed cities.)

• The Radiological Dispersal Device program, which helps to secure the radiological materials located abroad that pose the greatest risk to U.S. security, though visits by technical assessment teams comprising experts in physical security, materials control and accounting, and health physics.

Mission

By exploiting the technical and analytical expertise of our staff and our facilities for nuclear research, we support the efforts of federal agencies to reduce threats to national security resulting from the proliferation or possible use of weapons of mass destruction and radiological weapons capable of causing mass disruption. In addition, we help to implement associated U.S. policy initiatives.

Issues and Strategies

We plan to integrate and increase our support for nuclear national security initiatives, particularly by exploiting our unique expertise in nuclear and sensor technologies. The RERTR activities will involve extensive cooperation with Russia and more than 25 other countries. Many international research reactors are today fueled with highly enriched uranium and cannot be converted to low-enrichment fuel by using current technologies. We plan to develop the required new nuclear fuels. In addition, we will develop new targets and chemical processing to produce molybdenum-99, an important medical radio-isotope, by using low-enrichment uranium instead of highly enriched uranium. Our expertise will be used to enhance the security of nuclear materials at additional sites in the FSU and also to reduce the availability of weapons-usable materials by reducing stockpiles of highly enriched uranium. Other activities will focus on developing spin-off projects related to our established MPC&A and training programs in Russia and independent FSU countries. Our technical staff will continue to support NNSA efforts to promote effective nuclear export controls. Argonne expertise will also assist in the development of radiological materials detectors. The IPP program will be extended to engage former biological and chemical weapons workers in the FSU. The NCI program will help place former nuclear weapons scientists in commercial projects at the Sarov Open Computing Center. On the basis of our expertise in nuclear fuel management, we have a technical leadership role in the final storage of the spent nuclear fuel at the BN-350 fast reactor in ways that improve resistance to proliferation. In addition, we were selected to serve as one of two lead laboratories for a proposed project to assist Russia with the design and construction of a dry storage facility for fuel awaiting reprocessing at Mayak. The initiative Nonproliferation Technologies, discussed below, proposes significant expansion of our work on the development, demonstration, and deployment of nuclear material safeguard technologies.

Recent terrorist attacks have made clear the need for increased attention to nuclear national security and homeland defense. Weapons of mass destruction and the materials that are key to their production must continue to receive intense attention. Moreover, the need to address nontraditional challenges, such as weapons that can cause massive disruption, has risen to unprecedented importance. Systems originally designed to address more traditional threats must evolve in order to plan adequately for new potential targets, different modes of delivery, different weapons, and different consequences, including functional defeat of critical economic infrastructure and processes. Systems for responding to actual events must also evolve.

To reduce threats from domestic and international nuclear events, we propose five new initiatives:

1. Nonproliferation Technologies
2. Nuclear Fuel Cycle Technology Applications
3. Training for Specialists in Nuclear Material Protection and Law Enforcement
4. International Nuclear Safety and Cooperation
5. Integrated Research Reactor Safety Enhancement Program

Initiative: Nonproliferation Technologies

We propose significant expansion of our activities related to the development, demonstration, and deployment of nuclear material safeguard and process monitoring technology. For NNSA and DOE-EM, our established sponsors in these areas, this initiative addresses nondestructive assay of materials, monitoring and surveillance systems, and advanced software products. We will also leverage our expertise in special nuclear material handling and physics, along with our associated facilities and materials, to conduct process testing of related technologies developed at Argonne and elsewhere in the DOE complex. Technology development initiatives will be tied to our unique physical resources — including our nuclear materials and remote handling facilities — and ongoing nuclear technology projects. These broadly applicable technologies could also serve DOE-Civilian Radioactive Waste Management and DOD, as well as other federal agencies. As part of this initiative, we also propose to help develop detectors for discerning the movement of radiological dispersion devices and to assist training on the threats these devices pose.

This Nonproliferation Technologies initiative strongly leverages core Argonne programs in spent nuclear fuel treatment, nuclear waste, nonproliferation, facility operations, nuclear safety modeling, and other areas. Related work supporting the Office of Emergency Response of the NNSA aims at technical integration to produce deployable tools and technologies for responding to nuclear and radiological emergencies.

Funding for this initiative will be sought from NNSA (NN), DOE-EM (EW), and DOD. See Table IV.8.

Table IV.8 Nonproliferation Technologies
($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	3.4	4.3	4.3	4.5	4.5	4.5	4.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	3.4	4.3	4.3	4.5	4.5	4.5	4.5
Direct Personnel	6.0	9.0	9.0	9.0	9.0	9.0	9.0

Initiative: Nuclear Fuel Cycle Technology Applications

Argonne is a leader in the technology of the nuclear fuel cycle. This initiative proposes application of our expertise and facilities to reducing the likelihood of diversion of nuclear materials throughout the nuclear fuel cycle, to identifying materials detected in illicit commerce, and to characterizing materials that might be encountered in a nuclear incident.

Methodology for Nuclear Fuel Cycle Observability and Transparency. Observability and transparency are critical objectives in improving the proliferation resistance of existing and future nuclear fuel cycles. Advanced nuclear fuel cycles must be designed to maximize those attributes for the facilities of all IAEA member states that do not already possess nuclear weapons. Initially designing fuel cycle processes and operations to be more observable and transparent reduces the potential for undetected proliferation. A formal methodology for implementing greater observability and transparency facilitates integration of attributes inherent in plant operation with advanced technologies for information management and unattended monitoring. Such integration will enable timely verification that only declared operations are being conducted within declared facilities. This kind of advanced methodology combines positive verification (i.e., material accountancy) with negative verification (i.e., operations accountancy) to increase the effectiveness of safeguards.

Nuclear Material Attribution. The ability to determine (1) where nuclear materials originated, (2) the capabilities by which they were produced, and (3) the ways in which they might be used is important for interdicting illicit commerce in nuclear materials and for determining the source of nuclear materials obtained by terrorists. We propose to apply our expertise in nuclear fuel cycles to these three tasks as an expansion of our current work on materials attribution for homeland defense.

Nuclear Material Characterization. Emergency response and mitigation in response to a terrorist attack involving a radiological dispersion device or a crude nuclear device require knowledge of the character of the materials involved and the phenomenology of the device. We propose to apply our expertise to planning for the characterization of materials produced from such a device (e.g., by understanding the materials' signatures), identifying possible pathways to communities and the environment, and developing means of mitigating impacts.

Resources for this initiative will be sought from DOE-Defense Nuclear Nonproliferation (NN), DOD, and other agencies involved in homeland defense. See Table IV.9.

Table IV.9 Nuclear Fuel Cycle Technology Applications ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	2.0	2.5	2.5	2.5	2.5	2.5	2.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	2.0	2.5	2.5	2.5	2.5	2.5	2.5
Direct Personnel	9.0	11.5	11.5	11.5	11.5	11.5	11.5

Initiative: Training for Specialists in Nuclear Material Protection and Law Enforcement

For several years we have supported the MPC&A program of NNSA by providing training to nuclear security personnel from Russia and the independent FSU countries. This training, conducted at the MPC&A Training Facility at Argonne-West, teaches the latest security concepts and gives students hands-on experience in operating electronic and computerized security systems. In coming years, we will offer to expand the number of classes conducted and thereby enable NNSA to accelerate completion of its MPC&A projects. In addition, we will offer our security training facility and expertise to help law enforcement officials meet their homeland security responsibilities. We are currently discussing with local law enforcement officials their training needs related to access control for courts, public buildings, and airports.

In addition to offering security experts for foreign projects, we stand ready to provide experts for surveys supporting homeland security.

Resources required are summarized in Table IV.10. Funding will be sought from DOE-Defense Nuclear Nonproliferation (NN).

Table IV.10 Training for Specialists in Nuclear Material Protection and Law Enforcement
($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	2.5	3.0	3.5	3.5	3.5	3.5	3.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	2.5	3.0	3.5	3.5	3.5	3.5	3.5
Direct Personnel	5.0	6.0	6.5	6.5	6.5	6.5	6.5

Initiative: International Nuclear Safety and Cooperation

We support the International Nuclear Safety and Cooperation program, which assesses the safety of Soviet-designed power reactors. This work has demonstrated the need for continued U.S. engagement with less developed countries seeking peaceful use of nuclear technologies. Moreover, this ongoing program has revealed important nuclear safety and security issues that indicate threats to these reactors. Therefore, we propose to expand our current program to collaborate with countries wishing to assess and address such issues. The focus of the program will be assessments of the risks facing nuclear installations from both internal and external threats. The program would include collaborative training, coordinated between Argonne and the IAEA, that facilitates the transfer of safety assessment technology to participating countries, as well as the linking of those countries into the network of international nuclear safety centers.

Resource requirements are given in Table IV.11. NNSA funding (AF-15-30) would be supplemented by funding from the U.S. Agency for International Development and from the Nonproliferation and Disarmament Fund.

Table IV.11 International Nuclear Safety and Cooperation ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	0.4	1.0	1.0	1.0	1.0	1.0	1.0
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	0.4	1.0	1.0	1.0	1.0	1.0	1.0
Direct Personnel	1.5	3.0	3.0	3.0	3.0	3.0	3.0

Initiative: Integrated Research Reactor Safety Enhancement Program

We propose to significantly expand our work in the area of cooperation and safety enhancement for international research reactors. Research reactors represent unique safety and security risks for less developed countries. An integrated approach to addressing these risks — based on our experience in work with research reactors, international safety networks, fuels, and decommissioning — can offer NNSA a more powerful way to improve research reactor safety. By leveraging existing safety infrastructures, we can approach facilities of concern in a cooperative manner, assess vulnerabilities, and provide substantial assistance in the areas of fuel characterization, stabilization, and disposition;

safety and security upgrades; safety infrastructure development; and emergency preparedness.

We have a long history of working with the owners and operators of foreign reactors and their support organizations to assess and improve nuclear safety. Establishment of networked international nuclear safety centers will continue to provide valuable liaisons with the nuclear communities in the countries of the FSU and elsewhere. This network can provide the framework for reducing risks associated with research reactors and can offer valuable support in areas such as emergency response and health physics training. Many research reactor facilities worldwide suffer from poor quality assurance programs, lack of trained personnel, insufficient safety reviews, and limited regulatory oversight. Working in parallel with the new International Nuclear Safety and Cooperation program proposed above, the Integrated Research Reactor Safety Enhancement Program can address both broader infrastructure issues and specific facility issues.

Synergies with existing Argonne work for the RERTR program and for material protection programs will be exploited to provide maximum benefit to NNSA. Cooperation with the IAEA and the U.S. Nuclear Regulatory Commission will further enhance the program's effectiveness.

Resource requirements are given in Table IV.12. NNSA funding (NN-30) may be supplemented with funds from the U.S. Agency for International Development and from the Nonproliferation and Disarmament Fund.

Table IV.12 Integrated Research Reactor Safety Enhancement Program ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	1.9	3.0	3.5	3.5	3.5	3.5	3.5
Capital Equipment	-	-	-	-	-	-	-
Construction	-	-	-	-	-	-	-
Total	1.9	3.0	3.5	3.5	3.5	3.5	3.5
Direct Personnel	2.5	5.0	7.0	7.0	7.0	7.0	7.0

b. Infrastructure Assurance and Counterterrorism

Situation

Our work on infrastructure assurance and counterterrorism aims to assure the security and reliability of critical U.S. infrastructures and other key national assets — as well as the safety of associated populations — that are threatened by disruptions resulting from natural events, accidents, or deliberate acts such as terrorist attacks. This work addresses cyber security and technologies, as well as capabilities for detecting, combating, and recovering from chemical, biological, and nuclear terrorism (a growing national security concern addressed in the preceding Nuclear National Security area plan, Section IV.A.3.a). Work in these areas of homeland security directly supports both DOE's overarching national security mission and the mission of the new Department of Homeland Security (DHS).

Our work on infrastructure assurance and counterterrorism draws on expertise, knowledge, technologies, and specialized research facilities developed over decades for other purposes. By leveraging our core science and technology competencies, this work responds to the shifting challenges facing the nation. These challenges are complicated by changes in threat profiles, weapons, targets, attackers, and motivations.

Our infrastructure assurance and counterterrorism programs have annual budgets totaling approximately $12 million. Significant components of these programs include the following:

- The Vulnerability Assessment program evaluates the safety and security of critical infrastructure by considering physical security, operations security, cyber security, and infrastructure interdependencies. The program includes comprehensive assessments and rapid surveys.
- The Energy Infrastructure Interdependencies program evaluates the

interdependencies among various types of infrastructures (e.g., between electric power and natural gas or between electric power and telecommunications); the potential for cascading impacts resulting from disruptions to one or more types of infrastructures; better methods of detecting events affected by infrastructure interdependency; and improved technologies and procedures for preventing, responding to, and recovering from such events.

- The Infrastructure Outreach program increases the awareness of infrastructure owners and operators concerning security issues. This program also promotes sharing of best practices and lessons learned in infrastructure assurance.

- The Community Critical Infrastructure Protection program, in collaboration with community emergency planners and local utilities, develops plans and procedures that municipalities can use to prevent, respond to, and recover from major disruptions to energy infrastructure (e.g., that for electric power or natural gas).

- The Interior Infrastructure Protection for Chemical/Biological Attacks program demonstrates technologies for mitigating impacts from chemical or biological attacks on interior infrastructure deemed to be at above-average risk, such as subways, airports, and public buildings.

In addition to the programs described above, we maintain the following significant capabilities and facilities for addressing potential chemical and biological threats:

- Instruments for detecting potential chemical or biological threats in air, water, and soil, whether dispersed over kilometers or hidden in caches.

- Facilities for evaluating the effectiveness of chemical and biological monitoring methods, at both laboratory scale and field scale.

- Capabilities for determining health and environmental risk from the dispersion of chemical, biological, and nuclear weapons.

- Capabilities for evaluating the effects of agents on materials and for developing protective materials and methods of decontamination.

- Laboratories and expertise for developing prophylactic drugs and vaccines based on structural analyses of biomolecules.

- Fast-response systems for protecting first responders, decreasing exposure times, and reducing risk.

- The capability to conduct laboratory and field analyses enabling attribution of chemical or biological attacks.

- The Electron Microscopy Center, which provides high-resolution scanning electron microscopes able to examine and characterize the nanoscale embodiments likely to be used in chemical and biological detectors.

- The Multi-Bay Robotics Laboratory, which can develop robotic manipulator systems for remote work in unstructured hazardous environments.

- The Mobile Laboratory for Chemical Agent Detection, which is used to characterize chemical agent contamination in U.S. Army buildings. Samples can be analyzed on-site for rapid turnaround, and the facility can confirm decontamination after cleanup operations.

- The Dilute Chemical Agent Facility, which is approved by the U.S. Army to Level 2 and is certified to accept agents such as soman, sarin, and lewisite. The facility is equipped for development of analytical methods, detector testing, development of decontamination technologies, and validation of transport models. This facility currently serves as an emergency response laboratory for the Environmental Protection Agency.

Other Argonne facilities also provide significant R&D capabilities for addressing potential chemical and biological threats. These include the APS and the associated Structural Biology Center and Midwest Center for Structural Genomics. Though most of the Laboratory capabilities and facilities identified here were not specifically established for R&D related to chemical and biological counterterrorism, they nevertheless are significant resources for addressing currently anticipated threats.

Mission

By leveraging our expertise and facilities, both physical and computational, we support DOE's overarching national security mission and the complementary efforts of other federal agencies to ensure the security and reliability of the nation's critical infrastructure and reduce threats from weapons of mass destruction.

Issues and Strategy

In the area of infrastructure assurance and counterterrorism, we support the development of technologies and strategies that improve detection, mitigation, response, and recovery. As described below, we plan to expand our work on infrastructure vulnerability and risk assessment, energy systems analysis, analysis of infrastructure interdependencies, emergency preparedness, consequence management, and protection from chemical and biological threats. These activities have been given high priority by DHS and the White House Office of Science and Technology Policy, and they are cornerstones of DOE's long-term R&D program on critical infrastructure protection.

In the area of counterterrorism, we continue to expand research related to chemical and biological threat analysis, vulnerability assessment, detection and speciation, and incident response and attribution. These activities are based on Argonne competencies that include (1) molecular biology, (2) structural analysis, (3) radiation chemistry and photochemistry, (4) catalysis and electro-chemistry, and (5) chemical and biological decon-tamination. For example, a microchip-type sensor that employs methods for isolating and labeling RNA (ribonucleic acid) is being evaluated as part of a comparative study sponsored by the Defense Threat Reduction Agency. We are also developing other detection methodologies that rely on biomolecular recognition, antibody pairing, or molecular fluorescence. Further current research focuses on ozone-based decontamination systems, aerosol monitoring, and risks associated with chemical warfare agents. During the coming year, we will submit new threat reduction initiatives to DOE and other concerned public agencies. These initiatives are based both on our expertise and on facilities such as the APS, the Structural Biology Center, and the Midwest Center for Structural Genomics.

Important recent developments in Argonne's work on counterterrorism are two NIH-funded entities: the Midwestern Regional Center of Excellence for Biodefense and Emerging Infectious Diseases Research (RCE) and the Regional Biocontainment Laboratory (RBL). The RCE, being led by the University of Chicago and Northwestern University, involves multiple universities, research institutes, and public health authorities and more than 100 scientists. The RBL will provide RCE researchers with facilities certified to "biosafety level 3" (the third highest of four levels). See Section S1.C for further information.

Initiative: Infrastructure Assurance and Counterterrorism

We propose to expand our current research, development, and analysis activities in the area of critical infrastructure assurance and counterterrorism. The goal of this work for DOE, DHS, and other federal agencies is to develop and apply innovative technologies, methodologies, models, and simulations that (1) will better protect critical U.S. infrastructure (including cyber-based information systems) and associated populations from disruption and (2) where disruptions do occur, will improve detection, mitigation of effects, response, and recovery. Our capabilities are particularly relevant to the infrastructures for energy (electric power, oil, and natural gas), transportation, agriculture, water supply, information and communications, and emergency services.

This initiative responds to major documents outlining U.S. policy toward homeland security, including the *President's National Strategy for Homeland Security* (July 16, 2002), the *USA Patriot Act of 2001*, and the *National Strategy for the Physical Protection of Critical Infrastructures and Key Assets*. The initiative is also consistent with the strategic thrust of DOE's Office of Energy Assurance, which was established in December 2001 to serve as the focus for DOE's activities in energy infrastructure assurance. Under these executive orders, DOE is the lead federal agency for assuring the continuity and viability of the nation's critical energy infrastructures.

Our long history of work related to infrastructure assurance and counterterrorism — reinforced by more intensive work over the past five years for the DOE Office of Energy Assurance, the Critical Infrastructure Assurance Office, DOD, and other government organizations — provides the foundation for this initiative. We will expand our work in the areas of vulnerability and risk assessment, energy and water systems analysis, information management, infrastructure interdependencies analysis, modeling and simulation of agent-based and complex adaptive systems, decontamination and remediation, and emergency preparedness and consequence management.

Improved technologies and capabilities are needed in all these areas to address the unprecedented range of physical and cyber threats to critical U.S. infrastructure from natural causes, accidents, and deliberate acts like the terrorist attacks on the World Trade Center and Pentagon. We will particularly emphasize development of methodologies and tools for analyzing the new vulnerabilities that have arisen because various components of the nation's infrastructure have become increasingly complex, automated, physically interconnected, and logically interdependent. The White House Office of Science and Technology Policy has given high priority to research on interdependent infrastructure, a cornerstone of DOE's long-term program on critical infrastructure protection.

We will continue to enhance our collaboration with other national laboratories as we conduct vulnerability surveys and assessments and develop cost-effective solutions to infrastructure assurance and counterterrorism problems. In the area of chemical and biological threats, we are currently leading multilaboratory teams of experts in modeling and analyzing infrastructure interdependencies and protecting civilian interior infrastructures (such as subway systems, airports, and public buildings) deemed to be at above-average risk.

Resources required for this initiative are summarized in Table IV.13. Funding will be sought from the DOE Office of Energy Assurance (GD-05), the NNSA Office of Defense Nuclear Nonproliferation (NN-20), other DOE program offices, and other federal agencies.

Table IV.13 Infrastructure Assurance and Counterterrorism ($ in millions BA, personnel in FTE)

	FY03	FY04	FY05	FY06	FY07	FY08	FY09
Costs							
Operating	13.0	12.0	12.0	12.0	12.0	12.0	12.0
Capital Equipment	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Construction	-	-	-	-	-	-	-
Total	13.1	12.1	12.1	12.1	12.1	12.1	12.1
Direct Personnel	60.0	55.0	55.0	55.0	55.0	55.0	55.0

c. Department of Homeland Security

Situation

Recent terrorist attacks on the United States and heightened threats resulting from the liberation of Iraq have underscored the need for increased emphasis on homeland security. The most recent immediate concern is the possibility that terrorist groups have obtained nuclear, biological, or chemical weapons — or their constituents — from Iraq. Addressing challenges from the unconventional weapons and delivery methods used by terrorist organizations will be a high national priority for the foreseeable future. To anticipate, detect, defend against, mitigate, and recover from such attacks — whether directed against domestic civilian populations, economic targets, or critical elements of the nation's infrastructure — the United States must both adapt existing security systems and implement new planning methods, new detection and monitoring systems, new communication and control processes, new remedial technologies, and new analytical methods.

With the other national laboratories, Argonne already supports post-911 national security research through programs funded by DOE and other government agencies. As indicated in the two area strategic plans above, our current diverse research on science and technology for nuclear nonproliferation, arms control, infrastructure assurance, and counterterrorism is based on expertise, experience, and facilities that were developed over decades to support the DOE mission. Other relevant R&D efforts and assessments for non-DOE agencies include work for DOD, the Environmental Protection Agency, and the Federal Emergency Management Agency in the areas of planning and technology for environmental health, infrastructure assurance, and counterterrorism.

Though many of these ongoing R&D activities are directly relevant to the mission of the new DHS, in April 2003 few Argonne programs were directly sponsored by DHS. We anticipate that more existing programs will be transferred to DHS by their current sponsors and that new DHS programs will be established.

Mission

We will apply Argonne's technical and analytical expertise, resources, and facilities — in physical, biological, and computational science and technology — to help DHS pursue its mission to reduce threats to U.S. populations, communities, and infrastructure resulting from terrorism, especially terrorism involving weapons of mass destruction and weapons capable of causing massive disruption.

Issues and Strategies

We have technical capabilities in a number of research areas that are highly relevant to the DHS mission, notably in the areas of nuclear, biological, and chemical instruments and sensors; analytical chemistry and biology; attribution analysis; applied computational methods; health and environmental risk assessment; detection, handling, and containment of hazardous nuclear, chemical, and biological materials; decontamination of sites and facilities; advanced materials technology; infrastructure protection planning; structural biology and genomics; biological detectors; robotics; and logistics systems analysis. We are also equipped to provide technical support for certain rapid response functions related to the DHS mission.

As its responsibilities and priorities are better defined, we plan to propose to DHS new R&D initiatives that are consistent with the Laboratory's mission, its responsibilities to DOE, and its core competencies. In preparation, Argonne has appointed an acting associate laboratory director with specific responsibility for organizing, focusing, and structuring the Laboratory's programs in homeland security and other areas of national security. Future editions of Argonne's *Institutional Plan* will spell out in more detail our current and planned work for DHS.

4. Collaborative R&D Partnerships

Situation

If our research is to have an impact and provide benefits, results must be readily accessible to commercial firms for further development and application to meet the needs of industry and the public. We pursue these objectives through broad publication of results, development of patent portfolios, and partnering with industry. Our research partnerships with industry contribute strongly to DOE's strategic goals and provide a basis for U.S. innovation.

As part of our focus on partnerships, we have expanded our collaboration with the University of Chicago through numerous joint research projects. The technology transfer offices at the two institutions work together to identify the most effective approaches to commercializing Argonne intellectual property. Day to day, Argonne's Technology Transfer Office works closely with Laboratory research divisions to develop productive research contracts with partners in industry, academia, and not-for-profit organizations, in order to provide competitive benefits to users of Argonne technologies and, ultimately, enhanced energy security and environmental quality for the nation.

Mission and Vision

The mission and vision of our technology transfer program include five elements:

- Enhance the competitiveness of U.S. industry by transferring Argonne technology solutions to industry and the marketplace.

- Expand and enhance Argonne's R&D programs and funding through cooperative research and technical interactions with government, academic, and private organizations.
- License Argonne intellectual property to enhance U.S. competitiveness while providing revenue to the Laboratory.
- Foster utilization of Argonne's R&D through proactive efforts to deploy results to industry and, ultimately, provide benefits to the public.
- Leverage technology transfer to increase returns to Argonne and significantly contribute to the Laboratory's fulfillment of its mission and strategic goals; to this end, use joint ventures, new company start-ups, and other productive business arrangements.

Approach

We use a variety of tactical approaches to accomplish our mission and provide benefits to the nation. Most importantly, we support numerous cooperative R&D agreements (CRADAs) through Laboratory research programs. Increasingly, we use work-for-others contracts as a vehicle for industrial agreements and transfer of our technology. In addition, we use "full funds-in CRADAs" as a basis for developing cooperative research partnerships that move Laboratory technologies toward commercialization. In FY 2002 Argonne initiated a joint program with the University of Chicago to identify technologies particularly well suited to commercialization by start-up companies and then to take steps toward organizing appropriate new ventures that can attract funding from outside investors.

For further information about technology transfer at Argonne, see Supplement 2.

B. Laboratory Directed R&D Program

The Laboratory Directed Research and Development (LDRD) program funds creative and innovative R&D projects at Argonne. Selection of projects is the responsibility of the laboratory director. The objectives of LDRD are to stimulate innovation and creativity, to continuously renew the scientific and technological vitality of the Laboratory, and to respond to rapidly emerging R&D opportunities. The program enhances our ability to attract and retain the high-caliber scientists and engineers essential for undertaking our missions for DOE and the nation. In addition, LDRD helps ensure that we provide scientific and technical leadership in fields related to our mission.

Our primary criteria for selecting LDRD projects are scientific and technical excellence, innovativeness and cross-disciplinary character, relationship to Laboratory strategic goals and objectives, expected contributions from the results, and prospects for continuation under programmatic support. Each year the laboratory director designates portions of the LDRD budget for support of particular types of projects. Categories include (1) competitive grants initiated by a principal investigator or a team on any mission-related topic and (2) competitive projects directly relating to or supportive of the Laboratory's strategic initiatives. The immediate objectives of Argonne's LDRD portfolio are (1) to reinforce our R&D planning by supporting our mission and strategic view (as described in Chapter II of this *Institutional Plan),* (2) to enrich our technical capabilities, (3) to encourage innovation and creativity by technical staff through the development of new concepts and principles and the undertaking of projects having high risk but potentially high reward, and (4) to exploit Argonne's technical potential for the benefit of the nation. As a result of the criteria used to select projects, our portfolio of LDRD projects is clearly tied to DOE's overarching national security mission (encompassing science, energy, environment, and security). In addition, the LDRD program has the very important benefit of enhancing the morale and vitality of our scientific and technical staff. Researchers' enthusiasm is nurtured by the knowledge that good new ideas, even those well beyond existing programs, are eligible to compete for the immediate funding they need.

Our LDRD program supports promising novel and innovative projects wherever they may appear across the broad spectrum of science and technology relevant to current or prospective

Laboratory missions. A report of accomplishments across the entire LDRD program is made to DOE each year. Our notable recent accomplishments include the following:

- Developed a finite-difference time-domain approach to calculating the light-scattering cross sections of metal nanoparticles.
- Demonstrated the feasibility of applying to counterterrorism (1) the concepts of agent-based complex adaptive systems and (2) computer simulations.
- Fabricated, through both patterning and self-assembly, a variety of nanophotonic structures having novel optical properties.
- Demonstrated at bench scale a single-step lithium reduction process for uranium oxide that is applicable to the reduction of spent oxide reactor fuel to metal.
- Reduced to 120 nanometers the lower wavelength limit of x-rays produced in the free-electron laser at the APS, thereby creating an unrivaled x-ray source for photo-ionization experiments and for studying self-amplified spontaneous emission phenomena.
- Successfully applied advanced search algorithms and artificial intelligence codes to elucidate protein structure as determined by amino acid sequences and "fold-templates."
- Developed a new process for removing hazardous organic compounds from ground-water by using a method exploiting centrifugal contactor-based solvent extraction.
- Developed a "phantom head" experimental model for studying cooling of the human brain as an emergency medical protocol.
- Developed the Open Link concept for efficiently linking computer codes and modules for environmental assessment.

The larger component of our LDRD emphasizes R&D aligned with Laboratory strategic initiatives, as reflected in this *Institutional Plan*. Strategic goals are periodically revised and reevaluated, as required. The specialized expertise of our staff naturally causes a substantial number of LDRD projects suggested by employees to fall into the various high-priority initiative areas, so they become eligible for a correspondingly high priority in the proposal selection process. As discussed in Chapter III, current major Laboratory initiative areas include Nanosciences and Nanotechnology, the Rare Isotope Accelerator, Functional Genomics, Petaflops Computing and Computational Science, Advanced Nuclear Fuel Cycle, and Hydrogen Research and Development.

Several LDRD projects will be supported under the auspices of the Competitive Grants component of the LDRD program. This component provides a direct avenue for single investigators and small multidisciplinary teams to propose projects to the laboratory director that do not fall within the Laboratory's defined strategic initiative areas, but that have high scientific or technical merit and are at the forefront of their fields. A Director's Review Committee, comprising scientists and engineers spanning the breadth of our disciplines and programs, subjects Competitive Grants proposals to a thorough and highly competitive merit review. The resulting ranking is used by the laboratory director to select winning proposals.

The LDRD program is funded Laboratory-wide through Argonne's indirect budget. As part of our LDRD planning before each fiscal year begins, we propose to DOE a maximum total LDRD expenditure. As indicated in Table IV.14, for FY 2003-FY 2004 this upper limit generally approximates 4.5% to 5.0% of our projected total of operating and equipment funding.

Table IV.14 Laboratory Directed R&D Funding ($ in millions)

	FY01[a]	FY02[b]	FY03[c]	FY04[c]
	20.9	20.9	22.5	25.0

[a] Actual expenditures.
[b] Authorized maximum expenditures for the LDRD program.
[c] Proposed maximum expenditures for the LDRD program.

V. Operations and Infrastructure Strategic Plan

Our fourth strategic objective is stated in Chapter II: "The University of Chicago and Argonne will continuously improve the cost-effectiveness, management, and operations of the Laboratory." This chapter presents strategic plans for the following areas of operations and infrastructure at Argonne: human capital; site and facilities; environment, safety, and health; integrated safeguards and security management; information management; communications, outreach, and community relations; performance management; and cost-effectiveness of support functions. The chapter begins with general statements of mission, situation, and goals and strategies for operations and infrastructure.

General Mission

Operations infrastructure and support activities are crucial to the effective and efficient achievement of our R&D mission. Operations organizations work as partners with Argonne's R&D programs, providing cost-effective, customer-focused infrastructure and services that enable the creation of world-class science, technology, and service products.

General Situation Analysis

Because operations and infrastructure are funded as a charge to the total program funding we receive, there is always great incentive to reduce these overhead costs while still maintaining the effectiveness and quality of operations and services. Every overhead dollar saved is an additional dollar for direct funding of research programs.

General Goals and Strategies

Management of our operations infrastructure and support functions has seven broad goals, specified below along with strategies for their achievement:

- Enable and support Argonne's R&D work. Provide efficient services, business processes, and information systems that are responsive to programmatic requirements and initiatives.
- Deliver distinctive customer service. Provide efficient customer-focused services that improve employee productivity, advance programmatic goals, and drive operational excellence.
- Provide exceptional infrastructure. Develop innovative strategies for building and maintaining highly reliable, cost-effective site utilities and facilities that support world-class science and technology.
- Enhance external and internal communication. Increase national recognition of our contributions to science and technology. Encourage sharing of information and ideas among all employees. Expand productive partnerships.
- Demonstrate success in safety and security. Effectively integrate safety and security into all operations, perform favorably compared to national standards and external peers, and continually improve performance. Provide appropriate access to Argonne and its user facilities through implementation of carefully considered policies and requirements for both safety and security.
- Promote Argonne as an employer of choice. Provide a high-quality work environment and competitive salary and benefits — all highly valued by employees.
- Deliver outstanding performance. Earn outstanding ratings from DOE in all contractual performance areas for Laboratory operations.

The cornerstone of our approach to efficient operations and successful research is integration of safety, security, environmental, and other operational responsibilities and activities into line management and work practices throughout the Laboratory, at all levels. Our Integrated Management program addresses the full range of relevant risks we face in our work. It encompasses our Integrated Safety Management program, our Integrated Safeguards and Security Management program, and our Environmental Management System. In all areas, Integrated Management involves careful attention to the following five steps: (1) define the scope of work, (2) analyze the risks, (3) develop and implement controls, (4) work within the controls, and (5) use feedback and make improvements. Policy formulation, leadership, and coordination are provided by the Environment, Safety, Security, and Health Committee. In addition, security considerations are included in assessments of performance of line management and in oversight conducted by the office for Environment, Safety, and Health/Quality Assurance Oversight.

We continually strive to increase the efficiency of our operations and support units while maintaining their effectiveness and quality. The performance-based contract between the University of Chicago and DOE, hereafter referred to as the *Prime Contract*, provides a system for encouraging continuous improvement in our operational functions (as discussed further in Section V.G). With collaboration and support from DOE's Chicago Operations and Argonne Area Offices, we continually strive to refine a full range of best business practices.

A. Human Capital

Situation

The quality of technical staff is a primary determinant of the performance of an R&D laboratory. Our human resources strategy is designed to develop strong leadership, to support a creative and diverse workforce, and to recruit and develop the talent needed to implement our programmatic activities and initiatives.

Human resources management at Argonne is conducted as a partnership between our programmatic and operations organizations and the central Human Resources Division. Critical to the success of this effort is a focus on Laboratory policies, programs, and initiatives that influence an individual's decision to join the Laboratory, that help shape the working environment for those making a career at Argonne, that contribute to the well-being of employees (even after they retire) through important benefits such as health insurance and retirement income, and that comply with federal and state regulations.

Total commitment to equal opportunity for all people is a fundamental Laboratory policy. We value the diverse cultural and ethnic backgrounds of our employees and strive to create an environment that capitalizes on these differences as one means of maintaining a high-performance workforce.

Goals

The goal of our human capital management is to support the strategic objectives of our programmatic and operations organizations by developing and implementing programs that attract, develop, compensate, and help to retain a qualified and diverse staff. Specific objectives include the following:

- Directly link and integrate centralized human resources strategies with the strategic needs of division managers.
- Improve the quality of employees' work life in order to foster staff satisfaction, individual contribution, and organizational effectiveness.
- Maintain a compensation policy that is competitive with policies at peer organizations and that rewards superior performance.
- Promote the commitment of managers at all levels to equal opportunity, affirmative action, and diversity.
- Develop Laboratory leadership and staff capabilities through targeted management training and skill development opportunities.
- Provide services that promote the well-being and productivity of Argonne employees.

Strategies

The key to effectively integrating centralized human resources strategies with the needs of individual programmatic and operations divisions is frequent dialogue with division managers, particularly regarding opportunities for centralized services that go beyond purely administrative functions. To achieve this integration, we use formal management surveys, input from human resources liaisons within the divisions, and direct dialogue involving division managers. During regularly scheduled one-on-one meetings, division directors and human resources representatives discuss personnel and recruitment needs, training, diversity targets, and the division's general human capital needs.

Achievement of our goals requires top-quality staff who find personal and professional fulfillment in their work. (Table V.1 describes their extensive academic training.) Our success in employing high-caliber staff starts with recruiting the best and the brightest, including people from diverse backgrounds. In FY 2002 Argonne recruiters participated in eight job fairs, through which they made direct contact with more than 800 potential new hires.

Table V.1 Academic Degrees of Argonne Staff[a]

Occupational Category	Total	PhD	MS/MA	BS/BA	Other[b]
Officials and Managers	553	265	141	102	45
Scientists	617	305	123	132	57
Engineers	570	209	143	145	73
Managers and Administrators	271	16	54	103	98
Technicians	527	1	6	70	450
All Others	976	0	3	59	914
Grand Total	3,514	796	470	611	1,637

[a] Number of full- and part-time regular employees as of September 30, 2002.

[b] Associate level degree or less.

We are committed to strengthening the vitality, quality, and diversity of our workforce. Maintenance of a competitive compensation structure is important in our competition for critical talent. We manage all components of compensation — base pay, merit increases, compensation supplements, and promotion-related increases — as a coordinated whole. Each employee's compensation (apart from fringe benefits) is linked to achieved performance, as evaluated under our appraisal process. That process focuses on sustained performance and compensation relative to peers and the external market. In its recent certification of Argonne's compensation system, DOE characterized the system as one "... that demonstrates continuous improvement, creativity, and effectiveness."

Total commitment to equal opportunity for all people is a fundamental Argonne policy. Our annual *Affirmative Action Plan* gives managers a summary of previous accomplishments and a blueprint for the future. Supervisors are held accountable for progress in this area. In FY 2002, job postings and recruitment ads were placed in 19 magazines and web sites that target minority job candidates, an increase from 8 in FY 2001. Table V.2 describes the Laboratory's current employee populations.

Our Performance Evaluation Process committee in FY 2002 developed and deployed a new process for evaluating the performance of employees. The committee solicited comments from employees and examined other laboratories and private industry as benchmarks. Employees were informed about the new process through a web site, news articles, and an all-employee meeting. The new process focuses on establishing a clear connection between the goals of each employee, the goals of the Laboratory, and the goals of the major intermediate levels of management.

We supplement the formal education of our employees with performance-enhancing training. Course offerings are based both on assessment of professional development needs and on compliance with DOE directives. The wide range of subjects offered includes supervisory skills, team building, project management, presentation skills, and R&D proposal development. We recently introduced a half-day workshop to orient new supervisors to their roles and responsibilities at the Laboratory. In FY 2002, 622 supervisors, old and new, received training to help them address discrimination, harassment, and similar challenges in the workplace.

Additional Argonne programs that promote the well-being and productivity of employees include health screening and wellness programs, financial education programs, and programs for dealing with life and family issues. Examples include programs on estate planning and

Table V.2 Equal Employment Opportunity at Argonne[a]

Occupational Category	Total		Minority Total		White	
	Male	Female	Male	Female	Male	Female
Officials and Managers	465	88	39	8	426	80
Scientists and Engineers	1,010	177	159	35	851	142
Managers and Administrators	108	163	5	27	103	136
Technicians	465	62	46	9	419	53
Clerical Workers	18	410	4	66	14	344
Craftsmen and Laborers	336	37	63	15	273	22
Service Workers	132	43	29	13	103	30
Totals	2,534	980	345	173	2,189	807

Occupational Category	African-American		Hispanic		Native American		Asian	
	Male	Female	Male	Female	Male	Female	Male	Female
Officials and Managers	4	3	6	2	0	0	29	3
Scientists and Engineers	16	2	14	4	3	0	126	29
Managers and Administrators	1	11	2	6	0	1	2	9
Technicians	17	2	19	1	1	1	9	5
Clerical Workers	2	29	2	26	0	1	0	10
Craftsmen and Laborers	45	11	14	3	1	1	3	0
Service Workers	19	7	4	5	2	1	4	0
Totals	104	65	61	47	7	5	173	56

[a] Includes both full-time and part-time regular employees as of September 30, 2002.

preretirement planning, a women's wellness series featuring seminars and health screenings, an interactive roundtable on elder care, and a health fair.

To increase the effectiveness and quality of human resources information and to reduce costs, we take advantage of new electronic approaches to information management and reduce our dependence on traditional paper documents. For example, we (1) created an electronic database of 37,000 past Argonne employees to ensure prompt compliance with requests from federal agencies for claims information, (2) implemented a process for scanning retiree files into an electronically accessible format, and (3) designed an automatic process to submit Laboratory job openings to the America Job Bank. Our intranet provides electronic versions of the employee handbook, policy and procedures manuals, benefit plan descriptions, and information on the historical performance of retirement funds.

B. Site and Facilities

Situation

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

The physical infrastructure at Argonne-East contains 4.8 million square feet of floor space, including 77 thousand square feet of nearby leased space. The facilities, valued at approximately $1.9 billion, currently accommodate about 4,800 persons (including DOE employees, contractors, and guests). Throughout the year, over 2,000 additional researchers use the Laboratory's scientific facilities as visitors or collaborators. Argonne-East facilities are nearly 99% occupied.

Argonne-West contains 581,000 square feet of floor space, with an estimated replacement value of $438 million. The site currently accommodates about 690 persons. Recent renovations and continuing maintenance of major facilities are enabling Argonne-West to pursue important research on nuclear technology for DOE. Program sponsors other than DOE-Nuclear Energy are charged for facility utilization in a manner similar to the space use charge-back system at Argonne-East. Site services such as fire protection and dosimetry are purchased from the site contractor for INEEL.

Supplement 3 (located near the end of this document) provides additional information on Argonne's sites and facilities, including plans for infrastructure and for the rehabilitation and modernization of facilities.

Vision

Argonne will retool its physical setting to achieve a 21st century infrastructure having appropriately configured research facilities that provide reliable, safe, secure, efficient, attractive working environments suitable for world-class science, engineering, and technical services.

Issues and Strategies

In the area of site and facilities, the principal challenges Argonne is addressing are the normal aging of buildings and infrastructure and a substantial need for upgraded laboratory facilities to meet the challenges of the 21st century. As Figure V.1 shows, 54% of Argonne-East facilities are over 40 years old, while at Argonne-West 65% of space is over 30 years old.

Argonne-East

In recent years Argonne-East has made substantial progress toward the rehabilitation and replacement of its facilities. However, the Laboratory's backlog of infrastructure and modernization needs is increasing, predominantly due to aging. Figure V.2 shows the condition of buildings at Argonne-East.

Over the infrastructure planning horizon, new programmatic facilities are expected to expand the base of modern, efficient space at Argonne-East. Nevertheless, substantial need for rehabilitation of older facilities remains.

Strategic modernization of Argonne-East facilities centers on three coordinated, phased upgrade projects addressing (1) building electrical systems, (2) building mechanical and control systems, and (3) laboratory space upgrades. The work scope of each project phase is based on priorities established through the Laboratory's Condition Assessment Survey process.

In general, Argonne-East upgrades a building's electrical system to support greater mechanical and functional power and lighting loads and to allow more extensive use of

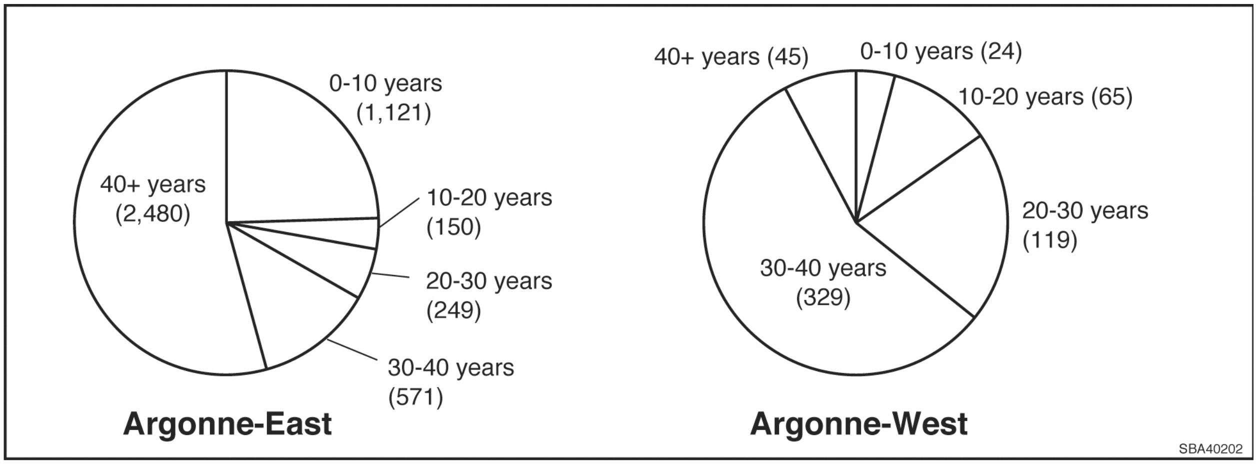


Figure V.1 Age of Argonne Facilities (values in thousands of gross square feet)

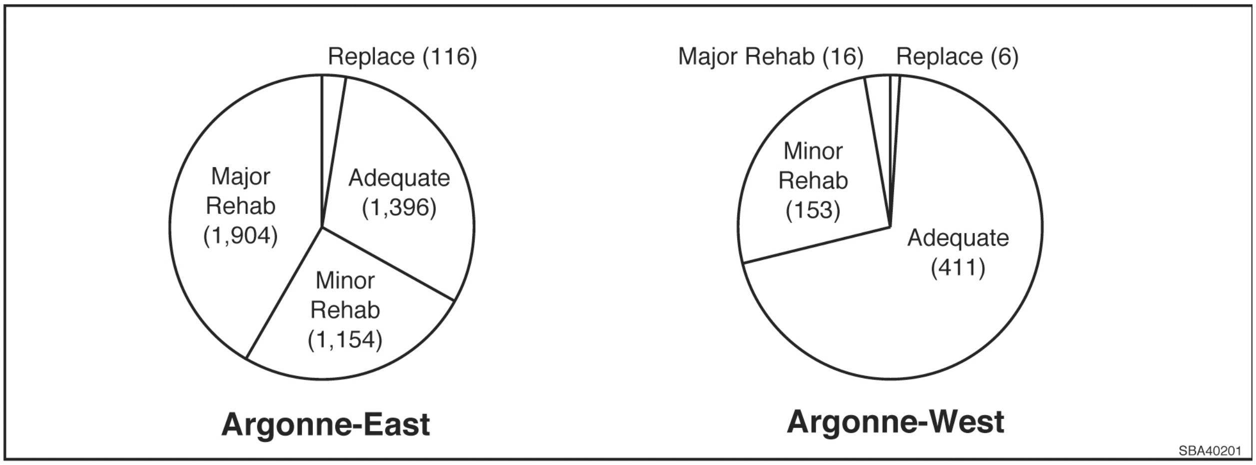


Figure V.2 Condition of Argonne Facilities (values in thousands of gross square feet)

equipment. Improved mechanical and control equipment and upgraded mechanical, distribution, and collection systems are installed as the basis for a building utility support network that is more flexible and adaptable.

In coordination with these efforts, Argonne-East plans significant upgrades to laboratory and office spaces to bring them to today's standards. Modernization is planned for 12 buildings providing 2 million gross square feet of space. The site's new central supply facility exemplifies application of the principles of sustainable design and facilities integration, which will be a hallmark of planned infrastructure upgrades.

To facilitate modernization of laboratory and office space, a general purpose laboratory-office building is needed for use during the accompanying relocation of research groups. In addition, a new high bay facility is needed for general program work.

Roof replacement is a major Argonne-East initiative as the roofs of major buildings near the end of their 20-year design life and the frequency and extent of repairs are increasing. Similarly, deteriorating roads and parking lots will require substantial investment over the next 5 years.

Other site improvements also have high priority. The proposed Phase V Fire Safety Improvements project will reduce the potential for property loss. In addition, the site's central heating plant will require a major upgrade of its auxiliary systems and equipment.

To achieve a 21st century infrastructure, Argonne-East requires total capital funds of approximately $279 million in FY 2004 through FY 2009. (See Supplement 3 for details.) Figure V.3 shows the distribution of the total between General Purpose Equipment (GPE), General Plant Projects (GPP), and line-item funding. In addition, the site requires a total of $63 million in direct operational funding from the DOE Office of Science to undertake needed environmental and demolition work not currently supported by funding from the DOE-Environmental Management program.

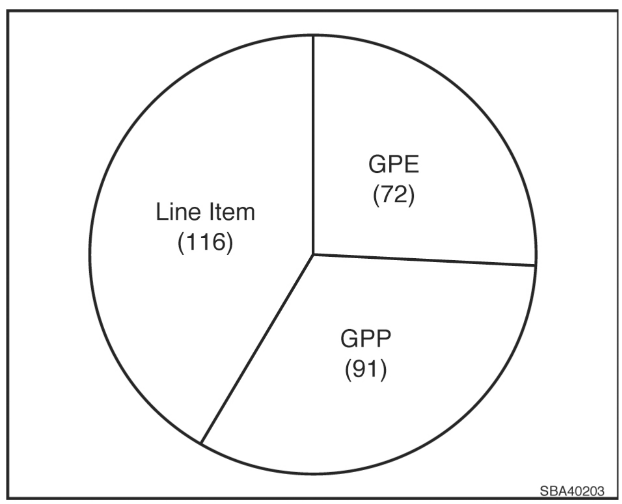


Figure V.3 Six-Year Capital Funding Requirement for Argonne-East ($ million)

Argonne-West

In recent years Argonne-West has endeavored to maintain the condition of its facilities in mission-ready status. However, as Figure V.2 shows, an estimated 4% of the site's occupied space still needs replacement, major rehabilitation, or upgrades, while 26% needs minor rehabilitation. Seventy percent of occupied space is considered to be in adequate condition.

Strategic modernization of Argonne-West facilities focuses on upgrading sitewide utilities and support equipment and on maintaining major nuclear and radiological facilities in a mission-ready state. Priorities are established through the Asset Management and Infrastructure Prioritization process. In general, Argonne-West upgrades and refurbishes existing facilities as new programs (such as the Radioisotope Power System/Heat Source Project) are secured.

Argonne-West also needs new facilities. A general purpose office building is needed to replace eight "temporary" office buildings presently housing administrative, engineering, and DOE personnel.

Roof replacement is a major Argonne-West initiative as the roofs of major buildings approach the end of their design life and the frequency of repairs increases. Similarly, deteriorating side-walks will require substantial investment over the next five years.

To achieve a 21st century infrastructure, Argonne-West requires total capital funds (GPP and GPE) of $11.2 million in FY 2003 through FY 2009. In addition, Argonne-West requires annual operational funding of $13.4 million for essential maintenance of real property, plus $5.3 million annually to maintain its facilities in mission-ready status.

The Experimental Breeder Reactor-II (EBR-II) Plant Closure Project, successfully completed in FY 2002, placed the facility in a safe, stable condition requiring minimal surveillance and maintenance. Under the RCRA (Resource Conservation and Recovery Act) Part B Permit for EBR-II issued by the state of Idaho in December 2002, DOE-Nuclear Energy must complete "RCRA clean closure."

The demand for hot cell and laboratory space at Argonne-West 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).

Argonne-West is planning construction of the Remote Treatment Facility, an $80 million major hot cell facility needed to handle and process for disposal remotely handled mixed transuranic waste from both Argonne-West and INEEL. Disposal of this waste outside Idaho by the year 2018 is required by the court-ordered settlement agreement between DOE and the state of Idaho. Moreover, after 2018 this facility will be a cornerstone — along with the Hot Fuel Examination Facility and the Fuel Conditioning Facility — for a much needed DOE hot cell center that will (1) develop base technologies to address problems associated with disposal of remotely handled waste and (2) support research to improve nuclear fuels and materials.

C. Environment, Safety, and Health

Situation

Protection of the environment, safety, and health (ES&H) is a fundamental value for Argonne. Safety statistics confirm that the Laboratory is a safe place to work, and both analysis and experience indicate that our operations have minimal environmental impact. For example, as Figure V.4 shows, for the past several years we have maintained case rates for recordable and lost/restricted workdays — as defined by the Occupational Safety and Health Administration — that are low relative to comparable industry rates. Our FY 2002 *Self Assessment* explains our progress in ES&H in detail (URL: www.ipd.anl.gov/cpmr/text.html).

We recognize the need for continuous evaluation and improvement in our ES&H programs, and we have firmly embraced Integrated Safety Management (ISM) policy as an operating philosophy. ISM maintains employee attention to essential ES&H issues, goals, and ideas. The structure of our ES&H program is described in depth in the *Integrated Safety Management (ISM) Program Description,*

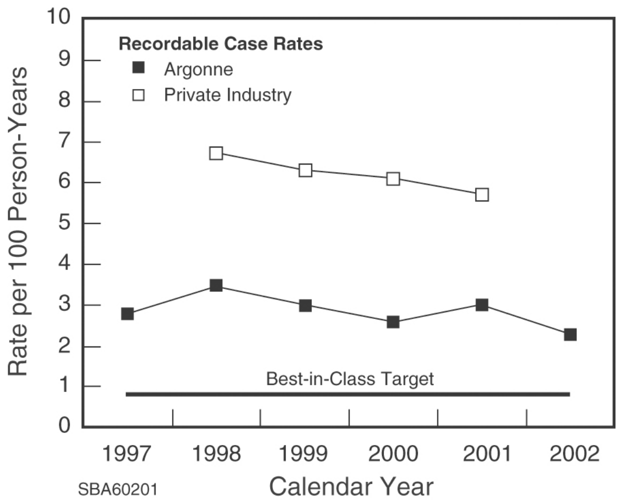


Figure V.4 Case Rates for Recordable Workdays

Revision 7, dated March 19, 2003 (URL: http://www.anl.gov/ESH/main/ism/pdf/ISM_rev7.pdf).

Our ISM program includes investigation of incidents and proactive management of Worker's Compensation claims through coordination of (1) medical department interventions and ES&H analyses with (2) investigations of causes by line managers. The central goal is to protect employees from occupationally related injury or illness.

Our medical department supports DOE's Beryllium Worker Protection Program and offers beryllium blood lymphocyte testing to voluntarily participating employees. In cooperation with DOE, we assist the Oak Ridge Institute for Science and Education (ORISE) in offering former employees an opportunity to participate in ORISE's Beryllium Medical Surveillance Program. Argonne strongly supports both of these beryllium-related programs.

Goals and Objectives

The overall goal of our ES&H program is to ensure that all activities are conducted (1) with minimal and measured adverse impacts to personnel and the environment and (2) within regulatory constraints. The central tenet of ISM throughout Argonne is line management responsibility and accountability, in conjunction with the expectation that each worker is involved in ISM and accepts responsibility for implementing and promoting it.

To strive for continuous improvement in achieving this overall goal, we have established five specific strategic objectives:

- Conduct an ES&H program that effectively supports R&D activities and is judged to be "outstanding" by both DOE and peer laboratories.
- Promote assessment planning by each major research and support organization, and ensure that their assessment plans include the proper mix of self-assessment and independent assessment to appropriately address the broad range of relevant ES&H issues.
- Establish and track appropriate indicators of ES&H performance that help promote improvements to the Laboratory's safety culture and research performance.
- Enhance the Laboratory's current environmental management system to support the goals of the *Greening of the Government through Leadership in Environmental Management (*Executive Order 13148) and DOE Order 450.1 by, in part, interpreting the environmental management system as part of the ISM program and continuing to work toward good relations with stakeholders and surrounding communities.
- Establish and maintain a long-term stewardship program for environmental monitoring of Laboratory remediation sites.

Strategies

We regularly (1) evaluate our ES&H requirement documents to ensure that they reflect changing regulations, (2) implement the documented requirements, and (3) assess various ES&H program elements to measure implementation of requirements and to promote continuous improvement.

We use limited available resources to address ES&H concerns that pose the greater risks. However, setting priorities often requires considerable judgment in such areas as promoting continuous improvement in the Laboratory's safety culture, in the performance metrics system, and in other ES&H systems. We rely on the creativity of our personnel to establish ES&H requirements and implementation strategies that are consistent with the risks presented by the work being done. Specific needs are documented as part of our *ES&H and Infrastructure* (*ESH&I) Management Plan* process.

We will continue to pursue our ES&H goals through our strategic objectives by using established systems operating pervasively under the ISM philosophy. We will continue to monitor our ES&H performance by using *Prime Contract* performance measures, other germane indicators, and our formal assessment program. We will continue to conduct frequent monitoring, surveillance, and evaluation in the workplace in order to implement specific ES&H performance measures and to address ES&H issues generally. We will continue to benchmark our processes and performance against those of other organizations. For example, we are contracting with safety services at DuPont for evaluation of our current programs and for training programs.

We use a structured approach to ensure that facility conditions affecting ES&H are appropriately identified and prioritized among all our infrastructure needs. Our *ESH&I Management Plan* addresses required reporting to DOE by means of a detailed prioritization of all ESH&I projects. Projects related to ES&H include life safety and fire protection upgrades, environmental restoration, wetlands management, mechanical and control systems, an electrical service upgrade line item, decontamination and decommissioning activities, and a facility to store remotely handled transuranic waste for final disposal.

Our assessment program includes (1) assessments conducted by line organization managers to evaluate their own processes; (2) other self-assessments conducted by line organizations to evaluate specific topics; and (3) independent assessments conducted by Laboratory organizations or committees, by committees of the University of Chicago, by DOE, or by other regulatory agencies or stakeholders. On the basis of the results of these assessments and other evaluations, we establish appropriate corrective action plans. Where corrective actions require significant resources and changes to the Laboratory infrastructure, we use the formal *ESH&I Management Plan* process to identify and prioritize resource allocation.

To address the requirements in DOE Order 450.1, we plan to include existing program elements in an environmental program description that is integrated with the current ISM program description. The environmental program description will explain (1) how our work meets DOE regulatory requirements and environmental regulations such as RCRA and the Comprehensive Environmental Response, Compensation, and Recovery Act and (2) ongoing Laboratory programs that promote pollution prevention, waste minimization, long-term stewardship, community relations, and continuous improvement.

D. Integrated Safeguards and Security Management

Situation

We have a responsibility to provide a safe and secure environment for all our employees and visitors. Facilities, equipment, and information must be protected from theft, disruption, or misuse. Argonne-West protects significant quantities of special nuclear material. (Argonne-East possesses only small quantities of nuclear materials for limited research use.) Detection and prevention of electronic intrusion are among the more challenging aspects of security that we face.

Our mission predominantly involves fundamental research or technology development, with results disseminated openly and shared with the scientific community or made available to private industry. The quality of such work depends intrinsically on open dialogue and exchange of information. To serve our mission, each year we host thousands of foreign visitors and assignees, with whom we encourage active information exchange. We also participate in several officially sanctioned training programs with Russia, other countries of the former Soviet Union, and the International Atomic Energy Agency. As a key player in leading-edge cooperative R&D with U.S. industry, we often conduct research involving vital commercial interests.

Most of our work is exempt from export regulation and is constrained only by prudent management to assure accuracy and proper disclosure. Nevertheless, certain Laboratory undertakings are subject to some combination of export control, classification, proprietary interest, and other restrictions on dissemination of results.

Objectives

The Argonne-West Nuclear Program Services Division, the Argonne-East Office of Safeguards and Security, the chief information officer, and the Office of Counterintelligence mutually integrate their efforts to ensure the following results:

- Appropriate controls, systems, and security personnel protect special nuclear materials, classified matter, and high-value property against theft, diversion, or destruction.
- Site access controls provide a safe, secure working environment for employees; for guests; and for the large, diverse community of visiting researchers using Laboratory facilities.
- An active cyber security program makes electronic information freely and readily accessible to authorized users while protecting the information against disruption, compromise, destruction, or misuse.
- Appropriate processes and procedures are in place to assure controlled access to classified and proprietary information.
- Active awareness training and information programs educate all employees in how to maintain and enhance Laboratory security.

Our security organizations work closely with each other and with senior management to ensure that policies and systems are optimized to protect Laboratory assets while enabling scientific progress.

Strategies

Protection of our physical assets requires a combination of access controls and other security measures. Protecting equipment, hardware, and materials at Argonne-East generally involves practices characteristic of industrial security. The protective forces at the Argonne-East site are trained security professionals who operate under contract to the Laboratory. Argonne manages and administers these forces, which include unarmed, trained security officers. The Laboratory is responsible for providing security for the entire Argonne-East site, including DOE offices and the New Brunswick Laboratory.

The larger quantities of special nuclear material at Argonne-West necessitate more extensive access controls and security force capabilities. The site's security force is armed and certified by DOE to the SPO-II level. Some officers are certified to the SPO-III level and are assigned to special response teams. All members of the Argonne-West security force are regular Laboratory employees. The site also employs physical protection systems such as sensors, alarms, physical barriers, entry control devices, and surveillance systems. An extensive, documented vulnerability analysis has been completed, utilizing DOE's *Design Basis Threat*.

Protection of intellectual property involves implementing an integrated network of policies, procedures, and practices. We meet all federal regulations relating to national security and export control, including all applicable DOE regulations. Key to our program are access control and awareness training, supplemented by an extensive cyber security program for both classified and unclassified computing and by counterintelligence activities. A graded approach is used to determine the type and intensity of protective measures implemented.

Our cyber security program is designed to provide sophisticated, multitiered protection of both Laboratory sites from unauthorized access to information and disruption of information systems, with minimal disturbance of open scientific discourse. The program identifies information having national security interest; information whose distribution should be limited, from the perspective of Laboratory management, operations, and business activities; commercial or proprietary information; and research information that has not yet been approved for release. Access to all information other than general public use information is protected by graded or tiered access control mechanisms and is systematically monitored. Encryption is used where appropriate.

Reporting and tracking capabilities are employed locally to anticipate cyber security problems before they occur, and a full response capability is maintained. Cyber security systems are evaluated and tested regularly, and improvements are deployed continuously to counteract changing threats. We provide computer security training to all our computer users.

At both sites, we maintain an Operations Security (OPSEC) program designed to minimize the ability of foreign intelligence agencies or other adversaries to exploit sensitive DOE activities or information and to prevent the inadvertent disclosure of such information. The OPSEC program is supported and overseen by an OPSEC working group, which represents both programmatic and operations organizations. Support by the working group includes (1) development and review of the site's *OPSEC Program Plan, Critical Program Information,* and *Comprehensive Local Threat Statement;* (2) participation of group members in OPSEC assessments; and (3) review of assessment results and countermeasures. The OPSEC working group also provides oversight and advice to senior management on the Laboratory's broader safeguards and security program, as well as advice to program managers.

We have a robust classification program at each site to establish policies and procedures that ensure the proper identification and classification of information requiring protection in the interest of national security. The classification officer at each site develops and implements training programs for persons working with classified information. Trained, knowledgeable persons are certified as "authorized derivative classifiers" to support both individual projects and routine Laboratory work. These individuals and classification officers review potentially sensitive information to ensure that all classified information is identified and protected.

The DOE Office of Independent Oversight and Performance Assurance (DOE-OA) inspected the safeguards and security program and the cyber security program at Argonne-East in March and April 2003. The purpose was to evaluate the protection being provided for nuclear materials, classified matter, and sensitive unclassified information. DOE-OA reported that DOE and Argonne-East management have demonstrated strong commitment to the site's security program. Improvements in cyber security were considered particularly noteworthy, demonstrating an effective balance between security concerns and scientific productivity. All areas reviewed were determined to have "effective performance."

In late October 2002 DOE-OA inspected safeguards and security programs at Argonne-West. Both limited-scope and major force-on-force performance tests were included. DOE-OA noted substantial improvements in the site's safeguards and security programs since the previous inspection in 2000, including a major upgrading of the physical security system and establishment of an in-house capability to assess vulnerabilities. Also acknowledged were strengths in management involvement and in security-related skills and knowledge among the site's population. DOE-OA indicated that improvements and additional funding were needed for the protective force and for management of the protection program at the site, in order to establish the resources needed for safeguards and security over the long term. To address these concerns, the Laboratory hired additional personnel by using FY 2003 funding.

The main objective of our counterintelligence (CI) program is to support DOE's CI program generally and the Laboratory specifically, by detecting, counteracting, and preventing political, economic, industrial, and military espionage and other clandestine intelligence-gathering activities directed at Argonne personnel, information, activities, facilities, and technologies. Our CI program is designed to deter and neutralize intelligence gathering on behalf of foreign governments or others. At both Argonne sites, this multifaceted program encompasses CI awareness, CI aspects of cyber security, CI-related investigations, and threat analysis, as well as liaison with federal, state, and local law enforcement and the U.S. intelligence community.

The CI program at each Argonne site supports and strengthens the Laboratory's overall safeguards and security program by working in concert with programs addressing security education and awareness, foreign visits and assignments, foreign travel, cyber security, operations security, information security, personnel security, nuclear material control and accounting, and physical security.

E. Information Management

Information management at Argonne emphasizes the effective development, communication, and management of scientific, technical, operational, and administrative information. Because of the broad importance of information management and its associated infrastructure, we manage those two intimately related areas both as integral parts of research programs and as institutional functions.

Vision

We will maintain high-performance, cost-effective infrastructure and services in information management. These capabilities will support excellence and efficiency in our R&D programs by providing for optimal use of text, data, images, and sound in appropriate media. Employees will be proficient in the computer-related skills needed to realize fully the benefits from the Laboratory's information systems.

1. Information Technology

Situation

We provide a wide range of central services to support the digital collection, creation, dissemination, and archiving of R&D and business information. Service organizations also operate a Laboratory-wide spectrum of systems and services for software development and application, telecommunications, and computing. Strategic planning, funding, and coordinated management for the Laboratory's information infrastructure and systems are addressed collaboratively by policy and planning groups supported by review and implementation teams.

To ensure that our information management infrastructure evolves as required to support programmatic needs, we lead or collaborate in various national initiatives in information access, networking, and telecommunications, particularly through pilot projects that test the applicability of new information technologies to DOE-funded R&D. We maintain national network connections, such as ESnet (the DOE Energy Sciences Network), MREN (a high-speed test network in the Chicago metropolitan area, recently upgraded from 155 megabits per second to 622 megabits per second), and I-Wire (a statewide network test bed operating at 10 gigabits per second). Sophisticated network intrusion detection capabilities provide for identification and dynamic blocking of intruders and for detection of cyber security anomalies in network traffic. Each day, as many as 300,000 potential intruder alarms are scrutinized, and a terabyte of network traffic data is analyzed for cyber security anomalies.

Goals and Objectives

The primary goal of information technology at Argonne is to maximize the ease and effectiveness with which information is acquired, created, communicated, stored, retrieved, and applied, both within the Laboratory and with our partners in government, academia, and the private sector. Our operations organizations have the following supporting objectives:

- Develop a comprehensive architecture for all aspects of information technology at the Laboratory.
- Streamline administrative operations by using rapid prototyping methods of application development.
- Develop and maintain an efficient, standards-based infrastructure for communications, computer networking, and information systems.
- Make the support organization for information technology more focused on solutions and more nimble.
- Seed collaboration technology to facilitate internal and external exchange of information.
- Maintain strong cyber security via both infrastructure and operational programs.
- Maintain strong core competencies in state-of-the-art and emerging information technologies that enable timely deployment of systems and services tailored to mission needs.

- Extend the currently available high-performance network to all Laboratory desktops.
- Evaluate emerging information technologies through aggressive use of demonstrations and pilot projects.

Strategies

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

Key strategies for achieving secure, high-performance, cost-effective network facilities include the following:

- Upgrade Laboratory network backbones and local connections to support seamless high-speed network access.
- Reengineer remote-access systems to allow secure use of Internet service providers.
- Ensure our interoperability with other DOE sites and commercial service providers through the continued use of test beds based on standards adopted at the Laboratory.
- Test and plan for an upgrade of the existing PBX (private branch exchange) system to an integrated voice-data-video network based on "Voice-over-IP" technology, which uses Internet protocol.

We operate a suite of central information systems in the areas of records, finance, personnel, procurement, facilities, scientific and technical information, environmental protection, and employee health and safety. Key strategies for achieving high-quality, cost-effective central information systems include the following:

- Pursue new initiatives that improve Laboratory-wide access to data supporting both R&D and operations.
- Simplify user access to operational and administrative information through expanded use of web interfaces.
- Build the information infrastructure needed to facilitate the migration of existing incompatible business applications to more open, integrated, web-based solutions.

2. Scientific and Technical Information

Situation

Scientific and technical information (STI) is both an essential driver and the main product of our R&D. We manage our STI via an integrated suite of programmatic and support activities. Infrastructure that supports effective stewardship of STI throughout its life cycle includes virtual and physical library systems, publishing and presentation services, and records management services.

Through digital, print, and staff resources, our research library provides efficient, structured access to the full range of global scientific and engineering information needed to undertake R&D. The Argonne Information Management (AIM) System is the key mechanism for delivering library resources to researchers. Serving as a web portal to multidisciplinary information resources and services at Argonne and around the world, the AIM System averages about 20,000 user sessions per month. Over the past five years, customer usage of this system has increased 86%, and the average cost per use has dropped 45%.

Dissemination of results from our R&D is made more effective by centralized publishing and presentation support services at both major Argonne sites. These services encompass communications planning, writing, editing, the visual arts, and document production, with award-winning products in all conventional and digital media. Final Laboratory publications are posted to a central Internet site to broaden their availability to the global scientific community.

Our central records management services support the preservation of scientific and business information in accord with federal requirements. Services provided include technical assistance to records originators, a records inventory system, storage and disposal of older records, and records searches.

Goals and Objectives

The goal of STI management at Argonne is to enhance the quality, productivity, and recognition of our R&D by enabling scientists and engineers to acquire and use relevant information rapidly and to communicate their findings effectively. Supporting objectives are (1) to provide high-performance digital systems and human services that give rapid, easy, continually improving access to STI and (2) to operate STI systems and services cost-effectively.

Strategies

Key strategies for providing high-performance STI systems and services include the following:

- Influence the direction of electronic publishing to the benefit of Argonne and other national laboratories through collaboration with private-sector publishers, other research institutions, and federal agencies, taking advantage of national and international forums such as the Library Advisory Council of the Institute of Electrical and Electronics Engineers, Inc.

- Integrate industry-leading, standards-based, commercial hardware and software systems, as well as forefront creative practices, into the Laboratory's communications, library, and records management functions.

- Apply insights from internal customer feedback and external peer reviews to enhance the quality of Argonne's STI infrastructure and services. One example of external review is entry of publication and presentation products into professional peer competitions, which annually bring substantial numbers of awards to the Laboratory.

- Enhance the STI resources available on the desktops of our researchers through the AIM System. The system's growing virtual library includes electronic journals, scientific databases, reports, standards, specialized search and retrieval tools, and inventories of Argonne-authored publications and Argonne records. In 2003, 77% of the 1,090 journal titles purchased by the research library are available to our staff electronically, compared to 61% in 2002.

- Increase the global public availability of Argonne-authored technical reports and conference papers via both a Laboratory Internet site and DOE-operated information dissemination systems.

Key strategies for achieving cost-effective systems and services include the following:

- Leverage capabilities developed to acquire, use, and communicate STI to improve management of text-based business information. Current examples are the management of office copier rental programs by central document production groups at both major Argonne sites; the integrated management of scientific and business records; and the inclusion of Laboratory manuals, business correspondence, and forms in the research library's AIM System.

- Operate support organizations at both major Argonne sites to provide the STI systems and services that are most efficient when their management is centralized.

- Match the scope and timeliness of institutional STI services to the needs of Argonne's R&D programs, through collaborative planning and budgeting by programmatic and operations staff and management.

- Purchase library collection materials through cost-saving consortial agreements, such as those negotiated by the DOE laboratories' library consortium; link Argonne staff to external library collections of special value, notably those of the University of Chicago and other major research libraries in Illinois.

- Apply the best practices of industry to achieve efficiency in all STI activities.

F. Communications, Outreach, and Community Relations

Situation

To conduct its R&D operations efficiently and effectively, Argonne must have the confidence and support of its stakeholders. Our major non-DOE stakeholders include Argonne employees, the research community, local and national news media, the trade press, the broad national public, members of the public living near our two sites, the educational community, and potential licensees and research partners in industry. Accordingly, we take special care to maintain close, positive relationships with all of these groups 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 our constituents about our work and to involve them constructively in our activities.

The major elements of our programs in communications, outreach, and community relations involve the following activities:

• *Employee Communications.* Argonne's weekly employee newsletter is read in its entirety or in part by more than 99% of employees. Employee communications are also well served by daily sitewide electronic mail broadcasts, a continually updated intranet, a telephone INFO-line, on-site technical and scientific seminars and conferences, colloquia featuring renowned speakers, and a variety of special employee events.

• *The Research Community.* Ongoing communications with peers in the research community are conducted by scientific staff who publish more than 2,000 research papers and reports annually and who participate in scientific and technical conferences — often presenting papers or sponsoring events.

• *Media Relations.* Our external communications efforts mainly target the news media, which constitute our major avenue for informing the national and local public about both the long-term value of scientific research in general and the benefits of Argonne and DOE-funded research in particular.

• *Trade Press.* The trade press is an important vehicle for informing industrial researchers and executives about our research and facilities, which can help industry solve its research problems and can lead to other productive relationships, such as R&D partnerships.

• *Community Relations.* Our wide-ranging community relations programs reach all of our major stakeholder groups. These programs include site tours, special events, speeches by staff to external audiences, and a vast array of Argonne-sponsored conferences and seminars.

Communications and outreach are also important aspects of other major Laboratory activities discussed elsewhere in this *Institutional Plan*, notably science education (see Section IV.A.1.j) and technology transfer (see Section IV.A.4 and Supplement 2).

Goals and Strategies

We continually seek opportunities to further strengthen our programs in communications, outreach, and community relations. Pursuit of the following important opportunities is under way or being planned:

• We are increasing our traditional outreach to the general science news media through efforts such as increased representation at press briefings and annual meetings of professional research societies.

• We are augmenting outreach to all key audiences with a new monthly electronic newsletter, *What's New at Argonne*, to which anyone may subscribe.

• We have supplemented our widely read weekly employee newsletter with a successful and popular daily electronic newsletter distributed to all Argonne-East employees.

• We have increased the science content of our quarterly magazine *logos* and repositioned it to target a primary audience of internal and external researchers and "the interested layperson."

• We have strengthened and rejuvenated our Speakers Bureau through an aggressive outreach program, to make potential audiences more aware of our speakers and the relevance of their topics and expertise to the interests of stakeholder groups.

• We are planning a series of several community events to be held in lieu of a public open house, which is not possible in light of current national security concerns.

• We will continue to work closely with DOE-Chicago Operations and its Argonne Area Office to nurture a series of quarterly meetings with leaders from communities neighboring Argonne-East. This highly successful Community Leaders Round Table keeps our neighbors informed about our activities and expected impacts to the surrounding area, and it provides an informal forum for feedback.

For more than a half century, we have benefited from remarkably strong community support, positive news media relations, and strong management commitment to communications and outreach. The strategies outlined above are designed to build on those successes.

G. Performance Management

Situation

The performance-based *Prime Contract* under which the University of Chicago operates Argonne for DOE specifies objectives, performance measures, and incentives that foster outstanding performance by the Laboratory. Since FY 1996, our performance has been evaluated by DOE on the basis of previously negotiated measures and expectations, as specified in Appendix B of the *Prime Contract*. (The term of the current contract extends through September 2004.) Argonne's performance ratings have consistently been in the range of excellent to outstanding. (See Figure V.5.)

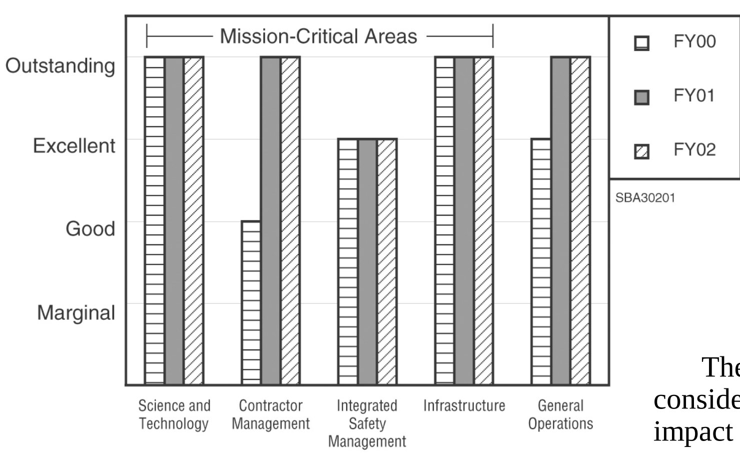


Figure V.5 Argonne Performance Ratings

Goals

Performance management begins with identification — by top Argonne management, the University of Chicago, and DOE — of high-level performance goals in three broad areas:

• *Science and Technology.* Argonne will deliver innovative, forefront science and technology aligned with DOE strategic goals and will conceive, design, construct, and operate world-class user facilities, all in a safe, environmentally sound, efficient manner.

• *Contractor Management.* The University of Chicago will provide leadership, guidance, and oversight that add value to the overall management of Argonne.

• *Operations.* Argonne will conduct all work and operate facilities cost-effectively and with distinction to achieve integration with and support of its mission in the areas of science, technology, energy, and environment, plus full protection of its workers, users of its facilities, the public, and the environment.

Strategies

Performance measures are developed for Argonne with the following criteria in mind:

• Contributes directly to or enhances the Laboratory's ability to accomplish its R&D mission.

• Drives performance by concentrating on desired outcomes.

• Compels the Laboratory to focus on systems performance, cost-effectiveness, and continuous improvement of functions and services essential to its mission.

• Allows for meaningful analysis of trends and rates of change.

• Adds commensurate value in the context of the Laboratory's mission and its entire performance plan.

The Mission-Critical performance category considers functions that have direct and significant impact on the Laboratory's ability to carry out its mission. Performance in these areas determines the annual fee received by the University of Chicago from DOE. In FY 2002 the Mission-Critical functions were science and technology, contractor management, ISM, project and infrastructure management, and cyber security. Table V.3 gives examples of performance measures in those five functional areas. Figure V.6 indicates the weightings given the five areas.

A number of operational activities not identified as critical are nevertheless included in Argonne's performance management process. Performance in these general operations activities (see Table V.4) does not directly affect the University's performance fee, but it does affect the size of the Laboratory's annual employee bonus pool.

Table V.3 Mission-Critical Functions — Examples of Performance Measures

Functional Area	Measure
Science and Technology	Success in constructing and operating research facilities
Integrated Safety Management	Laboratory air and water effluents compared to U.S. Environmental Protection Agency compliance standards
Project and Infrastructure Management	Actual costs and milestones compared to predetermined schedules
Leadership	Effective succession planning demonstrated for key personnel
Cyber Security	Identified system vulnerabilities addressed on schedule

Table V.4 General Operations Functions

Communications and trust	Procurement
Counterintelligence	Property management
Finance	Publishing
Human resources and diversity	Safeguards and security
Information management	Technology transfer
Legal management	Work for others

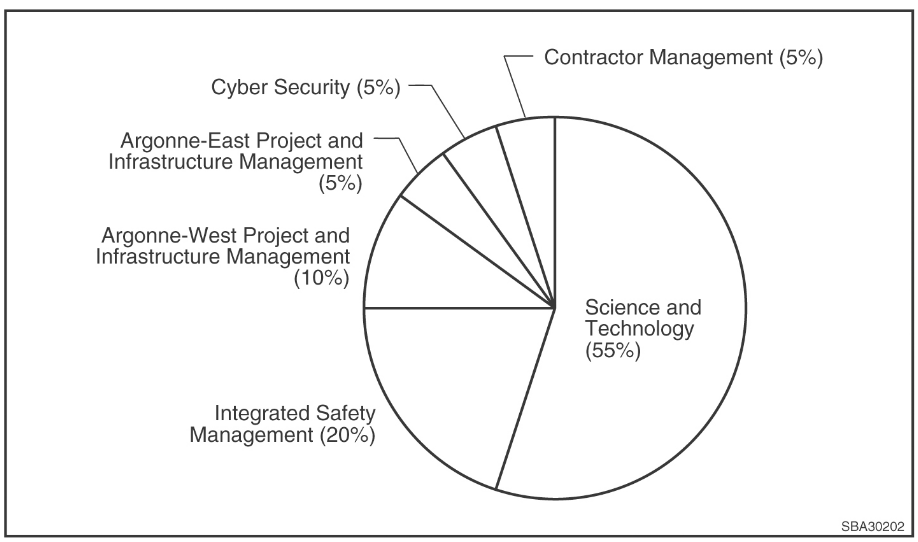


Figure V.6 Mission-Critical Functions by Contribution to Performance Fee (FY 2003)

Working together, DOE, the University of Chicago, and Argonne have built strong momentum in continuously enhancing performance through ongoing feedback and improvement across the Laboratory. Ongoing improvement includes refinement of the measures used to drive performance, in order to better reflect desired outcomes and value added to the Laboratory's research programs. As a general strategy, the university and the Laboratory are seeking to increase the use of peer review in the oversight and management of Laboratory operations.

H. Cost-Effectiveness of Support Functions

As a broad goal, we seek to achieve productivity improvements sufficient to accommodate a moderate decline in the total constant-dollar resources we receive. More specifically, we seek increased efficiency and effectiveness in our overhead and technical support services sufficient to maintain a stable scientific workforce.

Situation

Our overhead management process has contributed significantly to reducing our overhead rate over the past several years, a time when DOE initiatives exerted great cost pressure. As indicated in Figure V.7, we were able to reduce our overhead cost percentage performance metric from 22.4% in FY 1994 to 18.6% in FY 2002. We have maintained an efficient balance of researchers and support personnel, while we have improved the cost-effectiveness of our support functions. Figures V.8-V.10 show further performance metrics indicating our successful commitment to improving efficiency.

Challenges and Strategies

We must continuously improve the productivity of our scientific and support activities and keep our overall cost of operation among the lowest for a DOE multiprogram laboratory. To this end, we perform diligent, focused reviews of all our support costs, with particular attention to opportunities for additional process improvements. Reviews of support costs (1) use thorough, activity-based costing plans and tracking mechanisms to identify high-cost activities; (2) focus on documentation of baseline data and benchmarking of processes; and (3) generally create an atmosphere conducive to results-oriented management. Careful attention is given to identifying more effective cost distribution methodologies. We seek out and adopt best practices in other organizations, including private firms and other laboratories. At the same time, best practices within the Laboratory are identified for broader application.

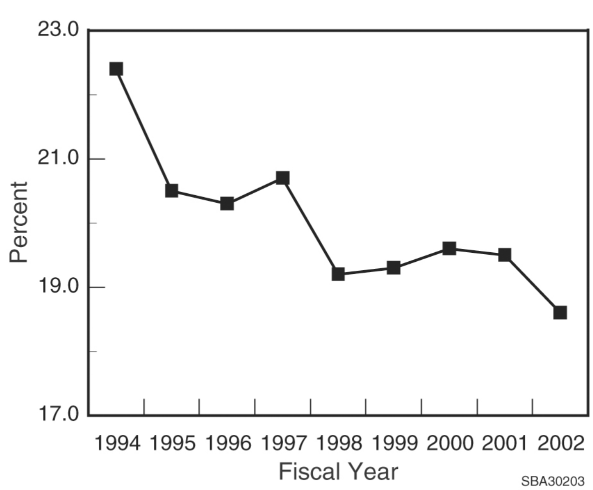


Figure V.7 Overhead Management Performance (overhead cost as a percent of total operating cost)

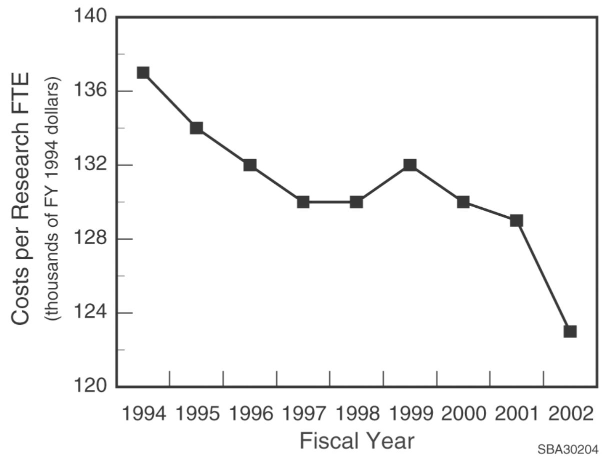


Figure V.8 Operating Costs per Research FTE

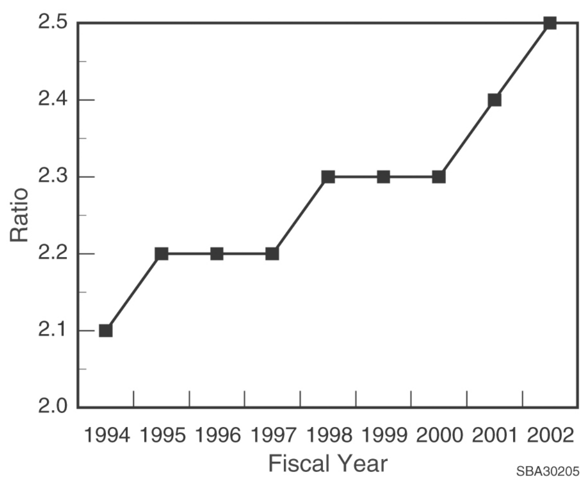


Figure V.9 Research to Support Ratio (research labor costs divided by support labor costs)

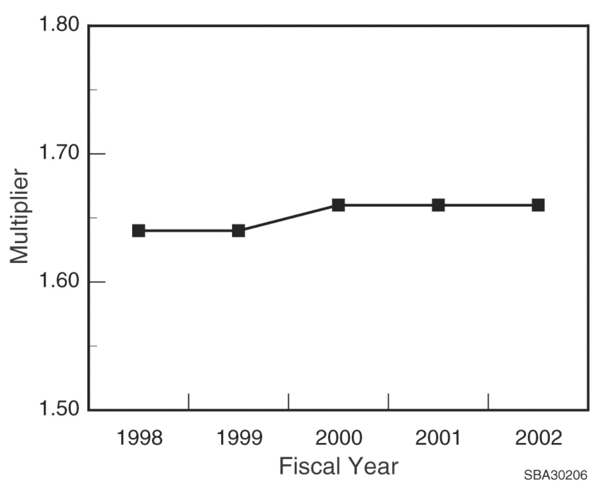


Figure V.10 Composite Support Cost Multiplier on a Direct Research Dollar

VI. Resource Projections

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

The standard reporting date for information in the *Institutional Plan* is early spring of the year, so FY 2003 financial data in this chapter are midyear projections. Projections for programs currently conducted at Argonne-West are included for all years.

The projections show levels of activity at Laboratory, program, and subprogram levels. The resources required for Argonne's initiatives for years beyond FY 2003 generally are not included in these resource projections. Funds received in FY 2002 and FY 2003 for initiatives are included in the funding levels shown for those years. Only funded and budgeted construction projects are included in the tables.

The figures for FY 2002 represent historical dollar values. The midyear projections for FY 2003 are in current dollars. Projections beyond FY 2003 incorporate annual cost escalation percentages that have been reviewed by DOE.

The resource projections are presented in 16 tables:

- Tables VI.1 summarizes Laboratory total funding, while Table VI.2 gives total full-time-equivalent (FTE) personnel levels.
- Tables VI.3 and VI.4, respectively, summarize total Laboratory funding and total personnel (FTE) levels for each DOE secretarial office.
- Tables VI.5-VI.16 give operating, capital equipment, and construction funding for each subprogram within specified DOE secretarial offices and for work supported by non-DOE organizations. Tables VI.5-VI.12 describe work funded directly by DOE, Table VI.13 considers work funded by DOE contractors (as well as funds transferred by Argonne to other DOE contractors), and Tables VI.14-VI.16 pertain to work funded by all other organizations.

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

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
DOE Funding	424.1	399.3	429.0	475.8	488.7	492.5	494.4
Funds Transferred to Other DOE Contractors	-15.9	-24.3	-21.3	-19.1	-19.1	-19.1	-19.1
Work for Others (WFO) Program	85.1	97.4	90.3	80.8	76.8	75.2	75.0
Department of Homeland Security (DHS) Effort[a]	0.0	2.7	7.1	7.0	7.0	7.0	7.0
Additional Funding from Non-DOE Organizations	2.5	6.5	1.8	1.9	1.9	1.9	1.9
Total Operating	495.8	481.6	506.9	546.4	555.3	557.5	559.2
Capital Equipment[b]	14.2	17.0	20.3	26.9	23.5	22.7	22.9
Construction[b,c]	4.0	17.0	17.0	13.0	4.0	0.0	0.0
General Purpose Equipment	1.6	2.2	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects[c]	4.3	4.3	4.3	0.0	0.0	0.0	0.0
General Plant Projects[c]	7.8	7.6	21.9	0.0	0.0	0.0	0.0
Science Laboratories Infrastructure Program[c]	2.8	3.0	5.2	0.0	0.0	0.0	0.0
Total Laboratory Funding	530.5	532.7	577.8	588.5	585.0	582.4	584.3

[a] Reflects direct funding from the Department of Homeland Security (DHS) and DHS work administered through the Work for Others program.

[b] Capital Equipment and Construction can include funding from sources other than DOE. The state of Illinois is projected to provide funds for (1) the Center for Nanoscale Materials building and (2) the Rare Isotope Accelerator Science Center building (see Table VI.16).

[c] As required by DOE instructions, projections for Construction, Accelerator Improvement Projects, General Plant Projects, and Science Laboratories Infrastructure Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.3 for a description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.2 Laboratory Personnel Summary (in FTE)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Direct Personnel							
DOE Effort	1874.1	1790.2	1835.5	1928.7	1905.5	1885.0	1884.0
Work for Others (WFO) Program	277.0	334.4	303.9	259.3	247.2	238.3	232.0
Department of Homeland Security (DHS) Effort[a]	0.0	7.8	19.9	18.9	18.4	17.7	17.2
Additional Funding from Non-DOE Organizations[b]	7.9	2.4	3.1	3.1	3.1	3.1	3.1
Subtotal	2159.0	2134.8	2162.4	2210.0	2174.2	2144.1	2136.3
Other Direct[c]	555.2	558.1	560.7	573.1	558.3	550.5	548.5
Total Direct Personnel	2714.2	2692.9	2723.1	2783.1	2732.5	2694.6	2684.8
Indirect Personnel	1255.3	1224.8	1249.1	1276.6	1243.7	1226.3	1221.8
Total Personnel	3969.5	3917.7	3972.2	4059.7	3976.2	3920.9	3906.6

[a] Full-time equivalents reflect direct funding from the Department of Homeland Security (DHS) and DHS work administered through the Work for Others program.

[b] Includes FTEs associated with services provided to Advanced Photon Source users and work for partners in cooperative R&D agreements.

[c] The “other direct” personnel category includes FTEs for general Laboratory services, program management and administration, staff temporary assignments, and Laboratory Directed Research and Development.

Table VI.3 Funding by Assistant Secretarial Office ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
DOE WORK							
Table VI.5 — Science							
Operating	214.2	206.0	215.0	236.8	239.9	242.1	243.8
Capital Equipment	13.4	16.2	16.3	21.2	21.6	20.9	21.1
General Purpose Equipment	1.6	2.2	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects[a]	4.3	4.3	4.3	0.0	0.0	0.0	0.0
General Plant Projects[a]	7.4	5.0	14.9	0.0	0.0	0.0	0.0
Subtotal	240.9	233.7	252.7	260.2	263.7	265.2	267.1
Science Laboratories Infrastructure Program[a]	2.8	3.0	5.2	0.0	0.0	0.0	0.0
Total Science	243.7	236.7	257.9	260.2	263.7	265.2	267.1
Table VI.6 — Nuclear Energy, Science and Technology							
Operating	75.9	71.0	99.4	111.3	114.7	118.2	118.2
Capital Equipment	0.4	0.5	2.2	0.4	0.3	0.2	0.2
General Plant Projects[a]	0.4	1.6	6.0	0.0	0.0	0.0	0.0
Total	76.7	73.1	107.6	111.7	115.0	118.4	118.4
Table VI.7 — Energy Efficiency and Renewable Energy							
Operating	35.4	40.1	39.9	40.9	41.8	41.8	41.8
Capital Equipment	0.4	0.3	1.7	5.2	1.6	1.6	1.6
Total	35.8	40.4	41.6	46.1	43.4	43.4	43.4
Table VI.8 — Fossil Energy							
Operating	5.3	5.8	5.7	5.2	5.2	5.2	5.2
Table VI.9 — Environmental Management							
Operating	10.5	11.7	12.1	19.7	28.8	26.4	26.6
Capital Equipment	0.0	0.0	0.1	0.0	0.0	0.0	0.0
General Plant Projects[a]	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Total	10.5	12.7	13.2	19.7	28.8	26.4	26.6
Table VI.10 — National Nuclear Security Administration							
Operating	28.9	24.7	31.1	32.1	28.6	29.1	29.1
Capital Equipment	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Total	28.9	24.7	31.1	32.2	28.6	29.1	29.1

Table VI.3 Funding by Assistant Secretarial Office (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Table VI.11 — Security and Emergency Operations							
Operating	1.6	1.1	1.2	1.2	1.2	1.2	1.2
Table VI.12 — Other DOE Programs[b]							
Operating	4.1	4.8	3.2	3.3	3.2	3.2	3.2
Table VI.13 — Work for Other DOE Contractors							
Operating	48.2	34.1	21.4	25.3	25.3	25.3	25.3
TOTAL WORK FOR DOE PROGRAMS							
Operating	424.1	399.3	429.0	475.8	488.7	492.5	494.4
Capital Equipment	14.2	17.0	20.3	26.9	23.5	22.7	22.9
General Purpose Equipment	1.6	2.2	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects[a]	4.3	4.3	4.3	0.0	0.0	0.0	0.0
General Plant Projects[a]	7.8	7.6	21.9	0.0	0.0	0.0	0.0
Subtotal	452.0	430.4	477.7	504.9	514.4	517.4	519.5
Science Laboratories Infrastructure Program[a]	2.8	3.0	5.2	0.0	0.0	0.0	0.0
Total	454.8	433.4	482.9	504.9	514.4	517.4	519.5
Funds Transferred to Other DOE Contractors (Operating)	-15.9	-24.3	-21.3	-19.1	-19.1	-19.1	-19.1
Table VI.14 — Work for Others (WFO) Program							
Operating	85.1	97.4	90.3	80.8	76.8	75.2	75.0
Table VI.15 — Department of Homeland Security Effort							
Operating	0.0	2.7	7.1	7.0	7.0	7.0	7.0
Table VI.16 — Additional Funding from Non-DOE Organizations							
Operating	2.5	6.5	1.8	1.9	1.9	1.9	1.9
Construction	4.0	17.0	17.0	13.0	4.0	0.0	0.0
Total	6.5	23.5	18.8	14.9	5.9	1.9	1.9

Table VI.3 Funding by Assistant Secretarial Office (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
TOTAL OPERATING FUNDING	495.8	481.6	506.9	546.4	555.3	557.5	559.2
TOTAL CAPITAL EQUIPMENT	14.2	17.0	20.3	26.9	23.5	22.7	22.9
TOTAL CONSTRUCTION[a]	4.0	17.0	17.0	13.0	4.0	0.0	0.0
TOTAL GENERAL PURPOSE EQUIPMENT	1.6	2.2	2.2	2.2	2.2	2.2	2.2
TOTAL ACCELERATOR IMPROVEMENT PROJECTS[a]	4.3	4.3	4.3	0.0	0.0	0.0	0.0
TOTAL GENERAL PLANT PROJECTS[a]	7.8	7.6	21.9	0.0	0.0	0.0	0.0
TOTAL SCIENCE LABORATORIES INFRASTRUCTURE PROGRAM[a]	2.8	3.0	5.2	0.0	0.0	0.0	0.0
GRAND TOTAL LABORATORY FUNDING	530.5	532.7	577.8	588.5	585.0	582.4	584.3

[a] As required by DOE instructions, projections for Construction, Accelerator Improvement Projects, General Plant Projects, and Science Laboratories Infrastructure Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.3 for a description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

[b] Other DOE programs include B&R codes WN-05, HC, PE, ES, CN, TA, and IN. (See Table VI.12.)

Table VI.4 Personnel by Assistant Secretarial Office (in FTE)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
DOE WORK							
Science	1033.3	944.0	956.0	980.9	986.1	985.7	984.7
Nuclear Energy, Science and Technology	366.2	358.9	464.7	502.3	501.6	503.5	503.5
Energy Efficiency and Renewable Energy	152.0	155.8	150.5	148.4	148.0	148.0	148.0
Fossil Energy	23.3	30.0	28.5	24.1	24.1	24.1	24.1
Environmental Management	59.0	88.2	79.8	104.3	92.0	74.1	74.1
National Nuclear Security Administration	82.3	93.3	79.6	80.7	65.7	61.6	61.6
Other DOE Programs[a]	13.7	19.3	11.0	11.0	11.0	11.0	11.0
Security and Emergency Operations	7.0	3.1	3.1	2.9	2.9	2.9	2.9
Work for Other DOE Contractors	137.3	97.6	62.3	74.1	74.1	74.1	74.1
Work for Others (WFO) Program	277.0	334.4	303.9	259.3	247.2	238.3	232.0
Department of Homeland Security[b]	0.0	7.8	19.9	18.9	18.4	17.7	17.2
Additional Funding from Non-DOE Organizations[c]	7.9	2.4	3.1	3.1	3.1	3.1	3.1
SUBTOTAL	2159.0	2134.8	2162.4	2210.0	2174.2	2144.1	2136.3
Other Direct[d]	555.2	558.1	560.7	573.1	558.3	550.5	548.5
Total Direct Personnel	2714.2	2692.9	2723.1	2783.1	2732.5	2694.6	2684.8
Indirect Personnel	1255.3	1224.8	1249.1	1276.6	1243.7	1226.3	1221.8
Total Personnel	3969.5	3917.7	3972.2	4059.7	3976.2	3920.9	3906.6

[a] Includes B&R codes WN-05, HC, PE, ES, CN, TA, and IN. (See Table VI.12.)

[b] Full-time equivalents reflect direct funding from the Department of Homeland Security (DHS) and DHS work administered through the Work for Others program.

[c] Includes FTEs associated with services provided to Advanced Photon Source users and work for partners in cooperative R&D agreements.

[d] The "other direct" personnel category includes FTEs for general Laboratory services, program management and administration, staff temporary assignments, and Laboratory Directed Research and Development.

Table VI.5 Science: Funding by Subprogram ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Fusion Energy Sciences (AT)							
Operating	1.6	1.4	1.1	1.2	1.4	1.6	1.6
Capital Equipment	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Total	1.6	1.4	1.1	1.3	1.5	1.7	1.7
Safeguards and Security — Science (FS-10)							
Operating	12.4	7.3	8.7	9.3	9.7	10.0	10.3
General Plant Projects[a]	2.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	14.4	7.3	8.7	9.3	9.7	10.0	10.3
Proton Accelerator-Based Physics (KA-11)							
Operating	4.5	4.5	4.5	4.7	5.2	5.2	5.2
Capital Equipment	1.5	1.4	1.3	1.3	1.4	1.4	1.4
Total	6.0	5.9	5.8	6.0	6.6	6.6	6.6
Theoretical Physics (KA-14)							
Operating	1.6	1.5	1.5	1.6	1.8	1.8	1.8
Advanced Technology R&D (KA-15)							
Operating	2.1	2.1	2.1	2.2	2.4	2.4	2.4
Capital Equipment	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	2.2	2.2	2.2	2.3	2.5	2.5	2.5
Total High Energy Physics (KA)							
Operating	8.2	8.1	8.1	8.5	9.4	9.4	9.4
Capital Equipment	1.6	1.5	1.4	1.4	1.5	1.5	1.5
Total	9.8	9.6	9.5	9.9	10.9	10.9	10.9
Medium Energy Physics (KB-01)							
Operating	3.2	3.2	3.4	3.6	3.6	3.6	3.6
Capital Equipment	0.1	0.5	0.1	0.4	0.4	0.4	0.4
Total	3.3	3.7	3.5	4.0	4.0	4.0	4.0
Nuclear Theory (KB-03)							
Operating	1.7	1.7	1.7	2.2	2.2	2.2	2.2
Low Energy Physics (KB-04)							
Operating	11.9	13.1	13.8	15.7	15.7	15.7	15.7
Capital Equipment	1.2	1.0	1.1	2.2	2.2	2.2	2.2
Accelerator Improvement Projects[a]	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Total	13.5	14.5	15.3	17.9	17.9	17.9	17.9

Table VI.5 Science: Funding by Subprogram (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Total Nuclear Physics (KB)							
Operating	16.8	18.0	18.9	21.5	21.5	21.5	21.5
Capital Equipment	1.3	1.5	1.2	2.6	2.6	2.6	2.6
Accelerator Improvement Projects[a]	0.4	0.4	0.4	0.0	0.0	0.0	0.0
Total	18.5	19.9	20.5	24.1	24.1	24.1	24.1
Waste Management (KC-02)							
Operating	7.8	0.0	0.0	0.0	0.0	0.0	0.0
Materials Sciences (KC-02)							
Operating	33.9	35.2	35.9	38.0	39.4	40.8	42.2
Capital Equipment	3.3	5.9	4.7	6.5	6.8	6.1	6.3
Total	37.2	41.1	40.6	44.5	46.2	46.9	48.5
Advanced Photon Source (KC-02)							
Operating	79.8	81.9	84.8	100.1	100.1	100.1	100.1
Capital Equipment	5.4	5.4	5.8	8.4	8.4	8.4	8.4
Accelerator Improvement Projects[a]	3.9	3.9	3.9	0.0	0.0	0.0	0.0
Total	89.1	91.2	94.5	108.5	108.5	108.5	108.5
Total Materials Sciences (KC-02)							
Operating	121.5	117.1	120.7	138.1	139.5	140.9	142.3
Capital Equipment	8.7	11.3	10.5	14.9	15.2	14.5	14.7
Accelerator Improvement Projects[a]	3.9	3.9	3.9	0.0	0.0	0.0	0.0
Total	134.1	132.3	135.1	153.0	154.7	155.4	157.0
Chemical Sciences (KC-03)							
Operating	14.7	14.5	14.5	14.5	14.5	14.5	14.5
Capital Equipment	1.5	1.8	1.8	1.8	1.8	1.8	1.8
General Purpose Equipment	1.6	2.2	2.2	2.2	2.2	2.2	2.2
General Plant Projects[a]	5.4	5.0	14.9	0.0	0.0	0.0	0.0
Total	23.2	23.5	33.4	18.5	18.5	18.5	18.5
Total Basic Energy Sciences (KC-02, KC-03)							
Operating	136.2	131.6	135.2	152.6	154.0	155.4	156.8
Capital Equipment	10.2	13.1	12.3	16.7	17.0	16.3	16.5
General Purpose Equipment	1.6	2.2	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects[a]	3.9	3.9	3.9	0.0	0.0	0.0	0.0
General Plant Projects[a]	5.4	5.0	14.9	0.0	0.0	0.0	0.0
Total	157.3	155.8	168.5	171.5	173.2	173.9	175.5

Table VI.5 Science: Funding by Subprogram (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Excess Facilities Disposition Program (KG)							
Operating	0.8	1.1	1.0	1.0	1.0	1.0	1.0
Mathematical, Information, and Computational Sciences (KJ-01)							
Operating	12.9	12.0	11.6	12.0	12.2	12.5	12.5
Laboratory Technology Research (KJ-02)							
Operating	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Total Computational and Technology Research (KJ)							
Operating	13.5	12.0	11.6	12.0	12.2	12.5	12.5
Workforce Development for Teachers and Scientists (KL)							
Operating	0.0	1.8	2.6	2.6	2.6	2.6	2.6
Life Sciences (KP-11)							
Operating	4.6	4.6	5.2	4.8	4.8	4.8	4.8
Capital Equipment	0.2	0.1	1.2	0.3	0.3	0.3	0.3
Total	4.8	4.7	6.4	5.1	5.1	5.1	5.1
Environmental Processes (KP-12)							
Operating	18.4	18.5	21.0	21.7	21.7	21.7	21.7
Capital Equipment	0.0	0.0	0.2	0.1	0.1	0.1	0.1
Total	18.4	18.5	21.2	21.8	21.8	21.8	21.8
Environmental Remediation (KP-13)							
Operating	1.1	1.4	1.4	1.4	1.4	1.4	1.4
Capital Equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.2	1.4	1.4	1.4	1.4	1.4	1.4
Medical Applications and Measurement Science (KP-14)							
Operating	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table VI.5 Science: Funding by Subprogram (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Total Biological and Environmental Research (KP)							
Operating	24.3	24.7	27.8	28.1	28.1	28.1	28.1
Capital Equipment	0.3	0.1	1.4	0.4	0.4	0.4	0.4
Total	24.6	24.8	29.2	28.5	28.5	28.5	28.5
Total Office of Science Program Direction (KX)							
Operating	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Total Science							
Operating	214.2	206.0	215.0	236.8	239.9	242.1	243.8
Capital Equipment	13.4	16.2	16.3	21.2	21.6	20.9	21.1
General Purpose Equipment	1.6	2.2	2.2	2.2	2.2	2.2	2.2
Accelerator Improvement Projects[a]	4.3	4.3	4.3	0.0	0.0	0.0	0.0
General Plant Projects[a]	7.4	5.0	14.9	0.0	0.0	0.0	0.0
Subtotal	240.9	233.7	252.7	260.2	263.7	265.2	267.1
Science Laboratories Infrastructure Program[a]	2.8	3.0	5.2	0.0	0.0	0.0	0.0
Total Science	243.7	236.7	257.9	260.2	263.7	265.2	267.1

[a] As required by DOE instructions, projections for Construction, Accelerator Improvement Projects, General Plant Projects, and Science Laboratories Infrastructure Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.3 for a description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.6 Nuclear Energy, Science and Technology ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Nuclear Energy Research and Development (AF)							
Operating	75.9	71.0	99.4	111.3	114.7	118.2	118.2
Capital Equipment	0.4	0.5	2.2	0.4	0.3	0.2	0.2
General Plant Projects[a]	0.4	1.6	6.0	0.0	0.0	0.0	0.0
Total	76.7	73.1	107.6	111.7	115.0	118.4	118.4

[a] As required by DOE instructions, projections for Construction, Accelerator Improvement Projects, General Plant Projects, and Science Laboratories Infrastructure Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.3 for a description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.7 Energy Efficiency and Renewable Energy: Funding by Subprogram ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Solar and Renewable Resource Technologies (EB)							
Operating	4.1	4.8	5.0	5.3	5.3	5.3	5.3
Capital Equipment	0.3	0.3	1.0	1.0	1.0	1.0	1.0
Total	4.4	5.1	6.0	6.3	6.3	6.3	6.3
Building Technology, State and Community Sector (EC)							
Operating	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Industries of the Future (Specific) (ED-18)							
Operating	1.7	3.0	0.8	0.6	0.6	0.6	0.6
Industries of the Future (Crosscutting) (ED-19)							
Operating	0.0	1.0	0.5	0.3	0.3	0.3	0.3
Total Industry Sector (ED)							
Operating	1.7	4.0	1.3	0.9	0.9	0.9	0.9
Vehicle Technologies R&D (EE-05)							
Operating	24.3	25.3	26.6	27.6	28.5	28.5	28.5
Capital Equipment	0.1	0.0	0.7	2.5	0.6	0.6	0.6
Total	24.4	25.3	27.3	30.1	29.1	29.1	29.1
Fuels Utilization R&D (EE-06)							
Operating	0.5	0.1	0.1	0.1	0.1	0.1	0.1
Materials Technologies (EE-07)							
Operating	1.9	2.1	2.8	2.9	2.9	2.9	2.9
Technology Deployment (EE-08)							
Operating	1.0	1.2	1.2	1.2	1.2	1.2	1.2
Capital Equipment	0.0	0.0	0.0	1.7	0.0	0.0	0.0
Total	1.0	1.2	1.2	2.9	1.2	1.2	1.2
Implementation and Program Management (EE-09)							
Operating	0.9	1.0	1.0	1.1	1.1	1.1	1.1

Table VI.7 Energy Efficiency and Renewable Energy: Funding by Subprogram (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Total Transportation Sector (EE)							
Operating	28.6	29.7	31.7	32.9	33.8	33.8	33.8
Capital Equipment	0.1	0.0	0.7	4.2	0.6	0.6	0.6
Total	28.7	29.7	32.4	37.1	34.4	34.4	34.4
Policy and Management (EH)							
Operating	0.1	0.3	0.4	0.4	0.4	0.4	0.4
Distributed Energy Resources (EO-01)							
Operating	0.7	1.1	1.4	1.3	1.3	1.3	1.3
In-House Energy Management (WB)							
Operating	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Total Energy Efficiency and Renewable Energy							
Operating	35.4	40.1	39.9	40.9	41.8	41.8	41.8
Capital Equipment	0.4	0.3	1.7	5.2	1.6	1.6	1.6
Total	35.8	40.4	41.6	46.1	43.4	43.4	43.4

Table VI.8 Fossil Energy: Funding by Subprogram ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Coal (AA)							
Operating	3.4	4.5	4.6	4.7	4.7	4.7	4.7
Gas (AB)							
Operating	0.7	0.8	0.6	0.3	0.3	0.3	0.3
Petroleum (AC)							
Operating	0.9	0.5	0.4	0.1	0.1	0.1	0.1
Gas and Electricity (AU)							
Operating	0.3	0.0	0.1	0.1	0.1	0.1	0.1
Total Fossil Energy							
Operating	5.3	5.8	5.7	5.2	5.2	5.2	5.2

Table VI.9 Environmental Management: Funding by Subprogram ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Uranium Facilities Maintenance and Remediation (EU)							
Operating	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Environmental Restoration and Waste Management — Defense (EW)							
Operating	4.3	1.1	1.1	10.2	19.1	17.0	17.0
Environmental Restoration and Waste Management — Non-Defense (EX)							
Operating	6.1	4.0	2.5	1.0	1.0	0.6	0.6
Safeguards and Security — Environmental Management (FS-30)[a]							
Operating	0.0	6.6	8.5	8.5	8.7	8.8	9.0
Capital Equipment	0.0	0.0	0.1	0.0	0.0	0.0	0.0
General Plant Projects[b]	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Total	0.0	7.6	9.6	8.5	8.7	8.8	9.0
Total Environmental Management							
Operating	10.5	11.7	12.1	19.7	28.8	26.4	26.6
Capital Equipment	0.0	0.0	0.1	0.0	0.0	0.0	0.0
General Plant Projects[b]	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Total	10.5	12.7	13.2	19.7	28.8	26.4	26.6

[a] The Safeguards and Security program (FS-30) currently funded by Environmental Management will be funded by the Office of Nuclear Energy, Science and Technology, beginning in FY 2004.

[b] As required by DOE instructions, projections for Construction, Accelerator Improvement Projects, General Plant Projects, and Science Laboratories Infrastructure Program include only funded and budgeted projects. They do not include proposed projects and, unlike other funding categories, are not intended to represent a reasonable baseline for Laboratory planning in the later years of the planning horizon. (See Table S3.3 for a description of construction projects that have been funded or budgeted by DOE [as included in these resource projections], as well as other projects the Laboratory has proposed to DOE that have not yet been funded or budgeted.)

Table VI.10 National Nuclear Security Administration: Funding by Subprogram ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Weapons Activities (DP)							
Operating	2.2	1.5	2.2	2.3	2.2	2.2	2.2
Capital Equipment	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Total	2.2	1.5	2.2	2.4	2.2	2.2	2.2
Defense Nuclear Nonproliferation (NN)[a]							
Operating	26.7	23.1	28.8	29.7	26.3	26.8	26.8
Program Direction — National Nuclear Security Administration (PS)							
Operating	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Total National Nuclear Security Administration							
Operating	28.9	24.7	31.1	32.1	28.6	29.1	29.1
Capital Equipment	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Total	28.9	24.7	31.1	32.2	28.6	29.1	29.1

[a] Funding for B&R code NN-2004 is excluded here and included instead in Department of Homeland Security Effort (Table VI.15).

Table VI.11 Security and Emergency Operations: Funding by Subprogram ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Nuclear Safeguards and Security (GD)							
Operating	1.6	1.1	1.1	1.1	1.1	1.1	1.1
Office of Security (OS)							
Operating	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Security and Emergency Operations (SO)							
Operating	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Total Security and Emergency Operations							
Operating	1.6	1.1	1.2	1.2	1.2	1.2	1.2

Table VI.12 Other DOE Programs: Operating Funding by Assistant Secretary ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Management, Budget, and Evaluation (WN-05)[a]	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Environment, Safety, and Health (HC)	0.4	0.4	0.6	0.6	0.6	0.6	0.6
Policy and International Affairs (PE)	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Office of Energy Assurance (ES)	1.2	2.0	0.0	0.0	0.0	0.0	0.0
Counterintelligence (CN)	1.1	1.2	1.3	1.4	1.3	1.3	1.3
Energy Information Administration (TA)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Intelligence (IN)	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Total Other DOE Programs	4.1	4.8	3.2	3.3	3.2	3.2	3.2

[a] Recovery of safeguards and security costs associated with work for sponsors other than DOE.

Table VI.13 Work for Other DOE Contractors ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Operating	48.2	34.1	21.4	25.3	25.3	25.3	25.3
Funds Transferred to Other DOE Contractors	-15.9	-24.3	-21.3	-19.1	-19.1	-19.1	-19.1

Table VI.14 Work for Others (WFO) Program: Operating Funding ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
NUCLEAR REGULATORY COMMISSION	11.6	11.6	10.5	9.3	8.6	7.0	7.0
DEPARTMENT OF DEFENSE							
U.S. Air Force	1.4	2.1	1.6	1.2	1.2	1.2	1.2
The Joint Staff	2.6	3.7	3.0	2.7	2.7	2.0	2.0
U.S. Army	10.7	10.8	9.5	9.0	9.0	9.0	9.0
U.S. Navy	3.0	2.5	2.5	2.0	2.0	2.0	2.0
Defense Threat Reduction Agency	5.3	1.3	2.2	1.5	0.5	0.5	0.5
Defense Advanced Research Projects Agency	0.9	3.3	2.5	2.5	1.4	1.4	1.4
Other Defense	0.5	0.3	3.5	1.5	1.5	1.5	1.5
Total Department of Defense	24.4	24.0	24.8	20.4	18.3	17.6	17.6
OTHER FEDERAL AGENCIES							
Environmental Protection Agency	0.7	1.3	0.9	0.9	0.9	0.9	0.9
Emergency Preparedness and Response Directorate	0.6	0.2	0.0	0.0	0.0	0.0	0.0
Department of State (International Atomic Energy Agency)	2.6	3.4	3.0	3.7	3.0	3.7	3.0
Department of Health and Human Services[a]	5.8	3.6	5.9	4.2	4.2	4.2	4.2

Table VI.14 Work for Others (WFO) Program: Operating Funding (Cont.)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Department of Transportation	2.0	0.2	0.0	0.0	0.0	0.0	0.0
Department of Agriculture	7.6	5.5	7.1	6.8	6.8	6.8	6.8
National Aeronautics and Space Administration	1.9	1.9	1.4	1.2	1.1	1.1	1.6
Department of the Interior	0.8	2.5	3.5	3.5	3.5	3.5	3.5
Department of Justice	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Other Agencies	0.2	0.3	0.2	0.0	0.0	0.0	0.0
Total Other Federal Agencies	23.2	19.9	23.0	21.3	20.5	21.2	21.0
NONFEDERAL ORGANIZATIONS							
Private Firms	12.3	12.9	11.8	10.4	10.4	10.4	10.4
Universities	4.4	6.1	5.0	4.8	4.8	4.8	4.8
University of Chicago Grants[a]	1.7	16.7	10.7	10.7	10.7	10.7	10.7
State and Local Governments	5.9	3.4	2.5	2.3	2.3	2.3	2.3
International Organizations and Foreign Countries	1.6	2.8	2.0	1.6	1.2	1.2	1.2
Total Nonfederal Organizations	25.9	41.9	32.0	29.8	29.4	29.4	29.4
TOTAL WORK FOR OTHERS (WFO) PROGRAM	85.1	97.4	90.3	80.8	76.8	75.2	75.0

[a] Grants that are funded by the National Institutes of Health are reported as University of Chicago Grants.

Table VI.15 Department of Homeland Security Effort ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Department of Homeland Security[a]							
Operating	0.0	2.7	7.1	7.0	7.0	7.0	7.0

[a] Reflects direct funding from the Department of Homeland Security (DHS) and DHS work administered through the Work for Others program.

Table VI.16 Additional Funding from Non-DOE Organizations[a] ($ in millions BA)

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
CRADA Partners	1.2	0.4	0.6	0.6	0.6	0.6	0.6
Services to APS Users	1.3	6.1	1.2	1.3	1.3	1.3	1.3
Illinois State Government Grants[b]	4.0	17.0	17.0	13.0	4.0	0.0	0.0
Total Additional Funding from Non-DOE Organizations	6.5	23.5	18.8	14.9	5.9	1.9	1.9

[a] Certain work performed by Argonne for non-DOE sponsors is neither administered under the Laboratory's Work for Others program nor sponsored by the Department of Homeland Security and so is considered separately in this table. Included here are (1) funds received from cooperative R&D agreement (CRADA) partners, (2) funds received from collaborative access teams at the APS for services performed, and (3) grants from the state of Illinois.

[b] Funding from the state of Illinois for (1) the Center for Nanoscale Materials building and (2) the Rare Isotope Accelerator Science Center building.

Supplement 1: Work for Sponsors other than DOE

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

In the area of national security, we perform a wide range of work funded by federal organizations other than DOE. In the future, sponsorship of some follow-on work will be shifted to the new Department of Homeland Security. Discussion in this edition of Argonne's *Institutional Plan* is organized according to the sponsoring agency in early FY 2003. Future editions will discuss the Department of Homeland Security in detail. Currently, Argonne provides training, technical support, and R&D in the general area of national security for the Defense Threat Reduction Agency, Nuclear Regulatory Commission, Army, Air Force, Navy, Federal Emergency Management Agency, Federal Aviation Administration, Department of Transportation, Department of Agriculture, Federal Transit Administration, and other federal organizations.

Our work for non-DOE sponsors supports accomplishment of our mission (see Chapter II) and development of our initiatives (see Chapter III). From a national perspective, this "work for others" (WFO) allows our unique facilities and capabilities to be applied to national security needs and other R&D priorities.

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

A. Nuclear Regulatory Commission

We conduct research for the Nuclear Regulatory Commission (NRC) under a legislatively mandated memorandum of understanding between DOE and the NRC. Most of our work for the NRC has for many years involved supporting the Office of Nuclear Regulatory Research in its development of rules regarding plant safety and the condition of physical components. The largest efforts have addressed materials issues, steam generator tubing degradation, high-burnup fuel, and severe-accident behavior. Recently Argonne performed studies to enhance environmental pathway models for analyzing the transport of residual radioactive contaminants and develop parameters suitable for implementing NRC rules designed to assure public health and safety at nuclear facilities during the termination of licensed operations. We are now preparing portions of supplemental environmental impact statements for the renewal of reactor operating licenses. In addition, Argonne provides technical assistance to the Office of Nuclear Reactor Regulation and to the Office of Nuclear Materials Safety and Safeguards.

Both the research and the technical assistance performed for the NRC take advantage of the Laboratory's hot cells and its special capabilities in nuclear reactor technology, technical evaluation, systems analysis, materials science, computer code development, environmental risk modeling, and assessment of environmental and health impacts. Argonne's work helps to ensure that U.S. nuclear power plants will continue their safe and efficient production of electricity without emission of carbon dioxide.

1. Office of Nuclear Regulatory Research

Our materials research focuses on the degradation of structural materials in light-water reactors caused by reactor environments, including the effects of water chemistry and neutron irradiation. These studies include measurements of (1) growth rates of stress corrosion cracks in irradiated and nonirradiated materials and (2) the fatigue life of stainless and ferritic steels used in the reactor core, piping, and pressure vessel. Results from these studies are used by the NRC to ensure the structural integrity of plants as they age. Currently, we are examining portions of a leaking nozzle and a degraded pressure vessel head from the Davis Besse plant.

A comprehensive study of degradation in the steam generator tubing of nuclear power plants is under way. Critical areas being addressed include (1) evaluation of techniques used for in-service inspection of steam generator tubes and recommendations for improving the reliability and accuracy of those inspections, (2) validation and improvement of correlations and models for predicting degradation in aging tubes during operations, and (3) investigation of the potential for environmental degradation of Alloy 690, which has been used in most replacement generators in the United States.

Argonne is investigating the behavior of high-burnup nuclear fuels for the NRC. To reduce operating costs and minimize the accumulation of spent fuel, nuclear utilities are striving to increase the burnup of their nuclear fuels. However, at high burnups, fuel pellets and cladding are potentially less resistant to damage under some conditions. These considerations may necessitate modification of (1) fuel rod damage criteria used in NRC regulations and (2) materials properties assumed in safety analyses. Furthermore, new alloys and fabrication procedures designed to counter burnup effects may also affect regulatory criteria and safety analyses. To help address these issues, Argonne is determining the behavior of high-burnup fuel under accident conditions where coolant is lost and is establishing a database for the mechanical properties of high-burnup cladding, which is needed for licensing safety analyses. The Laboratory is also investigating the way high burnup might affect cladding and the behavior of spent fuel during long-term dry storage, a strategy now being employed at the sites of many nuclear power plants.

The NRC continues to use Argonne's broad expertise in severe-accident phenomena. The Commission was a partner in the recently completed Melt Attack and Coolability Experiment (MACE) program, which was organized by the Electric Power Research Institute. The Laboratory's contributions to this program are described in Section S1.E.1. The NRC will continue to rely on Argonne's expertise in this area through participation in the Melt Coolability and Concrete Interaction program, which is a follow-on to MACE sponsored by the Organization for Economic Cooperation and Development (see Section S1.E.5).

The NRC license termination rule assures public health and safety at nuclear facilities during the termination of licensed operations. To support the development of implementation guidance for this rule and an associated standard review plan, the NRC is using the Argonne software RESidual RADioactivity (RESRAD), expansion of which it sponsored earlier. The expanded program will specifically address the cleanup of contaminated sites and buildings during the decontamination and decommissioning (D&D) of facilities. The software was originally developed for DOE to help analyze environmental remediation at DOE sites. The NRC-sponsored work extended the existing models to include probabilistic dose analyses, thereby allowing NRC licensees to demonstrate compliance with the license termination rule and supporting NRC evaluation of the licensees' applications for facility termination.

We are initiating work on an alternative siting rule for NRC to use in evaluating new reactor sites. This rule will be used to evaluate alternatives in the early site permit and combined license applications submitted to NRC.

2. Office of Nuclear Reactor Regulation

Argonne assists the Office of Nuclear Reactor Regulation in a variety of areas related to aging and the performance of materials, components, structures, and systems in nuclear power plants.

This work helps assure that safety will be maintained as plant components age.

Argonne provides technical support to the NRC in the review of license renewal applications in areas including fatigue of metal components, thermal fatigue of cast austenitic stainless steels, irradiation-assisted stress corrosion cracking, and irradiation-induced void swelling.

We participate on interlaboratory teams preparing supplemental environmental impact statements related to the renewal of nuclear plant operating licenses. These analyses have covered issues of land use, ecology, and air quality that are related to continued power plant operations.

The Laboratory is reviewing aging effects and their management for nuclear plant systems, structures, and components that must meet license renewal rules. Previous work contributed to the development of a report and an associated standard review plan that serve as guidance documents for NRC reviews of license renewal applications. The Laboratory is currently updating and revising this guidance. Argonne also provides other kinds of technical support to the Office of Nuclear Reactor Regulation.

3. Office of Nuclear Materials Safety and Safeguards

For the Office of Nuclear Materials Safety and Safeguards, we are modeling environmental and health effects from uranium recovery operations to help the NRC (1) deal with changes in regulatory requirements and (2) consider revisions of existing licenses and applications for new licenses for uranium mining and processing. Enhancements of the current model will take into account *in situ* uranium leaching technology and associated processing. A key issue is the transport of uranium and decay product radionuclides (including radon gas), as well as the associated environmental and health impacts. At the same time, we are developing an Internet-based communication mechanism to facilitate distribution of the software code for the model and the NRC's interaction with prospective licensees. In other work, we are helping to prepare an environmental impact statement for construction and operation of a mixed-oxide fuel fabrication facility to be built at the DOE Savannah River Site. The facility will convert surplus weapons-grade plutonium into mixed-oxide fuel suitable for irradiation in light-water reactors.

B. Department of Defense

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

1. Office of Secretary of Defense

We assist in developing components for the Joint Warning and Reporting Network, using the Laboratory's maps and data browser system to display active, vector-based spatial data from sensors and models.

2. U.S. Air Force

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

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

We also perform studies to identify for the Air Force the most cost-effective technical approaches to environmental management. For the Air Force Materiel Command, we are developing innovative approaches to computer-assisted management of large numbers of air pollutant emission sources in complex industrial areas. For the Air Force Center of Excellence, we are developing approaches for assuring that Air Force actions conform to state and local air quality maintenance strategies. New approaches to environmental management will shift the emphasis from compliance to pollution prevention. In addition, we are assisting the Pacific Air Force in its implementation of novel, cost-effective methods of carrying out environmental stewardship, including the management of cultural and natural resources at military installations in the United States and abroad.

We support a number of programs that serve Air Force Headquarters weather programs. For the Air and Space Natural Environment Executive Agent, we evaluate technologies and procedures for the Integrated Natural Environment Authoritative Representation Program. This program generates authoritative environmental databases and models for use by the DOD modeling and simulation community. For the Air Force Combat Climatology Center, we are continuing our development of the Weather Effects for the Warfighter system, an operational planning tool for assessing the impact of the environment on military systems and operations. Also for the Combat Climatology Center, we are developing a cluster-based, mesoscale weather forecasting system for use in training and simulation. Simulated weather forecasts from this system will provide a rich training environment for staff weather officers.

As an extension of an earlier project, we are customizing an enhanced version of an advanced information tool to assist the Secretary of the Air Force, Office of the Inspector General, in handling requests made under the Freedom of Information Act. We are also conducting R&D on advanced battery technologies for the U.S. Air Force. This work includes fundamental investigations of the mechanisms for ion conduction in new battery materials and the design and optimization of battery cells based on these materials.

3. The Joint Staff

We support the J-8 Directorate of the Joint Staff by evaluating emerging technologies and applying them to the mission challenges faced by the Joint community in the area of information management for modeling, simulation, and analysis. We help J-8 operations divisions conduct analyses more quickly and reliably by providing advanced simulation and analysis tools and methodologies. The key activities being supported include (1) validation and verification of data and models during the various phases of an analysis; (2) application of object-oriented and agent-based techniques to modeling and simulation; (3) information and knowledge management; (4) development of modeling and simulation architectures that provide interoperability among legacy models, new models, and application packages; (5) development of logistics and deployment simulations; and (6) development of designs and applications for enhancing system security and evaluating new security technologies.

Analysis of logistics and mobility has become increasingly important to the U.S. military because of continuing rapid changes in the ways that forces are deployed. The objectives are lower costs, greater transparency, and more efficient management of the larger and more flexible logistic operations needed for modern warfare. Because more of the U.S. military is now stationed in the continental United States, greater importance is attached to contingency planning for deploying forces, both for missions such as disaster relief and peacekeeping and for military operations. Our work on logistics and deployment modeling and simulation has focused on four areas: developing prototype models and simulations, developing novel system architectures by integrating multiple model and simulation components, conducting technology feasibility studies, and providing technical guidance regarding technologies and systems designs.

The development of modeling and simulation architectures has been a primary focus of our work for the Joint Staff since 1987. One of the most useful results has been the Dynamic Information Architecture System (DIAS), an object-oriented simulation architecture capable of easily interfacing existing models and information processing applications. One notable application is an Integrated Ocean Architecture system that supports U.S. Navy operations.

Another major Argonne object-based framework, FACET (Framework for Addressing Cooperative Extended Transactions) supports the construction of models of complex, cooperative behavior by agents. FACET can be used to implement simulation models of organizational processes, such as the complex interplay of participating individuals and organizations engaged in multiple concurrent transactions in pursuit of their respective goals. Transactions can be patterned on, for example, business practices, government and corporate policies, military standard operating procedures and doctrine, clinical guidelines, or office procedures. FACET can also incorporate other complex behaviors, such as biological life cycles or manufacturing processes.

For the Joint Staff, we are developing a tool that is being used to study interdiction strategies for countering the South American drug trade. The Complex Adaptive System Countermeasure Analysis Dynamic Environment-Counter Drug (CASCADE-CD) tool is intended to aid drug interdiction analysts in deriving and justifying force structure and operational planning recommendations. CASCADE-CD is an agent-based complex adaptive system simulation framework that models the trafficking aspects of the South American cocaine trade and the entire interdiction chain. Agents on both sides are provided with adaptive behaviors that are manifested at several scales and granularities.

4. U.S. Army

Argonne (in conjunction with the Department of Homeland Security) assists the Army's implementation of the Chemical Stockpile Emergency Preparedness Program (CSEPP). The Laboratory supports program development, policy analysis and development of associated guidance, emergency preparedness planning, institutional analysis, development of hazard-specific risk communications and emergency public education mechanisms, and testing and assessment of response capabilities. Argonne also assists in technical management. This work involves hazard analysis; modeling of chemical agent dispersion; development of cost estimation and measurement methodologies; integration of emergency planning; and collection, analysis, and validation of meteorological data at each CSEPP installation.

For the Operations Support Command, we are developing the Joint Munitions Planning System, a planning tool to support ammunition sourcing and movement strategies. This tool designs sourcing and movement strategies that best meet operational requirements established by battlefield commanders.

For the Army Environmental Center (AEC), Argonne is conducting research at a series of demonstration sites to develop techniques for the environmental characterization of contaminated installations and for monitoring *in situ* remediation in the continental United States. The research focuses on developing methodologies for characterizing groundwater pathways and contaminant plume configurations that will serve as models for other installations, thereby expediting the selection of remediation technologies and the cleanup or closure of bases at many sites.

We also support the AEC through R&D on environmental restoration at various Army installations, including several sites that have been placed on the National Priorities List. Specific activities include the development of state-of-the-art environmental data management systems to expedite remedial decision making and the use of groundwater and soil gas models to evaluate alternative methods of restoring aquifers. In addition, we support compliance and regulatory analyses for the AEC, including critical issues related to military munitions and environmental management of military ranges.

Argonne also helps the Army Corps of Engineers implement projects under Superfund and the Defense Environmental Restoration Program through the Savannah and Kansas City Districts. For the New York, Buffalo, and Omaha Districts, we are developing specialized approaches to remedial investigations and feasibility studies, particularly for sites having risk of radiological contamination and involving water resource restoration.

Argonne assists several districts of the Army Corps of Engineers in the efficient execution of the Formerly Utilized Sites Remedial Action Program, which was transferred from DOE to the Corps in FY 1998. The specialized technical capabilities we bring to this cleanup program include the Adaptive Sampling and Analysis Program (ASAP), the RESRAD code for dose assessment, expertise in approaches specified in the *Multi-Agency Radiation Survey and Site Investigation Manual*, multiplatform geophysical characterization, and advanced tools for management of environmental data.

We are conducting an integrated program of environmental and engineering research and technical support for the Army Corps of Engineers in the Mobile, Baltimore, and New England Districts and for the AEC, examining issues such as land restoration, solid waste management, site characterization, detection of buried objects, and cleanup of hazardous waste sites.

For the Army Soldier and Biological Chemical Command, we assist in the development and analysis of restrictions regarding the land disposal of chemical agents and their by-products in the environment. Studies are coordinated with multiple environmental agencies within the Army and with several states. We also support the Command's Assembled Chemical Weapons Assessment Program in the area of environmental compliance for demilitarization of assembled munitions, by exploring alternatives to incineration of material from the U.S. chemical agent stockpile. For the Chemical Demilitarization Program, we investigate chemical methods for (1) analyzing agent standards and waste streams and (2) detecting heavy metals in waste streams. In addition, we are employing models and analyses to address environmental management issues at the Command's Rocky Mountain Arsenal, Pueblo Depot Activity, Tooele Chemical Agent Disposal Facility, and Aberdeen Proving Ground.

We provide technical assistance for environmental restoration activities at Aberdeen Proving Ground, which has a legacy of chemical contamination. We are seeking solutions to such problems through a restoration study at the J Field site and through sitewide remote sensing. Work addresses management of environmental information, wetlands issues, and the natural attenuation of groundwater contamination.

We have undertaken studies of the environmental risks posed by active and former test ranges for the Army Developmental Test Command. We are now conducting specific environmental restoration and compliance assessment studies at three installations of the Command (Dugway Proving Ground, Yuma Proving Ground, and White Sands Missile Range).

For the U.S. Army Defense Ammunition Center (USADAC), a part of the Operations Support Command (OSC), we are developing a data system for hazardous waste characterization to support environmental compliance related to the destruction of munitions and explosives at Army installations and to the reuse and recycling of components. In related efforts, we are developing a demilitarization planning and management system that incorporates the USADAC system and other information to improve the Army's ability to plan for cost-effective and environmentally sound demilitarization. In addition, we perform specialized environmental modeling and data analyses to address radiological risk and restoration problems at OSC installations (currently the Seneca Army Depot). We are also developing the Joint Munitions Planning System, an advanced technology simulation tool for managing the global distribution of munitions.

For the Army National Guard, we provide specialized technical assistance in the analysis of issues related to the environmental management of military ranges, evaluation of the performance of cleanup remedies, innovative site characterization, and modeling of groundwater.

We continue to use our DIAS simulation architecture to design and develop integrated modeling systems for installation management by the U.S. Army. The DIAS architecture is most recently being used for a new U.S. Army initiative called Fort Future, which will develop the capability to model, simulate, assess, and optimize installations that can support transformation of the Army to meet future needs. In particular, DIAS will be the model integration framework for simulating and optimizing force projection for Fort Future. The system will also contain an air dispersion model for analyzing force protection.

Also for the Army, we are developing biological microchips (biochips) for use as sensors and detectors. In FY 2003 custom chips for detecting biological agents are being tested around the country, and new technology for on-chip PCR (polymerase chain reaction) amplification of phylogenetic and functional gene target nucleic acids is under continued development. We are developing methods of manufacturing biochips in enclosed flow cells and pursuing other advancements that will allow a single biochip to be used in the field either for custom analysis or PCR amplification.

5. U.S. Navy

We support the Naval Facilities Command (NAVFAC) and the Civil Engineer Corps Officer School in the area of ecological risk assessment, in part by transferring to the Navy restoration program the ecological risk assessment methodologies developed for DOE cleanup programs and also by developing information management systems to increase the efficiency of responses to ecological risk assessments. We also assess particular new cleanup methodologies and technologies. In addition, we provide technical leadership for NAVFAC characterization and risk assessment of depleted uranium in the environment of the Navy's China Lake facility.

6. Defense Threat Reduction Agency

As part of its R&D program in support of arms control and homeland security, we develop treaty verification and threat attribution procedures and technology for the Defense Threat Reduction Agency. Currently, our verification programs focus on the overall long-term information and organizational requirements for verification, validation, and compliance as additional treaties are being implemented. This activity includes analysis of functional requirements, technical evaluation, independent verification, and validation for new automated systems; prototyping for automated training techniques; and assistance in implementation planning. We also conduct life cycle analyses in support of strategic planning for arms control treaty software systems and perform studies and technical evaluations in support of the Open Skies Treaty. Recent additions to the homeland security component of this program include an investigation of methods for attributing a domestic nuclear threat to its perpetrators and a project to evaluate and develop biological microarrays for detecting and analyzing potential biological threats.

7. Defense Advanced Research Projects Agency

For the Defense Advanced Research Projects Agency, we are developing oxide thin-film technology for radar and communications systems. We are also investigating toxin removal from the bloodstream by magnetic particles, as well as biomagnetic self-assembly with virus technology.

8. Joint Program Office for Special Technology Countermeasures

For the Joint Program Office for Special Technology Countermeasures, we are (1) identifying, collecting, and synthesizing data about the U.S. natural gas, petroleum fuels, and water infrastructures and (2) developing and applying analytical tools for isolation and system analyses. In addition, we are examining trends in the petroleum refining industry, modeling infrastructure interdependencies as complex adaptive systems, and examining risk-based decision methodologies. The overall objective is a capability to identify susceptibilities and operational dependencies in critical infrastructure that, if not remedied, could threaten accomplishment of vital military missions.

C. Department of Health and Human Services

Funding for Argonne's work for the Department of Health and Human Services either flows through the University of Chicago or is received directly through interagency agreements with DOE. (In Chapter VI see University of Chicago Grants and Department of Health and Human Services, respectively.)

University of Chicago Grants

The National Institutes of Health (NIH) supports a broad range of fundamental studies at Argonne. These investigations often apply techniques developed in DOE-supported programs to studies in structural biology, biophysics, carcinogenesis, mutagenesis, and physiology. In turn, our work for NIH benefits our resources for addressing the DOE science mission, including the DOE Genomes to Life program. Most of our studies for NIH emphasize structure-function relationships or mechanisms underlying biological responses.

Our biophysical studies for NIH are addressing the properties of human antibody light chains that lead to pathologic deposition in myeloma. Investigations of *in vitro* aggregation of light chains consider their structure and pathologic characteristics. For example, one project is developing new procedures for the heterologous expression of functional membrane proteins in quantities sufficient for x-ray crystallography to determine the proteins' structures and functions.

We are among the initiators of the U.S. structural genomics program. NIH now is supporting a major effort in structural genomics at Argonne, with an ultimate goal of determining the structures of all protein families. This effort for NIH, in partnership with the DOE-funded Structural Biology Center (SBC) at the Advanced Photon Source (APS), created the Midwest Center for Structural Genomics (MCSG). Argonne is the lead institution in the MCSG consortium, which also includes six universities. NIH will provide approximately $5 million annually through FY 2005 to establish high-throughput methods for determining the three-dimensional structures of proteins from bacteria and higher eukaryotes. As recently as 1990, solving a single protein crystal structure could take one or more scientists several years. At Argonne, improved techniques for data collection, analysis, and structural determination now allow the structure of a protein to be solved in as little as six hours. Using x-rays from the APS, the SBC collects data of very high quality significantly faster than was possible even a few years ago. By developing (1) robotic methods to carry out tedious experimental procedures and (2) advanced computational methods for data analysis and structure determination, we have achieved huge leaps in productivity. The MCSG is continuing to develop high-throughput methods in molecular biology, protein purification, and crystallization. Combined with highly efficient SBC beamlines and automated crystallography, these methods will further accelerate the process of determining new protein structures. NIH support of the MCSG will enable further major improvements in productivity.

We are collaborating with the University of Chicago Medical School to develop an ice slurry treatment that will decrease cell death due to reduced blood flow and oxygen availability after cardiac arrest or stroke. A medical-grade slurry is used to cool the brain and heart rapidly and induce hypothermia. NIH recently funded a five-year project for further development of the coolant and associated clinical procedures.

In other work, NIH supports Argonne's development of models that simulate turbulence in the carotid artery. This effort, conducted by Argonne computer scientists in collaboration with researchers at the University of Illinois at Chicago and the University of Chicago, aims to help physicians make treatment decisions tailored to individual patients.

We will contribute to improving national defense against biological warfare as a member of the NIH-funded Midwestern Regional Center of Excellence for Biodefense and Emerging Infectious Diseases Research (RCE). This multidisciplinary, multisite effort focuses on the diseases anthrax, botulism, hemorrhagic fever, plague, and tularemia. Led by the University of Chicago and Northwestern University, the RCE involves multiple universities, research institutes, and public health authorities and more than 100 scientists — including several from Argonne. Central objectives are to improve basic understanding of the diseases' pathogenesis, create novel therapeutics, develop vaccines or other preventive strategies, and develop better diagnostic technologies. Argonne is proposing projects to investigate (1) whether genetic determinants essential to the pathogenesis of anthrax disease can serve as targets for therapy; (2) bioinformatics analysis of certain important genomes, along with metabolic and pathogenic reconstruction; (3) use of affinity imprinting to develop a new system for detecting hemorrhagic fever viruses; and (4) development of a powerful data analysis and computational environment for use by RCE participants. In addition, the Laboratory is to contribute to overall administration of the center.

To support the RCE, a Regional Biocontainment Laboratory (RBL) is to be built at Argonne through a proposal by the University of Chicago to NIH. This laboratory will provide RCE researchers with facilities certified to "biosafety level 3" (the third highest of four levels). Placing the RBL at Argonne will ensure ready access to complementary Argonne facilities such as the APS, the SBC, the MCSG (with its focus on rapid selection, robotic generation, purification, crystallization, and structural analysis of proteins), the Mathematics and Computer Science Division (for information analysis and modeling), and the Center for Nanoscale Materials.

Interagency Agreements with DOE

The National Institutes of Health is also partnering with Argonne to construct and operate a new collaborative access team (GM/CA-CAT) at the APS. This effort will parallel and cooperate with the SBC and the MCSG. Utilizing two undulators and a bending magnet, GM/CA-CAT will develop three x-ray beamlines optimized for macromolecular crystallography. Office and laboratory space for staff and users has been developed in a new office-laboratory module to be constructed at the APS. The beamlines will include high-throughput robotic sample delivery, high-speed data collection with online analysis, and remote access through interactive computer networks. Construction of the beamlines, begun in FY 2003, will proceed in two sequential phases that will allow data collection at the first beamline to begin during construction of the other two beamlines.

Argonne provides technical support to the U.S. Public Health Service, Division of Federal Occupational Health, in the development and implementation of an environmental health and safety assessment program for the U.S. Social Security Administration. The principal objective is to develop an overall program framework, plans and protocols, and facility assessments at randomly selected facilities in ten regions. Information gathered during pilot assessments in a few regions will be used to guide subsequent work.

D. Other Federal Agencies

1. Environmental Protection Agency

We apply our DIAS architecture as the framework for ecosystem modeling and environmental health assessment through a U.S. Environmental Protection Agency (EPA) system known as MIMS (Multimedia Integrated Modeling System). MIMS allows researchers to consider the environment for nutrients and chemicals across air, water, and land. We are also helping the EPA develop a prototype multicompartment model within MIMS.

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

For the EPA Office of Research and Development (ORD) at the National Center for Environmental Assessment, we are evaluating and implementing methodologies related to assessing cumulative risks, including risk of exposures to chemical mixtures by multiple pathways. Applications to DOE sites are being demonstrated. For the National Homeland Security Research Center at EPA-ORD, we are developing rapid risk assessment methods.

We will assist the EPA Technology Innovation Office with its Triad Program of systematic planning, dynamic work plans, and field analytics, which aims to accelerate environmental cleanup by employing Argonne's experience with adaptive sampling, expedited characterizations, and brownfield sites. This effort may include support to EPA regional offices.

For the EPA Office of Radiation and Indoor Air, we are assisting in the evaluation of technologies and methods for detecting and analyzing radioactive contamination in imported scrap metal. A pilot study at the ports of New Orleans and Charleston included deployment of a detection system and analysis of imported scrap metal.

For the EPA Office of International Activities, we are evaluating thermal destruction technologies to treat persistent organic pollutants, including polychlorinated biphenyl compounds and obsolete pesticides. The technology is to be demonstrated in the Russian Federation. Results are expected to benefit DOE sites directly.

2. Federal Emergency Management Agency

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

3. Department of State and International Atomic Energy Agency

Throughout most of its existence, Argonne has actively supported the worldwide transfer of peaceful applications of nuclear technology. Shortly after the Laboratory was founded, the first international training activities were established as part of the Eisenhower Atoms for Peace program. Participants came from throughout the world to learn about the new, rapidly developing field of nuclear reactor technology. In many countries, graduates are today the leaders of national programs involving the peaceful applications of nuclear technology.

In 1976 we were designated by the Department of State as host institution for U.S. participation in the new Nuclear Power Training Program of the International Atomic Energy Agency (IAEA). Under this program we today continue to develop, organize, and conduct training courses covering a full range of topics in the peaceful applications of nuclear technology. Subject areas include nuclear safety, security and research reactor safety, D&D, energy planning, nuclear electronics, isotope hydrology, and medical physics. Approximately 3,000 professionals from over 100 countries, representing essentially all developing member states of the IAEA, have received intensive training through these courses.

We provide technical and management support to the Department of State and directly to the IAEA. One major activity is evaluation of technical cooperation projects proposed for funding by the United States, along with monitoring and facilitation of the implementation of such projects once funded. We developed and now maintain — by means of an electronic database — an “institutional memory” of U.S. support for technical cooperation projects, as well as extensive project files, IAEA reports, and evaluation studies. We also support the Department of State and the IAEA in their initiatives to improve the agency’s technical cooperation program. Argonne regularly reviews and analyzes the program’s management and achievements. We also develop recommendations on matters of policy or practice related to U.S. support for the program. By providing experts for technical cooperation programs, Argonne has helped many countries develop the ability to analyze the operation of their energy systems.

We also support the Department of State by placing IAEA fellows at research institutions throughout the country.

4. Department of Transportation

For the Research and Special Projects Administration, we continue to model the effects of accidents resulting from transportation of chemicals on the nation’s highways and railways. These models will address (1) the effectiveness of establishing protective distances from accidents involving spills on highways and rails and (2) chemical spills into bodies of water from highway and rail accidents. In support of regulation development, the Laboratory is involved in a national assessment of risks (especially risks through inhalation) associated with transporting toxic chemicals.

5. Department of Agriculture

As part of an ongoing program for the Commodity Credit Corporation of the U.S. Department of Agriculture (CCC/USDA), Argonne supports remediation of sites having contaminated groundwater and soil by integrating field sampling, groundwater modeling, and engineering cost analyses. We are also developing new cone penetrometer technologies and using them — in combination with innovative sampling, analytical, and computer data processing methods — to map the subsurface distribution of contaminants in soils and groundwater at former CCC/USDA grain storage sites. In addition, we are conducting pilot studies of spray irrigation as an alternative to traditional methods of treating contaminated groundwater.

We are assisting in the technical development of the Research, Education, and Economics Information System (REEIS), a "data mart" that integrates multiple databases in the USDA's Research, Education, and Economics program by using a web-based information architecture. REEIS will improve access to information by employing a consistent, integrated framework and will provide automated tools for analyzing the information.

The U.S. Forest Service, DOE's Argonne Area Office, and Argonne have signed a master interagency agreement that facilitates the use and application of Laboratory technical resources to support management of the nation's forests and grasslands.

6. National Science Foundation

Funding for most Argonne work for the National Science Foundation (NSF) flows through universities (see Chapter VI).

We are a partner in the National Computational Science Alliance, funded by the NSF Partnerships for Advanced Computational Infrastructure program. Researchers are developing software for collaborative problem solving, distributed computing technology, advanced visualization tools, and parallel input-output technology.

We are one of five institutions participating in the TeraGrid project, which aims to develop the world's first multisite supercomputing system, the Distributed Terascale Facility. The TeraGrid is led by the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign and by the San Diego Supercomputer Center, two leading sites of NSF's Partnerships for Advanced Computational Infrastructure. By integrating the most powerful computers, software, networks, data-access systems, and applications, the TeraGrid will create a unique national resource to support scientific breakthroughs.

As a world leader of emerging grid technologies, we collaborate on several NSF-funded projects, including the Network for Earthquake Engineering Simulation project with the NCSA; the GRIDS Center project with the University of Chicago, the University of Southern California Information Sciences Institute, the University of Illinois at Urbana-Champaign, and the University of Wisconsin; and the Grid Physics Network project with more than two dozen U.S. universities.

We are also pursuing several smaller computer science projects funded by NSF, including development of extensible network services for the Access Grid, design of adjoint compiler technology, and development of a Java commodity toolkit for computational grids.

We are collaborating with other NSF projects to develop the National Science Digital Library. In particular, under NSF funding we are leading Eastern Illinois University and the University of Utah in producing a digital library collection that improves the accessibility and usability of DOE Atmospheric Radiation Measurement Program data for the education and research communities.

7. National Aeronautics and Space Administration

For the National Aeronautics and Space Administration (NASA), Argonne is developing test beds to study applications of distributed computational grids. Argonne researchers, together with investigators at the University of Southern California's Information Sciences Institute, are also teaming with NASA researchers to implement Globus Toolkit technology on the NASA Information Power Grid.

For NASA we are also developing an Earth systems modeling framework for coupled climate models used in simulating climate variability and change.

In addition, Argonne is building a state-of-the art laboratory for trace element detection to study the composition of interstellar dust from supernovas and from comet tails, as well as the composition of components of the solar wind retrieved from Earth satellites. These studies will reveal secrets of the origin and evolution of the universe.

In other work for NASA, Argonne is providing technical assistance and oversight for the Plum Brook Reactor Facilities Decommissioning Project. Four Argonne staff members are serving in the areas of management of construction, quality assurance, health and safety, and radiation safety. This project is expected to continue until 2007.

For use in advanced propulsion systems and outer shells for high-speed aircraft, NASA is investigating advanced ceramic composite materials. In support of this effort, we are developing noncontact, nondestructive test methods to determine the condition of the materials before, during, and after a test cycle.

8. Department of Commerce

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

The NIST Advanced Technology Program (ATP) requires participating private companies to match NIST funding. The private sector can then choose to subcontract to the national laboratories in the pursuit of new technology. (See Section S1.E.2.)

9. Department of the Interior

We provide technical support on environmental issues to the Bureau of Land Management (BLM) of the Department of the Interior, helping BLM maintain long-term stewardship of public lands while allowing production of resources such as oil and natural gas.

We are developing atmospheric dispersion models that will evaluate the effects on regional air quality resulting from enhanced methane production from coal beds in the Powder River Range of Wyoming. We are also funded directly by DOE to support BLM energy planning in the Farmington (New Mexico) and Worland (Wyoming) field offices. These projects test new tools designed to enhance data sharing and provide baseline measurements needed for energy development. For BLM we also conducted several technical studies, and in FY 2003 we completed an environmental impact statement for renewal of the right-of-way for the Trans-Alaska Pipeline System. (As indicated in Section S1.E.2, this work was funded by Alyeska Pipeline Service Company.)

For the Interior Department's Fish and Wildlife Service, we develop environmental information and communications systems. One of the systems is being developed jointly with the Chicago Wilderness Society.

E. Nonfederal Organizations

1. Electric Power Research Institute

Argonne conducts research for the Electric Power Research Institute (EPRI) on topics related to the risk of a severe accident at a nuclear power plant. Research for the Melt Attack and Coolability Experiment (MACE) program was particularly important. This work investigated the ability of water to quench and cool a pool of molten core debris without formation of a continuous insulating crust, thereby terminating an accident and preventing basemat penetration. The investigations attracted worldwide attention because of their importance to strategies for managing accidents at existing plants and their great relevance to design decisions for future light-water reactors. These experiments were sponsored by the 15-nation Advanced Containment Experiments program headed by EPRI, which pursued realistic understanding of the consequences of an accident involving core melting. A successor to the MACE program is now being conducted under the sponsorship of the Organization for Economic Cooperation and Development. (See discussion of the Melt Coolability and Concrete Interaction program in Section S1.E.5.)

Complementary Argonne programs for EPRI aim to resolve key safety issues through a combination of analysis and experiments. The recently developed computer code CORQUENCH, based on data from Argonne experiments, is being used to analyze accident phenomena.

Other work for EPRI includes identifying and characterizing technologies and processes for mitigating the environmental impacts of cooling water intake structures at electric power plants. We also assess the use of these technologies and processes in innovative approaches to meeting environmental regulations (e.g., integrating methods such as wetlands restoration, artificial reefs, and artificial supplementation of aquatic systems into strategies such as wetlands banking and effluent trading).

2. Private Firms

We conduct research for a number of private firms, making use of our unique facilities and technical resources. Current work for private firms includes the following:

- Alyeska Pipeline Service Company: An environmental impact statement on renewal of the right-of-way for the Trans-Alaskan Pipeline System, for submittal to the BLM.
- BASF Corporation: Production of specialty chemicals in pilot plant quantities to test a new process using electrodialysis.
- Climax Molybdenum: Development of hydrosulfurization catalyst materials.
- General Atomics: Development of a tile computer display wall.
- General Motors Electro-Motive Division: Improvement of the efficiency and emissions characteristics of diesel engines.
- General Motors Global Alternative Propulsion Center: For advanced vehicles and fuel propulsion systems, analysis of “well-to-wheel” energy efficiencies and emissions of greenhouse gases and criteria pollutants.
- IBM: Development and implementation of the Open Grid Services Architecture, a set of specifications and standards that will combine the benefits of grid computing and web services.
- Kraft Foods: Application of nuclear magnetic resonance technology to study water distribution in processed cheeses.
- Microsoft: Development of Globus Toolkit libraries for Windows XP; porting of elements of the Access Grid Toolkit to Windows XP.
- NRG Energy, Inc.: Environmental impact analysis for a 500-kV transmission line.
- Quallion, LLC: Development of an advanced battery for implantable micro-stimulator devices for patients with strokes and Parkinson’s disease. (Funding is from the NIST ATP.)
- Solar Turbines, Inc.: Application of new nondestructive evaluation technologies to ceramic materials being developed for gas-fired turbine engines that emit less pollution and operate more efficiently.
- Superior Graphite Company: Development of nonintrusive controls for an electro-consolidation process intended to replace hot isostatic pressing in the forming of mechanical components. (Funding is from the NIST ATP.)
- Toyota Motor Corporation: Development of water-gas shift catalysts for use in fuel processors for fuel cell systems.

In addition to the activities administered under Argonne’s WFO program, as discussed in this Supplement 1, the Laboratory also performs work with its partners in cooperative research and development agreements (CRADAs). These activities are discussed in Supplement 2.

Argonne’s work for private firms often grows out of industry-laboratory collaborative projects. A good example is the Argonne Laser Applications Laboratory, which conducts R&D to support the use of high-power lasers. A recent project with the Gas Technology Institute could revolutionize the way we obtain new oil and gas supplies. The project is investigating the use of laser energy in well drilling and well completion techniques. Other projects relate to materials processing for manufacturing, such as laser heat treatment of casting dies. Processing techniques available at the Laser Applications Laboratory include high-power beam shaping and delivery, fiber optics, surface modification, and welding.

Industrial partners include automotive manufacturers and suppliers and also several small businesses. One example of benefits to private firms is a low-cost weld monitor being used in a DaimlerChrysler plant in Kokomo. This monitor has saved millions of dollars by improving weld quality. Work by the Laser Applications Laboratory generally supports Argonne's major facilities and programs, such as the APS, the Intense Pulsed Neutron Source, the fusion power program, and D&D of reactor systems. Current work focuses on applying laser ablation in D&D funded by DOE's Environmental Management Science Program.

3. Universities

Current Argonne work for universities includes the following:

- Indiana University: A high-performance network connection for research and education.
- Northern Illinois University: Collaboration on the development of MPICH-G2, a grid-enabled implementation of the Message Passing Interface standard that enables communications between machines having different architectures.
- Northwestern University: Participation in the Optimization Technology Center.
- Northwestern University: Educational outreach to place Illinois undergraduate students in summer research participation positions at the APS.
- Northwestern University: Development of innovative robotic control technology for remote applications in hazardous environments.
- Penn State University: Support for the design and engineering of a cold-neutron multichopper spectrometer for neutron scattering, to be installed at the Spallation Neutron Source at Oak Ridge National Laboratory.
- University of Chicago: Collaboration on the Grid Physics Network project in the areas of data grid and virtual data research, toolkit development, application challenge problems, and outreach.
- University of Chicago: Development of slurry ice cooling for treating cardiac patients.
- University of Chicago: As part of the Illinois Consortium of Accelerator Research project, technical support involving theoretical and simulation analysis of beam dynamics problems that are critical for the performance of linear colliders.
- University of Illinois at Urbana-Champaign: The Partnership for Advanced Computational Infrastructure program.
- University of Illinois at Urbana-Champaign: Assistance in developing middleware communication services for grid-based collaborations for the project Network for Earthquake Engineering Simulation.

4. State and Local Government

For the state of Illinois, Department of Commerce and Economic Opportunity, we are developing an advanced, high-capacity computer network (I-WIRE) linking major research centers and universities in the state. The network will enable detailed power and engineering feasibility studies, as well as development of advanced interfaces for geographically distributed applications.

We are working under two additional programs with the Illinois Department of Commerce and Economic Opportunity. The first involves developing biobased "green" solvents, such as ethyl lactate from corn and methyl soyate from soybeans, for industrial applications. In the second project, we are using our widely accepted GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model to estimate full fuel-cycle energy use and emissions from ethanol blends that may be used for light- and heavy-vehicle diesel propulsion.

For the Illinois Commerce Commission, we are analyzing the state's electric power transmission system by using a new modeling and simulation approach we developed to study complex adaptive systems.

In another project, we are working with DuPage County, Illinois, to develop precollege educational materials focused on recycling.

State groundwater regulatory agencies are prominent members of the nonprofit Ground Water Protection Council, along with federal agencies and other parties interested in protecting the nation's groundwater supplies. Argonne's work for the council involves preparing environmental analyses and developing environmental information management systems, all with a focus on the relationship of energy systems to groundwater protection.

5. International Organizations and Foreign Countries

With the World Bank and countries borrowing from the Bank, we are working on energy and environmental analyses addressing issues such as planning least-cost expansions for electrical generating systems, estimating marginal costs of electricity production, simulating the operation of mixed hydrothermal systems, projecting overall energy supply and demand, analyzing current and future environmental effects of energy production and consumption, estimating the potential for future pollution abatement projects and their costs, and estimating the costs and effects of greenhouse gas mitigation options. We typically conduct these studies in close cooperation with experts in the borrowing countries, who often are trained to use the analytical techniques themselves.

To advance nuclear reactor technology, international sponsors utilize Argonne's unique capability to perform severe-accident experiments with real reactor materials. We currently work with Atomic Energy of Canada, Ltd., on an experiment to explore molten fuel-fluid interaction for the CANDU reactor. We are conducting other accident-related research as part of the Melt Coolability and Concrete Interaction program sponsored by the Organization for Economic Cooperation and Development. The technical objectives of this multiyear program are to investigate the mechanisms by which debris cools outside the containment vessel and to address remaining uncertainties related to long-term, two-dimensional interactions between the reactor core and concrete. These objectives will be met through a series of experiments.

In other work, the Japan Nuclear Cycle Development Institute supports studies of the operational characteristics of reactor concepts, the testing needed for advanced fuels, and the irradiation behavior of materials. The Central Research Institute of the Electric Power Industry of Japan (CRIEPI) also supports studies of the irradiation behavior of structural materials. Argonne will work with CRIEPI on gathering and analyzing research data relating to the behavior of actinides and fission products in the electrometallurgical treatment of spent fuel. Argonne collaborates with the Korea Atomic Energy Research Institute (KAERI) on several aspects of nuclear reactor technology, safety research, and advanced computing applications. We are also working with KAERI on International Nuclear Energy Research Initiatives (1) to evaluate structural materials for use in the pyrochemical processing of spent nuclear fuels and (2) to evaluate and develop materials for use in Generation IV supercritical-water reactors.

We work directly with many foreign countries to provide energy and environmental analyses, along with training in the use of supporting computer models. Included are two Argonne models, the ENergy and Power Evaluation Program (ENPEP) and the Generation and Transmission Maximization (GTMax).

In a major project we work with countries in eastern Europe (Romania, Bulgaria, Macedonia, Albania, Serbia, Montenegro, Croatia, and Bosnia-Herzegovina) to analyze the operation of their electric power systems as integrated entities rather than as separate systems. The objective is improving economic and operational efficiency. The project involves the U.S. Agency for International Development and the World Bank.

Argonne is the operating agent for the International Energy Agency program Implementing Agreement for a Co-Operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector. The Laboratory's main role is to keep member countries informed about the status of superconductivity research and its progress toward application. The implementing agreement is funded by organizations in 16 countries, including the United States.

We are collaborating with researchers at the European particle physics center at CERN on the DataGrid Project to build the next-generation computing infrastructure for handling computation and analysis of petabyte-scale databases across widely distributed scientific communities. This work will build on technologies developed by Argonne's Globus Project™. Researchers in the Globus Project™ are also working with the Poznan Supercomputing and Networking Center in Poland to develop GridLab. Globus Toolkit services and libraries, such as GridFTP and Globus Resource Allocation and Management, will be used to support the development of dynamic grid-enabled applications. In addition, Argonne's Globus Project™ has formed a collaboration with the University of Manchester on the GRid Interoperability Project (GRIP). The aim is to develop a software layer that will enable secure resource management across different grids, specifically grids controlled by UNICORE and Globus Toolkit technologies.

Supplement 2: Technology Transfer

We interact extensively with researchers from industry, academia, and not-for-profit organizations in pursuit of our technology transfer role. That role focuses on providing technical solutions to challenges in the fields of energy, the environment, transportation, information, materials, and the life sciences. Our interactions, in most cases conducted under formal R&D agreements, enhance our programs and provide a means of transferring into use the technologies and methodologies created by our researchers. These interactions ultimately enhance U.S. economic productivity, international competitiveness, and society as a whole.

A. R&D Agreements

Argonne's Office of Technology Transfer (OTT) is responsible for a broad range of activities. The office's overall objective is to increase the impact of our research and expand use of its R&D results. OTT (1) manages the development of R&D agreements, including cooperative R&D agreements (CRADAs) and "work-for-others" (WFO) contracts; (2) seeks opportunities to increase collaboration with the University of Chicago; (3) develops partnerships with industry and licenses intellectual property we have developed; (4) manages the process of developing intellectual property; and (5) serves as a point of contact for our outreach activities and for incoming inquiries. Table S2.1 summarizes our technology transfer activities for FY 2000-FY 2002 and projects those activities for the subsequent three years.

Staff of OTT work closely with Argonne research divisions to develop new contract activities efficiently and to identify strategically important technology transfer opportunities with potential for high impact. OTT staff also are intimately involved with the Argonne Partnership Committee, under whose auspices participating research managers meet regularly in tactical working groups to explore opportunities for transferring technology to industry and to identify promising R&D programs that will have programmatic and commercial importance. The tactical working groups coordinate opportunities in eight focus areas based on our research: (1) transportation technology, (2) materials development, (3) process industries technology, (4) carbon management technology, (5) biotechnology, (6) environmental stewardship, (7) urban technology, and (8) national security.

Argonne research staff and OTT managers aggressively develop joint research programs and other collaborations with non-DOE organizations. They work with the Laboratory's operating contractor, the University of Chicago, to use the resources and facilities of both institutions more effectively.

B. Licensing

For Argonne inventions thought to have the greatest commercial potential — on the basis of their benefit to users, commercial value, and strategic need — OTT works with research divisions to develop market-based technology commercialization strategies. The assessment of commercial potential includes such factors as economic value compared with current alternatives, market size, cost of implementation, industry trends, and customer need for the technology. Through cooperative agreements, Argonne collaborates with industrial participants to seek the shortest and most effective route to technology commercialization and wide market adoption.

Table S2.1 reports royalties and other income received from licensing our inventions. Royalties received to date stem from two sources: (1) up-front payments for licenses, options, and assignments and (2) licensing agreements, as well as current royalties from continuing product and software sales. Income resulting from the commercial use of an Argonne technology is shared between its inventors or authors and the research divisions from which the technology

Table S2.1 Activities Conducted by Argonne's Office of Technology Transfer

	Actual Values			Projected Values		
	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
Office of Technology Transfer						
Funding ($ in millions)	2.0	2.3	2.0	2.0	2.1	2.3
Staffing (FTEs)	16	16	16	17	18	18
Active Agreements (including amendments)[a]						
Cost-shared (CRADAs)	27	27	32	32	37	37
Reimbursable (WFOs and technical service agreements)	230	246	248	278	300	300
With other DOE contractors	300	351	349	370	390	390
Total	557	624	629	680	727	727
Agreement Funding (funds to the Laboratory, $ in millions)[a]						
Cost-shared (CRADAs)	15.7	12.1	5.0	7.0	8.0	9.0
Reimbursable (WFOs and technical service agreements)	69.1	70.0	89.7	108.0	110.0	115.0
With other DOE contractors	37.5	35.3	49.9	50.0	55.0	60.0
Total	122.3	117.4	144.6	165.0	173.0	184.0
Intellectual Property						
Inventions reported	111	106	106	120	140	150
Software reported	8	17	15	20	25	25
Patent applications filed[b]	52	47	46	55	65	75
Patents issued[b]	28	46	27	30	35	40
Active licenses (all sources)[c]	78	121	150	175	195	200
Royalties (gross, $ in millions)	0.7	2.4	2.5	2.0	2.5	3.0

[a] Includes agreements with both nonfederal and federal organizations.

[b] Includes (1) patent applications filed by Argonne, ARCH Development Corporation, DOE, and others (e.g., inventors and companies) and (2) patents issuing from those filings.

[c] Includes licenses executed by Argonne, ARCH Development Corporation, and DOE.

originated. The divisions can use the funds for internally supported R&D, staff development, or educational activities (under policies set in accordance with the *Prime Contract*).

Argonne licenses copyrighted software codes and accompanying documentation to commercial and educational organizations for a fee. In addition, selected software is distributed broadly under free licenses to maximize market impact and overall benefits to users. The Laboratory also registers trademarks associated with its software and some elements of its invention portfolios, in order to distinguish and protect intellectual property when it is reported in scientific journals, in trade publications, or elsewhere.

Since 1999 we have made software available online from the *Argonne Software Shop* (URL: www.softwareshop.anl.gov). Argonne's home page links directly to this site. The following currently available software packages are enjoying significant use:

- LDAP Browser/Editor, a web-based server directory editor. Licenses have been executed with a number of organizations, including the University of California, Smart Trust of Sweden, Gordon Food Services, and MetaSolv Software.

• GCTool, a thermodynamic modeling software package with several modules, including a module for modeling the performance of fuel cell systems. Purchasers of the software include the Georgia Tech Research Institute and the Korean Electric Power Research Institute, as well as several commercial companies.

• GTMax, a software package used for energy policy management, analysis of spot energy markets, and planning for new energy and electricity facilities to meet predicted future demands. GTMax has been licensed to Adica Consulting, a small business, for application and distribution.

• The Glass Furnace Model (GFM), a model of the glass bath and the glass furnace that supports predictive optimization of glass production. This computer code was written by Argonne in collaboration with five glass companies (Osram Sylvania Products, Inc.; Techneglas; Libby, Inc.; Visteon Glass Systems; and Owens Corning) and two universities (Purdue and Mississippi State). The glass companies provided access to their furnaces, where the universities collected operational data.

Altogether, we have distributed more than 2,000 copies of software to over 50 commercial and government licensees through our web site.

In conjunction with licensing agreements, Argonne often also executes R&D agreements aimed at precommercial R&D, through either WFO contracts (as discussed in Supplement 1) or CRADAs. In FY 2002 we executed 32 new CRADAs. Other types of agreements, such as personnel exchanges and technical service agreements, are also used when the arrangement meets the needs of the Laboratory and its sponsor or customer.

During FY 2002 Argonne also executed two memoranda of understanding with sister national laboratories to facilitate licensing of inventions: (1) with Fermilab, for a microcurrent therapy process, and (2) with Brookhaven, for a plasma valve.

Some of our recently executed CRADAs had the following objectives:

• PACCAR: Develop commercial heavy-vehicle (truck) external designs to improve truck aerodynamics and reduce fuel consumption.

• Caterpillar: Improve diesel engine performance and reduce emissions.

• Eltron Research: Develop advanced hydrogen transport membranes for future pollution-free, multipurpose fossil fuel plants, as being conceptualized by DOE for its Vision 21.

• Fuel Cell Energy: Develop advanced bipolar plate materials for molten carbonate fuel cells.

• CH_2M Hill: Assess the potential applications of our Ceramicrete technology for treatment of hazardous and nuclear waste.

• Sud Chemie, Inc.: Develop an improved sulfur-tolerant reforming catalyst for application to fossil fuels.

• Caterpillar: Develop approaches to analyzing underhood thermal management by using computational codes that integrate computational fluid dynamics and systems analysis.

• ITN Energy Systems: Apply novel composite membranes to hydrogen separation for gasification processes in Vision 21 energy plants.

Supplement 3: Site and Facilities

A. Description of Site and Facilities

1. Overview of Site and Facilities

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

a. Argonne-East

Activities at Argonne-East support the full range of missions described in Chapter II. Major facilities at the site include the Advanced Photon Source (APS), the Laboratory's newest and largest user facility; the Intense Pulsed Neutron Source (IPNS); the Argonne Tandem-Linac Accelerator System (ATLAS); and the Electron Microscopy Center. Researchers from outside Argonne use all these facilities heavily. Argonne-East also houses a full spectrum of administrative and technical support organizations, as well as DOE's Chicago Operations Office and the New Brunswick Laboratory, both of which use facilities operated and maintained by Argonne.

Altogether, Argonne-East currently houses approximately 4,800 persons, including employees of DOE and contractors and other guests. An additional 2,200 individuals visit the site each year to use the Laboratory's research facilities. The Argonne-East site includes 101 buildings having 4.6 million total square feet of floor space. An additional 110,000 square feet of space is provided by various other structures and facilities throughout the site. The replacement value of all existing facilities and other structures at Argonne-East is estimated to be approximately $1.9 billion. (See Table S3.1.)

Research programs supported by DOE's Office of Science account for over half of the space usage at Argonne-East. Figure S3.1 summarizes the distribution of space at Argonne-East (and Argonne-West) by functional unit (administrative, R&D, housing, and so on) and by condition of space, as a percentage of gross square footage.

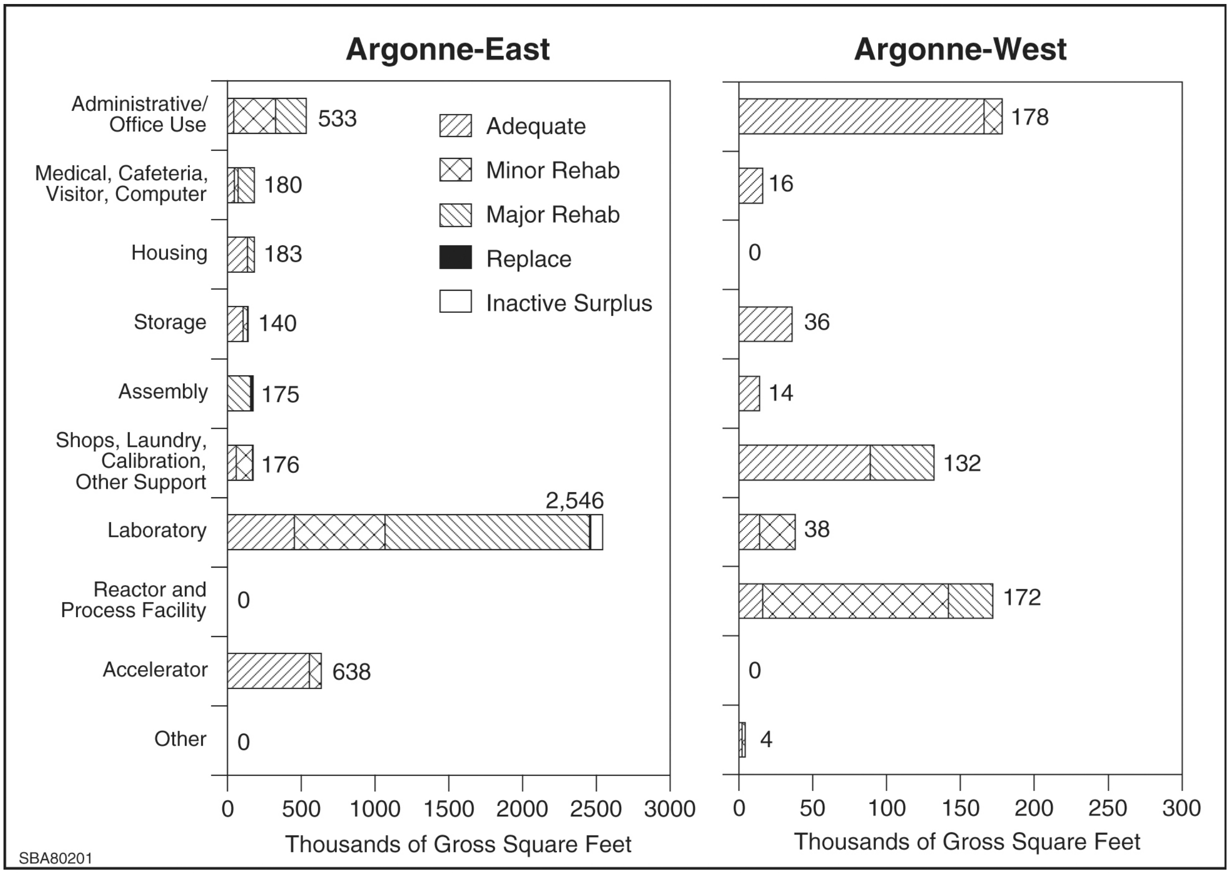
The Laboratory also leases 77,000 square feet of space near the Argonne-East site to alleviate a space shortage. Other leased property totals an additional 23,000 square feet, primarily for offices in the Washington, D.C., area and in Colorado. Occupancy of off-site space has remained stable for several years.

Adequate land is available to accommodate Argonne's plans for expanded programs in basic research and other areas. The site road and utilities infrastructure generally can accommodate modest growth. Facilities are now almost fully occupied, so additional construction will be required to satisfy the needs of growing programs.

Argonne's long-range vision is to "retool" its physical setting to a 21st century infrastructure having appropriately configured research facilities that provide reliable, safe, efficient, and attractive working environments suitable for world-class science, engineering, and technical services.

Table S3.1 Replacement Value of Argonne Facilities ($ millions)

Facilities Type	Argonne-East	Argonne-West
Buildings	1,087	242
Utilities	148	13
All Others	655	463
Total	1,890	718



	Space at Argonne-East					Space at Argonne-West				
	Active					Active				
	Adequate	Minor Rehab	Major Rehab	Replace	Inactive Surplus	Adequate	Minor Rehab	Major Rehab	Replace	Inactive Surplus
Administrative/Office Use	41	284	208	0	0	166	12	0	0	0
Medical, Cafeteria, Vistor, Computer	47	27	107	0	0	16	0	0	0	0
Housing	136	0	47	0	0	0	0	0	0	0
Storage	106	31	2	2	0	36	0	0	0	0
Assembly	0	0	156	19	0	14	0	0	0	0
Shops, Laundry, Calibration, Other Support	58	113	0	5	0	89	0	43	0	0
Laboratory	452	618	1,385	8	83	14	24	0	0	0
Reactor and Process Facility	0	0	0	0	0	16	126	30	0	0
Accelerator	557	81	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	2	2	0	0	0
TOTAL[a]	1,396	1,154	1,904	34	83	353	164	73	0	0
(Percent of All Space)	(30.5)	(25.3)	(41.7)	(0.7)	(1.8)	(59.8)	(27.8)	(12.4)	(0.0)	(0.0)

[a]Totals and column entries were rounded independently.

Figure S3.1 Distribution of Space at Argonne-East and Argonne-West in 2003 by Use and Condition
(thousands of gross square feet)

b. Argonne-West

Argonne-West conducts R&D and operates facilities for DOE. After termination of the Integral Fast Reactor program in FY 1994, the programmatic mission of the Argonne-West facilities changed significantly. Current primary missions are (1) the use of electrometallurgical techniques to treat driver and blanket assemblies from the Experimental Breeder Reactor-II (EBR-II) and (2) development of technologies for deactivating other sodium-cooled reactors. In addition to Nuclear Energy, Science and Technology, DOE programs using Argonne-West facilities include Environmental Management, Defense Nuclear Nonproliferation, and Defense Programs. The most prominent programmatic facilities and their current missions are described briefly below.

The EBR-II has been shut down and defueled. While it was being placed in an industrially safe, stable condition, it served as a demonstration facility for the development of deactivation methods applicable to other nuclear power plants. One key technology issue still being investigated is treating EBR-II spent fuel to stabilize it, by going from a mixed hazardous waste to a final form that meets the requirements of a geologic repository. This problem is being addressed in the Fuel Conditioning Facility (FCF), where sodium is removed from inside the EBR-II fuel and where the spent fuel is converted from a mixed hazardous waste to a stable metallic and mineral waste form. Resolution of two other technological issues has now been demonstrated. First, large quantities of contaminated sodium were processed into a nonreactive waste form for disposal. Second, a safe process was developed and implemented for controlled reaction of the sodium remaining in the reactor's primary system following drainage. In January 2003, the state of Idaho issued the Resource Conservation and Recovery Act (RCRA) Part B Permit for the EBR-II. The permit requires development and implementation of a *RCRA Clean Closure Plan* for treating and removing any remaining hazardous materials, such as residual sodium metal, contaminated lead, and other mixed waste.

The FCF, one of the original facilities at Argonne-West, has operated since 1964. A major refurbishment completed in 1996 made the FCF one of DOE's most modern hot cell facilities, meeting current safety and environmental requirements for handling irradiated materials, including transuranics. The FCF has two operating hot cells — one with an air atmosphere for handling contained fuel and the other with an inert argon atmosphere for conducting operations (including electrorefining) with exposed fuel materials. The FCF is the primary facility involved in applying electrometallurgical technology to the preparation of sodium-bonded spent nuclear fuels for ultimate disposition.

The main cell of the Hot Fuel Examination Facility (HFEF) is a large, multipurpose hot cell filled with inert gas, in which operations on highly radioactive fuels and materials can be performed. The HFEF is being used to prepare ceramic waste products as part of the treatment of sodium-bonded spent fuel. The HFEF is also used for post-irradiation testing of various irradiated fuels and materials, including spent fuel that has become degraded during storage and experimental target rods designed to determine the potential for producing tritium in commercial light-water reactors. The HFEF is an extremely versatile facility that is suitable for such work as examination (nondestructive or destructive) of radioactive materials and development of spent fuel waste forms, as well as for other kinds of work requiring remote handling of radioactive materials. The HFEF was modified in 1999 to accept for examination fuel assemblies as long as those used in commercial reactors.

The Waste Characterization Area (WCA) within the HFEF at Argonne-West is used for sampling and characterizing waste ultimately bound for the Waste Isolation Pilot Plant. The WCA features remote operations and glove boxes for sampling of various kinds, from gas sampling to core drilling.

The Neutron Radiography Reactor Facility, located in the basement of the HFEF facility, is a TRIGA (training, research, isotope, and general atomic) research reactor. It is equipped with two beam tubes and two separate radiography stations, making it one of the finest facilities in the world for radiography of irradiated and unirradiated components.

The Sodium Processing Facility treated sodium from EBR-II and other sources, converting elemental sodium into sodium hydroxide for ultimate disposal. The technology demonstrated could be adapted to processing sodium from other sodium-cooled reactors after they are deactivated, such as the Fast Flux Test Facility or the BN-350 reactor in Kazakhstan.

The Transient Reactor Test Facility (TREAT) is currently in standby status and is not operating. In the past, TREAT was used for testing of reactor physics and design and for analysis of nuclear materials, and it is still capable of performing that role. Nonreactor portions of TREAT are still supporting ongoing DOE programs, such as testing of waste treatment technologies.

The Zero Power Physics Reactor (ZPPR), now in standby status, was used for physics testing of new reactor core designs. The facility includes a large fuel storage vault that provides state-of-the-art storage for special nuclear materials. Associated Argonne experience in the care and treatment of special nuclear materials has been the basis for efforts to help the former Soviet Union with nonproliferation technology. The ZPPR facility and surrounding buildings will also support the Radioisotope Power System/Heat Source project that was recently funded by DOE-Nuclear Energy, Space and Defense Programs. This project will assemble and maintain radioisotope power systems (“space batteries”).

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

Supporting the major facilities at Argonne-West is an array of shops, warehouses, laboratories, offices, and utility systems. This array of supporting facilities includes a newly refurbished Analytical Chemistry Laboratory with full capability for analyzing irradiated nuclear materials, including transuranics.

Argonne-West houses about 690 persons. The site includes approximately 70 buildings having 600,000 gross square feet of floor space. Figure S3.1 summarizes the distribution of space at Argonne-West by functional unit and condition of space. Most of the buildings and other infrastructure were originally built during the mid to late 1960s but have since been upgraded and expanded. Figure S3.2 summarizes the ages since original construction for Argonne-West (and Argonne-East) facilities. The replacement value of existing facilities at Argonne-West is estimated to be $718 million. (See Table S3.1.)

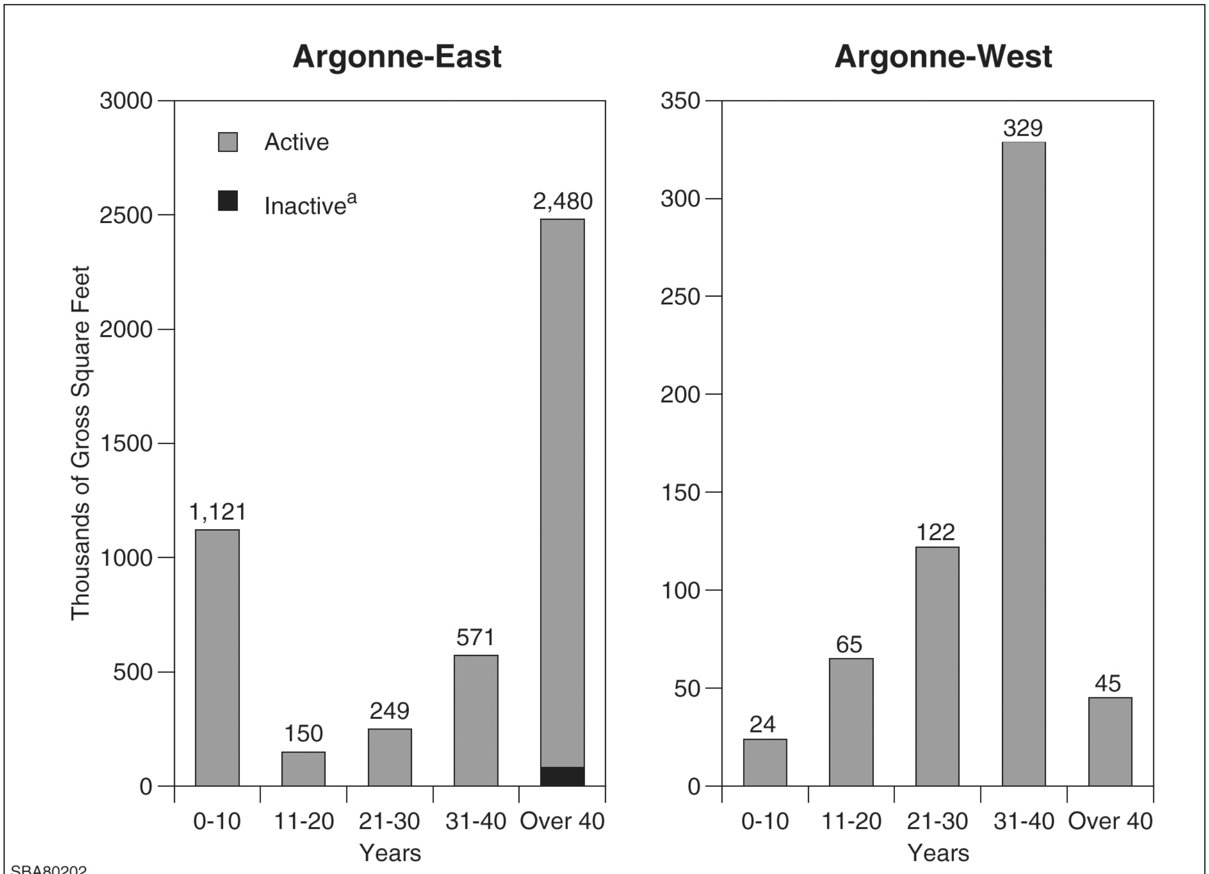
2. Status of Existing Facilities and Infrastructure

Because most building and facility infrastructure systems have a useful-life expectancy of 25-35 years, many Argonne facilities constructed in the 1950s and 1960s now require upgrading or replacement. This aging of facilities has caused the accumulation of a large inventory of needed revitalization. Figure S3.2 summarizes the ages of Argonne-East (and Argonne-West) facilities.

Argonne’s management of site and facilities includes a systematic, comprehensive program to ensure that facilities effectively satisfy research needs, as well as requirements for safety, health, security, and environmental acceptability. The Laboratory’s ongoing facility planning includes site development planning, the Condition Assessment Survey (CAS) process, and prioritization of resource requirements. The following discussions for Argonne-East and Argonne-West describe the current status of each site in the context of this management program.

a. Argonne-East

The principal challenges being addressed by Argonne-East are the normal aging of buildings and infrastructure and the need to upgrade laboratory facilities to meet 21st century challenges.



Active	1,121	150	249	571	2,397	24	65	122	329	45
Inactive[a]	0	0	0	0	83	0	0	0	0	0
Total	1,121	150	249	571	2,480	24	65	122	329	45

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

Figure S3.2 Age of Laboratory Buildings at Argonne-East and Argonne-West in 2003 *(thousands of gross square feet, distributed by age in years)*

As indicated in Figure V.1 in Chapter V, over 54% of Argonne-East facilities are over 40 years old. Systems and equipment in these older facilities must be upgraded to serve modern R&D adequately. In recent years, Argonne-East has successfully reduced substandard space to 2.5% of total space by replacing or rehabilitating older facilities and by adding new programmatic facilities. Figure V.2 in Chapter V summarizes the condition of all types of building space at the two Argonne sites.

Argonne employs a standardized approach to classifying facility condition, based on the cost of rehabilitation compared to the cost of replacement construction. Facilities are classified as “adequate” if the estimated cost ratio of rehabilitation to replacement is less than 10%; “minor rehabilitation” indicates a ratio from 10% to 25%, “major rehabilitation” a ratio from 25% to 60%. When the ratio is greater than 60%, facilities are recommended for replacement or disposal as excess. On the basis of these criteria, we estimate that 39% of occupied Argonne-East facilities space needs major rehabilitation or upgrades, while 31% is in adequate condition.

Table S3.2 Facility Condition Statistics for Argonne-East by Asset Type

Asset Type	Number of Buildings	Replacement Plant Value[a] ($ millions)	Gross Floor Area (square feet)	Deferred Maintenance Needs: Cost ($ millions)	Deferred Maintenance Needs: Index[b] (%)	Rehabilitation and Improvement Cost ($ millions)	Cost ($ millions)	Summary Condition Index[c] (%)
Buildings[d]								
Administrative/Office Use	11	90.9	532,901	0.9	1.0	18.4	19.4	21.3
Medical, Cafeteria, Visitor, and Computer	10	29.8	180.371	2.3	7.9	5.8	8.1	27.3
Housing	9	26.1	182,769	0.0	0.2	5.0	5.1	19.5
Storage	14	79.2	140,460	0.7	0.9	3.5	4.2	5.3
Assembly	4	37.8	174,568	6.3	16.6	8.6	14.9	39.5
Shops, Laundry, Calibration, and Other Support	10	36.7	175,918	0.4	1.1	5.1	5.5	15.0
Laboratory and Accelerator	43	783.7	3,184,005	11.3	1.4	167.1	178.4	22.8
Total Buildings	101	1,084.1	4,570,992	22.0	2.0	213.5	235.5	21.7
Other Structures and Facilities		256.3		17.9	7.0	34.9	52.8	20.6
All Argonne-East Facilities		1,340.4		39.9	3.0	248.4	288.3	21.5

[a] Excludes value of accelerators and scientific equipment.

[b] Deferred maintenance divided by replacement plant value.

[c] Deferred maintenance plus other needed rehabilitation and improvement, all divided by replacement plant value.

[d] Grouped by FIMS (Facility Information Management System) use code.

Since 1994 Argonne-East has eliminated a substantial amount of inefficient, obsolete space. Fifty-two owned or leased trailers accounting for more than 45,000 gross square feet were removed, leaving only 11 trailers in use. Also removed were 32 buildings totaling more than 198,000 gross square feet. Currently, some research staff are housed in a 77,000 square foot rental office facility about a mile from the site. The lease for the facility is scheduled to be renewed on July 31, 2003. Approximately 1.3% of space on the Argonne-East site is unused or vacant (not counting space undergoing or scheduled for decontamination and decommissioning [D&D]). This space is mostly in isolated small pockets that cannot be economically consolidated to house a new work group; the vacancy rate for administrative space (for offices, secretarial services, support services, and the like) is less than 0.5%. At the beginning of FY 2002, the removal of six buildings from the site's east area eliminated approximately 90,000 gross square feet of substandard space. At the APS, construction of an additional laboratory-office module increased the total number of buildings on the site to 101. Except for the New Brunswick Laboratory (Building 350), all of these buildings are owned and operated under the management responsibility of the DOE Office of Science (DOE-SC).

Among the site's 100 DOE-SC buildings, 7 are identified as excess. Two buildings (330 and 301) totaling 82,588 square feet have been shut down. Five others, totaling 19,497 square feet, remain operational, pending replacement and subsequent disposal. Altogether, active excess facilities account for less than 0.5% of the Argonne-East space inventory; shutdown facilities, associated with D&D supported by DOE-Environmental Management (DOE-EM) but not yet completed, account for less than 2% of the space inventory. Office trailers at Argonne-East house only about 18 staff. (Six further staff members are housed in trailers at remote research locations out of state.) For practical purposes, the site's active facilities are completely utilized.

In general, the capacities of site utility systems are adequate for anticipated needs. Still needed are upgrading of sewer system sections not rehabilitated during the 1990s and improvements in the reliability of the site's electrical distribution system. Further improvements to the Central Heating Plant are needed to modernize its auxiliaries and distribution systems, in order to extend the plant's service life and reliability. The general site circulation infrastructure (roads, walks, and parking) is substantially degraded and needs major rehabilitation or outright replacement.

Table S3.2 summarizes three statistics used by DOE-SC to evaluate the condition of various types of facilities at its laboratories: (1) deferred maintenance as a percentage of replacement plant value, (2) other costs for needed rehabilitation and improvements, and (3) total identified expenditures needed as a percentage of replacement plant value. (DOE-SC attaches condition descriptors ["poor" to "excellent"] to percentages in particular ranges, as indicated in the table.) These statistics reflect the increasingly urgent need for greater capital funding at Argonne-East to maintain reliability and support modernization as the site's facilities continue to age. The greatest need is for laboratory and accelerator buildings, especially for rehabilitation and improvement beyond current deferred maintenance. That rehabilitation and improvement of laboratory and accelerator buildings is the focus of modernization plans presented in the Argonne-East *Strategic Facilities Plan*.

b. Argonne-West

The Infrastructure Program at Argonne-West aims to (1) meet the needs of the Laboratory's programs; (2) meet environment, safety, security, and health (ESS&H) requirements; (3) provide a workplace that encourages high productivity and creativity; and (4) protect the large government investment in the site's facilities.

As indicated by Figure V.1 in Chapter V, more than half of Argonne-West facilities are over 30 years old. Although the major nuclear facilities have been well maintained and are generally "mission ready," their structures, systems, and equipment need to be rehabilitated and upgraded to ensure that they provide reliable, cost-effective support for R&D and demonstration activities, now and in the future. General purpose facilities have been maintained in a workable state of repair with limited available funds, but they need to be rehabilitated and upgraded to restore them to mission-ready status. The capacities of the site utility systems are generally adequate for current and anticipated needs, though most of the systems (e.g., electrical switchgear and the steam and condensate system) are over 30 years old and need to be replaced and upgraded. The general site circulation infrastructure — such as roads, sidewalks, and parking areas — has degraded significantly and needs major rehabilitation or complete replacement. The general policy at Argonne-West is to give priority to repairs or upgrades that are needed to ensure a safe, secure, and environmentally benign workplace. Remaining limited funds are used for tasks that are necessary to prevent much more costly future repairs. Limited funding over multiple years has caused a backlog of needed repairs and upgrades with a total deferred maintenance cost of approximately $14 million.

As existing programs evolve and new programs begin at Argonne-West, facilities are modified and upgraded accordingly. Infrastructure funding is generally not available to support such changes, so individual programs must fund them. For example, the Radioisotope Power System/ Heat Source project is funding modifications and upgrades to Building 792 that support associated assembly and maintenance activities. Figures S3.1 and S3.2 summarize the condition and age, respectively, of facilities at Argonne-West (and Argonne-East).

B. Site and Facilities Trends

Argonne manages its two sites to maximize the contribution that their physical resources make to the Laboratory's research programs while preserving the sites' environmental settings. This section discusses trends at each site that provide context for understanding the Laboratory's general plans and strategies for managing its sites and facilities.

1. Argonne-East

Management of the site and facilities at Argonne-East must cope with two contradictory major trends. First is the normal aging of buildings and infrastructure in the face of increasing needs for upgrades to meet 21st century challenges. Second is declining real capital funding for rehabilitation and upgrades.

For many years, R&D facilities at Argonne-East have accounted for about 60% of total built space. This preponderance of R&D facilities has allowed the Laboratory to adapt well to the shifting research priorities typical of a multiprogram laboratory. The site's R&D buildings today are generally larger, more complex, and more adaptable to changing research programs than they were in the past.

Argonne-East buildings fall into three major groupings having similar ages and needs. The site's original permanent structures, built in the early and mid 1950s, typically need wholesale modernization. The complex of facilities and support areas for the Zero Gradient Synchrotron, built in the 1960s, has been evolving into a collection of special-purpose facilities that today typically need selective modernization. The buildings of the APS complex were built in the mid 1990s and require little modernization.

Figure V.2 in Chapter V indicates that an estimated 31% of occupied Argonne-East space is in adequate condition. Figure S3.3 shows that the percentage of facilities considered to be in adequate condition has trended downward since FY 1998. The continued aging of these facilities — including those of the APS, which has now operated for nearly a decade — implies imminent increases in needed maintenance, replacement, and modernization.

Overall, the condition of utilities and other structures and facilities at Argonne-East is unchanged from prior years; that is, minor rehabilitation is required.

Argonne-East has historically received insufficient line-item construction project (LICP) funding to significantly reduce its backlog of needed upgrades to general purpose facilities. Now, LICP funding for new project starts has been eliminated for both FY 2003 and FY 2004, and recent budget guidance extends the elimination of new LICP funding through FY 2005. Delays in urgently needed LICP funding

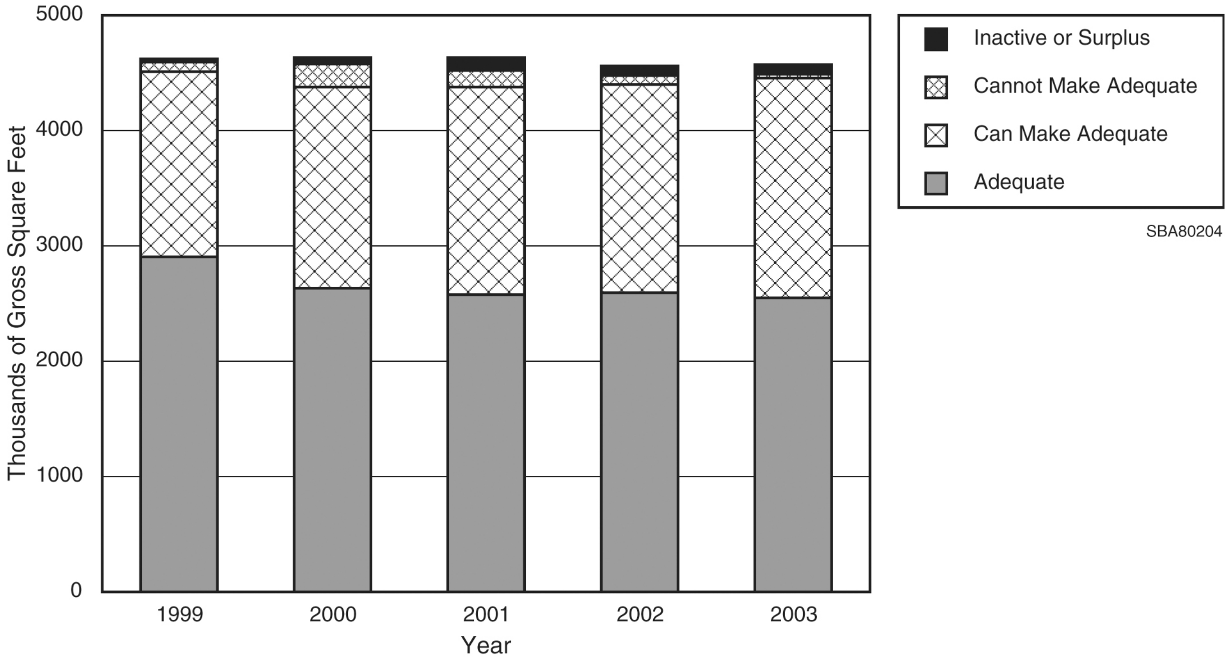


Figure S3.3 Condition of Argonne-East Buildings, 1999-2003

are inordinately burdening the Laboratory's General Purpose Project (GPP) and indirect funds. Increased capital funding projected in the Argonne-East *FY 2002 Strategic Facilities Plan* was intended to improve the site's overall infrastructure condition from "minor rehabilitation needed" to "adequate" over a five-year span. Continuation of capital funding at current levels, as proposed in the DOE budget formulation funding tables and related guidance, will lead to continued degradation of the Argonne-East physical plant.

Real GPP funding at Argonne-East has also been declining in recent years, causing an increasing backlog of unfunded facility upgrades. The Laboratory has accordingly raised its requests for GPP funds, especially to meet needs documented by its ESS&H and infrastructure (ESSH&I) process. Those needs total $14.8 million for FY 2004 and $17.2 million for FY 2005.

Delayed upgrades invariably lead to age-related equipment failures that must be resolved by using limited indirect funds. That strain on indirect funds in turn reduces resources available for routine maintenance and orderly replacement of building equipment. In recent years, 60% of the maintenance at Argonne-East has been corrective rather than scheduled. As reported in the DOE corporate physical assets database (FIMS [Facility Information Management System]), actual maintenance costs totaled $25.5 million in FY 2002 (including $19.0 million for buildings and $6.5 million for other structures and facilities); deferred maintenance totaled an additional $39.9 million ($22.0 million for buildings, plus $17.9 million for other structures and facilities). Estimated maintenance expenditures for FY 2003 are $19.6 million.

Insufficient General Purpose Equipment (GPE) funding over the past decade has led to serious aging and obsolescence of equipment for support activities and an inability to introduce needed major new equipment in a timely manner. Excluding laboratory equipment, the site's general plant equipment is now on average 73% depreciated (asset value weighted). For equipment that is not already fully depreciated, the average remaining life expectancy is approximately 3.8 years. This statistic reflects recent additions of new equipment, which nevertheless have been insufficient to retire much of the equipment remaining in service beyond its economic lifetime. Continuation of recent funding trends implies that the Laboratory will continue to be unable to replace general purpose equipment at recommended rates.

2. Argonne-West

The Argonne-West site includes 70 buildings and 8 government-owned trailers that altogether have a total floor space of approximately 600,000 gross square feet. (The 8 trailers provide approximately 4,850 square feet.) Most of the buildings and infrastructure were built during the mid to late 1960s. A new fire station (9,240 square feet) was completed during 1998. Total space at the site has increased only slightly in recent years. The expected trend is to maintain and possibly modify existing facilities for current and future missions. All trailers are currently in use, but long-run plans call for their removal.

Most of the upgrades for the Argonne-West infrastructure require GPP, GPE, or LICP funding. Over the past few years such funding has been inadequate. For FY 2002, Argonne-West requested $1,200,000 in GPP and GPE but received $450,000. For FY 2003, the site requested $2,480,000 in GPP and GPE, plus $750,000 in LICP, but received no funding. The request for FY 2004-FY 2009 is $8,586,000 in GPP and GPE, plus $80,400,000 in LICP. The continuing funding shortfall increases the backlog of unfunded facility upgrades, and it degrades the site's mission-ready status.

Funding for operational maintenance also continues to decline. Maintenance costs of $13.4 million for FY 2003 mainly support essential and corrective maintenance but not preventive and predictive maintenance. Deferred preventive and predictive maintenance results in running systems and equipment to failure and investing in corrective repairs only for equipment needed to meet ESS&H requirements — unless a research program is willing to fund a repair directly.

Currently, there are no surplus facilities at Argonne-West, but that situation might change when "RCRA clean closure" of EBR-II is complete. All facilities at the site are presently used to support R&D programs.

C. Facility Management Operating Strategies

Argonne remains fully committed to its formal strategic facilities planning processes for site development and management of facilities and real property assets. Argonne's sites and facilities support the execution of world-class basic and technology-directed research by providing reliable, efficient, cost-effective facilities offering work environments that are safe, secure, healthful, and environmentally sound and that generally stimulate creativity and high productivity.

1. Argonne-East

Three major goals and associated strategies support the Argonne-East vision for the 21st century: (1) maintain excellence in ESS&H, (2) ensure effective use of facilities and systems, and (3) maintain a setting suitable for world-class research.

a. Maintain Excellence in ESS&H

Argonne strives to comply with federal codes, standards, and regulations, both in ongoing operations and in the construction of its facilities. The Argonne-East prioritization process for ESSH&I focuses management attention on the most urgent infrastructure requirements.

Environmental restoration undertaken by Argonne has characterized and contained most formerly contaminated areas and waste disposal and storage sites. Corrective actions currently under way include remediation and monitoring to assure environmental quality. The D&D of contaminated reactors, accelerators, and hot cell facilities at Argonne-East aims to return these facilities to the site's space inventory, to the extent practical.

b. Ensure Effective Use of Facilities and Systems

Argonne-East employs several management strategies to ensure the effective use of its existing facilities.

Landlord and tenant roles are clearly delineated. The Plant Facilities and Services Division functions as landlord for the site, with responsibility for all aspects of the general purpose physical plant, including operation, maintenance, and compliance with ESS&H regulations. This approach ensures balanced, comprehensive prioritization of attention to all Laboratory facilities. Facility occupants are responsible for managing, maintaining, and repairing their own specialized equipment, experimental apparatus, and systems dedicated to programmatic activities, including ESS&H aspects of such equipment and systems.

Site development planning supports the efficient use of land and facilities. This planning is closely linked to the institutional planning process and to application of the CAS to existing facilities.

Land use planning considers natural aesthetics, as well as future development of major programmatic initiatives within dedicated development areas of the site. (See, for example, Section III.A.2 for discussion of the Rare Isotope Accelerator as a proposed expansion of ATLAS.)

Argonne-East manages its space to meet the needs of its research programs while satisfying General Services Administration guidelines, thereby maximizing occupancy rates and routinely accommodating changes in research programs. The Laboratory's clearly defined space management program requires that each organization pay rent based on the square footage of space occupied. Occupancy charges paid by all site users are based on operational and maintenance costs calculated for the individual facility. In FY 2002 these costs averaged approximately $5.77 per gross square foot. Utility use is metered and the cost passed on proportionately to facility occupants, if it is not directly charged to the operators of metered equipment. This system gives research programs a strong incentive to keep space and utility usage to a minimum.

The Laboratory's CAS uses industry and DOE standards to systematically evaluate the condition of the physical plant. Assessments performed by outside specialists provide a credible, auditable basis for determining physical plant needs. Each facility or utility is surveyed every three to five years, and a life-cycle-based ten-year forecast of needs is developed. These assessments use standard cost estimating data, and needs are rated by using the Capital Asset Management Process (CAMP; DOE Order 4320-2A) scoring system.

Further inspections and assessments performed include environmental surveys; safety and environmental audits and inspections; monthly life safety inspections; and semiannual environment, safety, and health inspections. Imminent dangers are corrected immediately. All safety inspection findings are tracked until they are resolved. The Laboratory's suite of internal, independent inspections ensures that facility deficiencies are identified and evaluated quickly and are corrected on the most advantageous schedule possible.

Argonne's ESSH&I prioritization process focuses on ranking the needs identified by the complementary processes discussed above. Facility needs are regularly analyzed, integrated into a single list, and prioritized in a formalized, documented process that includes representation from all support and programmatic personnel, up to the Laboratory's most senior level. Communication and agreement with DOE and other stakeholders help ensure comprehensive evaluation of facility needs, in preparation for the annual development of funding plans and the systematically prioritized use of limited resources.

Argonne manages some of the programmatic obsolescence of its facilities by simple reprogramming for a new use or remodeling and rehabilitation for reuse to meet a current need. An example is reuse of the Experimental Boiling Water facility, after D&D, as the Radioactive Waste Storage Facility. That reprogramming freed maintenance funds for productive use elsewhere.

Replacement of outmoded facilities with more efficient facilities reduces maintenance and overall operating costs. Demolition of surplus facilities and equipment reduces surveillance and maintenance costs and makes land available for reuse. For example, the east area and the 800 area of the site are now ready for redevelopment and reprogramming.

c. Maintain a Setting for World-Class Research

Achievement of world-class research is fostered by appropriate settings, both for the immediate workplace and for the surrounding campus. Argonne's goal is modern, flexibly appointed research and support facilities whose designs take advantage of the latest construction technologies to achieve sustainability, flexibility, versatility, and longevity. The new Central Supply Facility, a good example of the application of sustainable design and integration of facilities, recently received a silver award in the LEED evaluation process, the first federal facility to achieve this distinction. (The LEED [Leadership in Energy and Environmental Design] Green Building Rating System™ is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings.)

To maintain facilities that are an appropriate setting for world-class research, the Laboratory appropriately enhances both the functionality and appearance of interior work space, which helps to attract superior scientists and engineers and then contributes to their productivity and creativity. Projects undertaken include renovation of public areas, upgrades to increase accessibility, improvements of lobbies and conference facilities, modifications to landscaping and parking areas, and general enhancement of the site's appearance to reflect its world-class status.

Argonne-East has been notably successful in integrating its development pattern into the site's natural landscape and making the buildings in each area aesthetically compatible. Argonne-East is protecting environmentally sensitive areas of the site in their natural state, especially along existing natural areas, floodplains, streams, and steep slopes. Former ecology plots are being managed to enhance their natural biodiversity, which contributes to the park-like setting. These plots remain available as a strategic reserve for programmatic development that cannot be accommodated elsewhere on the site.

The campus-like ambience of Argonne-East has been enhanced by a site beautification program, the use of common architectural elements to unite various areas visually, and demolition of temporary and aged facilities, such as the large number of trailers employed earlier.

2. Argonne-West

Argonne-West conducts R&D and demonstration programs that support the Laboratory's overall mission in nuclear technology. Those programs generally fall into one of the following categories: (1) Advanced Fuel Cycle Initiative, (2) Generation IV Nuclear Energy program, (3) Space Nuclear Power, (4) Nuclear-Hydrogen Technology, (5) Homeland Security, or (6) International Safety and Nonproliferation.

In FY 2001, at the request of DOE-Nuclear Energy, Argonne-West formalized the Argonne-West Infrastructure Program to maintain the site's facilities in a mission-ready state and generally support DOE missions and programs. Mission-ready work scopes in the Infrastructure Program provide well-maintained facilities and support systems that are ready to serve research programs. These work scopes also provide core operational staff to assist in planning program-specific activities, preparing ES&H and quality assurance documents, and developing program-specific operational procedures, but they do not provide operations staff to perform direct programmatic work. Instead, specific programs fund the activities and resources needed to accomplish program implementation (e.g., spent fuel treatment). These resources include facility operators, technical staff, and operations support (e.g., health physics technicians).

The DOE-Nuclear Energy funding for the Infrastructure Program supports the operating costs of all Argonne-West nonprogrammatic facilities and site utilities, including both physical and human resources. First priority is given to "essential" work; as additional funds are available, they are applied to mission-ready work. Inadequate mission-ready funding results in problems such as (1) inability to keep nonessential facility systems and equipment ready for immediate use, (2) reduced facility availability, and (3) reduced availability of staff to respond immediately to programmatic requests.

Environmental activities command high priority at Argonne. The objective of the environmental program at Argonne-West is to ensure no adverse effect to the environment and compliance with environmental regulations. Major activities include (1) sampling, analyzing, and remediating past releases of hazardous materials into ponds, ditches, and other areas; (2) replacing underground pipes and tanks; (3) upgrading the radioactive scrap and waste facility with cathodic protection; (4) seeking permits from the U.S. Environmental Protection Agency and the state of Idaho for certain ongoing activities; (5) developing a facility for remotely handled mixed transuranic waste; and (6) converting elemental sodium into solid sodium hydroxide for disposal.

D. Planning Approach for General Purpose Infrastructure

Argonne's planning for general purpose infrastructure focuses on maintaining facilities that are both safe and efficient, upgrading R&D facilities to 21st century standards, and providing adequate utilities and transportation networks. This section describes the Laboratory's overall planning approach. Subsequent sections describe particular resource requirements.

1. Argonne-East

The Argonne-East site can physically accommodate facilities aggregating to two to three times the present state of development. Environmentally sensitive and interconnecting open-space areas that support the natural ecology and hydrologic drainage of the site are being retained in their natural condition. The intensity of planned development on the balance of the site — in terms of covered area, floor area ratio, and landscaping standards — will remain consistent with the character of areas already developed.

Achieving the Laboratory's strategic vision for the 21st century begins by eliminating deficiencies in existing facilities due to aging and obsolescence. Beyond restoring impaired functionality, the Laboratory must upgrade telecommunications, improve building electrical and mechanical services, and modernize the layouts and furnishings of laboratory space. Maintaining and upgrading sound but depreciated facilities is central to Argonne's operating strategy for existing general purpose facilities. Also proposed are construction of essential new facilities and disposal or replacement of inefficient structures.

Building systems upgrades and modernization are focused primarily on the older multiprogram laboratory-office buildings in the 200 and 300 areas. Of the 10 major building in those areas, 7 require major rehabilitation, and 3 require minor to moderate rehabilitation. Throughout Argonne-East, 12 buildings totaling 2 million gross square feet account for the bulk of the modernization requirements.

Argonne-East plans to implement its upgrading and modernization programs in rotating phases that concurrently address common system needs across several buildings. Broadly speaking, building electrical systems will be upgraded for reliability and load capacity. Mechanical and control equipment and distribution systems will be improved to provide a more flexible and adaptable building utility support network. Space will be reconfigured, rehabilitated, and modernized, in part by improving partitioning, laboratory furnishings, and architectural features. Argonne plans to implement modernization in wings or floors of buildings, so that entire buildings need not be shut down. However, because existing space is almost entirely utilized, a new multiprogram laboratory-office building is needed as the first step in the modernization process, to house research and operations programs with minimal disruption during work on their current space.

Also needed is a new general purpose high bay facility to supplement current facilities and to consolidate R&D during the upgrades to other high bay facilities discussed below. Aging high bay facilities suffer from many of the same problems as research laboratories. Particularly needed is more effective control of temperature and humidity. Midwestern temperature extremes, in both winter and summer, affect work in many high bay facilities, including the assembly area in Building 366 and work spaces in Buildings 306 and 363. These buildings need to be provided with adequate heating, lighting, air conditioning, and humidity control and to be made energy efficient.

Within the Laboratory's aggressive plan for rehabilitating and modernizing Argonne-East buildings, the replacement of roofs is the highest priority for FY 2005. Many roofs have reached the end of their design life, and costs of repair and replacement are beginning to escalate. Recent budget guidance from DOE indicates that these upgrades will not be supported by LICP funding.

The roads and utility systems at Argonne-East require further rehabilitation but are adequate for future expansion. Major rehabilitation of roadways and parking lots has not been undertaken in 20 years. The general site circulation infrastructure — roads, walks, and parking — is substantially degraded and needs major rehabilitation and outright replacement in certain locations. Operating funding alone is not sufficient to restore paved surfaces in a timely fashion.

Portions of major utilities also need rehabilitation, most notably the laboratory and sanitary sewer systems that were not fully restored in the 1990s. At the Central Heating Plant, auxiliary systems and components require upgrading during this planning period to extend service life and reliability. The site's electrical distribution system needs additional equipment upgrades to achieve reliability during maintenance shutdowns or unplanned service conditions, thereby assuring uninterrupted service to R&D facilities.

Argonne-East envisions demolition of Buildings 40, 301, and 604. Demolition of Building 330 is complicated by residual contamination that was not removed by the D&D project funded by DOE-EM, which has suspended funding for D&D and is not expected to restore funding until FY 2007. This suspension will delay elimination of some ES&H liabilities for at least another five years. By that time the Laboratory expects to be in a position to undertake D&D and demolition of the M-Wing hot cells in Building 200. However, DOE-EM is providing funding for surveillance and maintenance of Building 301, the Juggernaut Reactor in Building 335, and the Zero Power Reactor area in Building 315. Restart of the DOE-EM work program will require funding above current baseline projections to update plans for the work and to ensure compliance with future ES&H requirements.

2. Argonne-West

At Argonne-West, the main issue for general purpose facilities is facility aging, with its normal requirements for upgrading and renovation. When DOE-Nuclear Energy established the Argonne-West Infrastructure Program, the program office asked the site to develop a *Plant Assets Management Plan* identifying physical infrastructure needs, including both existing and new facilities, along with other resources required to support current and anticipated missions of the DOE office's programs. See Section S3.E.2 for details.

Argonne-West develops its *Plant Assets Management Plan* by using the recently enhanced Asset Management and Infrastructure Prioritization (AMIP) process, by which it identifies, prioritizes, and manages its physical asset needs. The AMIP process ensures systematic, comprehensive, consistent management and oversight of physical assets over their life cycles. The AMIP process comprises four major activities: identification, prioritization, scheduling, and information sharing. The first phase identifies all unfunded physical asset needs at Argonne-West, regardless of the prospective funding source (e.g., GPP, LICP, direct, or indirect). Asset needs are identified through four processes: (1) ES&H inspections, assessments, and audits; (2) mission needs calls for particular research projects or programs; (3) the CAS process; and (4) inspections, walkthroughs, and requests from managers of particular facilities or research divisions.

After an infrastructure need has been identified and documented, it is ranked for risk and prioritized with the CAMP methodology. The resulting comprehensive list of asset needs is the basis for making informed decisions on allocating available resources and developing funding requests. Generally, the top 10 to 15 GPP and GPE needs are included in the seven-year *Plant Assets Management Plan*. The work scope, costs, and schedule for implementing the funded upgrade projects for the current year are described in the *Infrastructure Program Implementation Plan*. This document provides the measures by which the performance of Argonne-West in managing its infrastructure is evaluated by

Laboratory management and DOE. The information developed and collected during the CAMP prioritization process is also used as a primary resource for other management and reporting processes, including the FIMS database of the DOE Office of Engineering and Construction Management and the Argonne-West Engineering Task Authorization database.

E. Facilities Resource Requirements

Argonne has historically received only part of the funding needed for (1) infrastructure improvements and replacement facilities and (2) remediation and upgrades to correct ESS&H and other deficiencies. This section discusses the particular projects needed to achieve the Laboratory's vision of a 21st century infrastructure.

1. Argonne-East

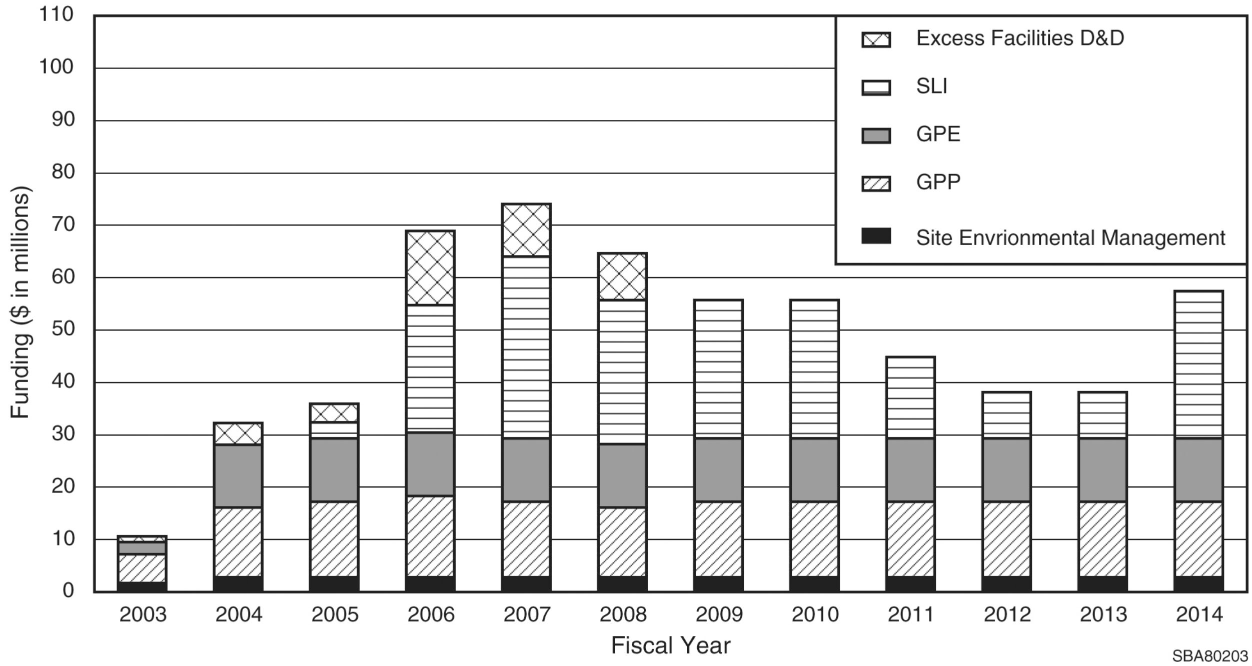
Funding received through the Science Laboratories Infrastructure (SLI) program and the GPP program allows Argonne-East to replace or rehabilitate functionally important or deteriorated elements of the site's infrastructure. These facilities serve a wide variety of evolving research programs and national user facilities, as well as support services and administrative functions needed to carry out the broad mandate of a multiprogram laboratory. The ability of Argonne-East facilities to continue functioning safely, efficiently, and economically depends on sustained support from DOE infrastructure funding.

Recommended funding to support the projects described in this section is described in Table S3.3 (located at the end of this supplement because of its length). The table also describes recommended GPP and GPE funding. These funding recommendations are consistent with the FY 2002 10-year *Strategic Facilities Plan* for Argonne-East, which specifies the infrastructure modernization needed to support current and planned mission activities in a cost-effective, safe, secure, and productive manner.

Figure S3.4 graphically summarizes total funding requirements for all infrastructure modernization needs at Argonne-East. The figure shows total 12-year (FY 2003-FY 2014) capital funding needs of approximately $495 million, consisting of $205 million from DOE's SLI program, $160 million from the GPP program, and $130 million from the GPE program. (These three DOE programs are discussed in the subsections immediately below.) In addition, Figure S3.4 shows $41 million for D&D and demolition of facilities that are excess, inactive surplus, or contaminated, plus $31 million for site environmental management at Argonne-East. (See the discussion of Inactive Surplus Facilities in Section S3.F.3.a.) The Laboratory proposes that both (1) site environmental management and (2) D&D and excessing of contaminated surplus facilities be supported by direct operating funding *apart from* that provided by DOE-EM. Beyond the infrastructure modernization investments by DOE summarized in Figure S3.4, maintenance at Argonne-East is supported by Laboratory indirect funding. This maintenance funding is projected to gradually rise from $17 million to approximately $20 million annually (see Section S3.E.1.d), representing an increase from 1.38% of infrastructure replacement plant value to 1.61%. (Restrictions on the use of Laboratory operating funding preclude devoting more to maintenance expenditures.)

a. Science Laboratories Infrastructure Program

The SLI program has provided an important part of recent funding for rehabilitation of major buildings and utility systems at Argonne-East, as well as funding for construction of new general purpose facilities. Total SLI funding has averaged approximately $6.5 million annually since 1995. The Laboratory estimates that future line-item SLI needs over the five-year planning horizon FY 2005-FY 2009 total $116 million, including $22 million for new facilities and $94 million for rehabilitation and modernization of existing facilities. The line-item projects included are summarized below.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Excess Facilities D&D	1.2	4.2	3.5	14.1	10.1	9.0	0.0	0.0	0.0	0.0	0.0	0.0
SLI	0.0	0.0	3.1	24.4	34.7	27.5	26.5	26.5	15.6	8.9	8.9	28.1
GPE	2.3	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
GPP	5.5	13.3	14.5	15.6	14.5	13.4	14.5	14.5	14.5	14.5	14.5	14.5
Site Envrionmental Management	1.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Total	**10.7**	**32.3**	**35.9**	**68.9**	**74.1**	**64.7**	**55.8**	**55.8**	**44.9**	**38.2**	**38.2**	**57.4**

Figure S3.4 Capital Funding Requirements for Argonne-East, FY 2003-FY 2014

i. New General Purpose Facilities

Multiprogram Laboratory and Office Building. This project provides for the design and construction of a Multiprogram Laboratory and Office Building (60,000 square feet) to house DOE-SC programs now in Building 212. The building will facilitate the rehabilitation of other laboratory and office space by providing appropriately designed, flexible space suited to the relocation of scientific programs without inordinate disruption of their work. Systems and components in the new building will be designed to minimize life cycle costs and improve environmental performance.

General Purpose Laboratory Facility. This project will provide a flexible high bay research facility (25,000 square feet) to supplement current facilities and to meet changing needs more readily. A freestanding location will facilitate expansion and reconfiguration and will achieve proximity to laboratory space with minimal physical obstructions. These capabilities cannot be achieved through rehabilitation or reprogramming of existing high bay areas, because of the resulting disruption of current work and the type of construction used in the existing buildings.

ii. Building Rehabilitation and Upgrades — Existing Facilities

Building Roof Replacements. This project involves comprehensive replacement of the roofing systems on older buildings, including all original buildings in the 200 and 300 areas and buildings constructed between 1970 and 1990. The last comprehensive roof replacement at Argonne-East occurred between 1983 and 1987 and used roofing systems with a predicted life of 20 years. Repair of small leaks is now necessary with increasing frequency.

Building Electrical Service Upgrades — Phases II-V. These projects will upgrade critical parts of the electrical power distribution system in the 200, 300, and 360 areas and their support facilities. The systems will be updated to meet current safety standards, to improve reliability and performance, to support new research programs, and to reduce maintenance and repair costs. The work will include (1) upgrading of lighting and power panel boards, 13.2-kV switches, 480-V switchgear, and transformers and (2) the provision of emergency power for selected buildings. Particularly important will be replacing 13.2-kV switches and 480-V switchgear with new equipment having state-of-the-art metering and protection devices.

Mechanical and Control Systems Upgrades — Phases I-IV. This series of four projects will upgrade critical parts of mechanical and control systems. The projects involve rehabilitation and upgrading of heating, ventilation, and air conditioning systems; exhaust systems; drainage systems; and controls to address concerns such as reliability of operations and environmental protection. Phase I was funded to begin in FY 2002.

Laboratory Space Upgrades — Phases I-III. These projects encompass essentially all aspects of modernizing laboratory space, including reconfiguration and upgrading of laboratory space envelopes; laboratory interiors; work area furnishings; communications, security, and electrical distribution systems; plumbing systems; and laboratory and process piping. The projects address safety and health concerns by including upgrades of fume hoods, vacuum frame hoods, canopy hoods, and glove boxes, along with associated utilities. Also included are removal and disposal of potentially contaminated or hazardous materials such as hoods, exhaust ductwork, piping, and asbestos insulation.

iii. Utilities and Site Infrastructure Upgrades

Roads, Parking, Walks, Street Lighting. Many roads, parking lots, and sidewalks at Argonne-East have deteriorated beyond amenability to general maintenance and basic repair. Other areas require additional parking and walkways. This project will rehabilitate or upgrade the surfaces of selected roads, parking lots, and sidewalks (and will use recycled materials where possible). The project will also replace inefficient lighting along streets and around parking lots and building exteriors. A new sitewide high-pressure sodium lighting system will cut electrical loads by approximately half and will provide better coverage at roadway intersections and in parking lots.

Central Heating Plant Auxiliaries Upgrade. Upgrading of the steam production auxiliary systems and components at the Central Heating Plant will improve the reliability and efficiency of the steam production process, saving energy and reducing overall operating costs. This project may be undertaken in part as an energy conservation project under third-party financing.

Electrical System Upgrade — Phase IV. This project will upgrade 5-kV overhead lines to 13.2 kV and will increase the capacity of the 13-kV overhead lines in the 200, 300, and 400 areas. The project will also replace 13.2-kV switchgear and interrupter switch lineups that serve the 300 area, increase the capacity of transformer T3, and replace transformer T6. Outdoor automatic transfer switches will be installed to serve Buildings 201 and 221. Most importantly, additional electrical service capacity will be brought to the site distribution system from Commonwealth Edison’s supply grid, increasing reliability and service levels.

iv. Environment, Safety, and Health Support Projects

Fire Safety Improvements — Phase V. This project addresses remaining capital improvements needed for fire protection. Work includes correction of deficiencies affecting property protection and potential interruption of work, installation or upgrading of fire barriers, replacement of halon systems and obsolete building sprinkler water supply connections, and repair of hydraulically deficient sprinkler systems not related to life safety.

Building 362 Asbestos Abatement. Asbestos-containing materials (ACMs) are present in numerous older buildings at Argonne-East. Damaged ACMs threaten building occupants and workers and must be repaired or removed; undamaged ACMs may be left undisturbed or sealed. This project will remove asbestos fireproofing materials now under floor decks and attached to steel structural elements in Building 362. Where needed, the project will clean up friable asbestos.

b. General Plant Project Funding

At Argonne-East, GPP funding averaging approximately $4.85 million annually in FY 1996-FY 2003 has supported urgently needed facility modifications and upgrades and replacement of equipment. GPP funding also supports environmental projects, near-term infrastructure improvements, and key safety upgrades. In general, GPP funds are crucial for work that goes beyond short-term maintenance and repair but must be undertaken more quickly than would be allowed by the normal lead times for LICP funds. GPP funding does not support particular R&D programs.

Historically, GPP funding received by Argonne has been inadequate to address infrastructure and modernization needs. Requirements over the six-year planning horizon of the *Institutional Plan* total more than $86 million, nearly three times current funding levels. Use of "institutional general-purpose project funding" does offer some flexibility in funding infrastructure upgrades of the scale appropriate for GPP. However, at this time the Laboratory has no plans to utilize this funding option.

Strategic application of GPP funds continues to fall into three general areas. First, the recent practice of applying GPP funds to smaller-scale upgrades and modifications of buildings will continue. These projects modernize smaller buildings and implement less extensive reconfigurations, thereby complementing larger-scale renovations.

Second, GPP funding will support upgrades to sitewide utility systems at selected locations. These systems include laboratory and sanitary sewer collection systems that were not completely rehabilitated under earlier projects supported by DOE-EM. Upgrades undertaken will also include continuing improvements to the canal water and storm water systems.

Third, GPP funding will complement LICP funding by supporting construction of smaller new facilities costing less than $5 million. GPP funding will also support construction of new general purpose support facilities. Examples are a replacement facility for the Emergency Services Department (Building 333) and replacement of scattered, older, contaminated storage facilities that are still active (i.e., Buildings 325C, 329, and 374A) with a better located, more efficient, centralized waste storage facility. These replacement facilities are envisioned to increase operational efficiencies without significantly changing the total building space involved.

c. General Purpose Equipment Funding

Argonne-East GPE funds will be used for vital support purchases, including (1) plant maintenance monitoring equipment; (2) operating equipment meeting current ESS&H standards; (3) equipment for monitoring and controlling release of effluents to the environment; (4) motor vehicles; and (5) technological support in areas such as computing, electronic data communications, cyber security, machine shops, and electronics.

Beginning in FY 2004, the annual GPE funding requirements of Argonne-East are $12 million, as shown in Table S3.4. Increases over current funding levels are required for purposes such as appropriately configuring and updating computer simulation equipment and high-bandwidth hubs. The increased funding level will allow the Laboratory to take advantage of current technologies and to satisfy researchers' increasing needs for computer simulation. The increase will also be used to acquire and rehabilitate general purpose equipment (but not to support specific R&D programs).

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

FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09
1.6	2.3	12.0	12.0	12.0	12.0	12.0	12.0

d. Maintenance Funding

Approximately 60% of maintenance at Argonne-East is devoted to corrective maintenance, as opposed to recurring, operational, or preventive maintenance. This situation reflects the large proportion of systems that are still operating beyond their normal service lifetimes. Modernization of older systems will lessen the current need for corrective maintenance, allowing the Laboratory to focus more on preventive maintenance that lengthens the service life of equipment and reduces costs in the long run.

Maintenance supported from operating funds remained roughly stable at approximately $17.1 million in FY 2003. As reported in the May crosscut budget, this real property maintenance is projected to be $19.0 in FY 2004, $19.5 in FY 2005, and $20 million in subsequent years. Replacement plant value (RPV) is expected to increase only slowly, following general inflation trends. Maintenance expenditures as a percentage of RPV are projected to rise to slightly more than 1.6%.

2. Argonne-West

As facilities and infrastructure at Argonne-West continue to age, the highest priority is to upgrade and renovate deteriorating assets, replace obsolete and heavily depreciated equipment, and plan for new facilities and capabilities to meet current and future needs of DOE programs and missions. Also vital is the ongoing maintenance of existing physical assets.

Argonne-West received $13.4 million for essential and corrective maintenance in FY 2003. An additional $5.3 million is needed in FY 2003 for preventive and predictive maintenance and for maintaining site facilities in a mission-ready state. The total deferred maintenance backlog is $14 million. Argonne-West has identified specific infrastructure needs of $10 million in GPP and GPE for FY 2003-FY 2009. Also needed are two LICPs having a total cost of $88 million. Specific GPP, GPE, and LICP requests are summarized below.

a. General Plant Projects

Argonne-West GPP funds support key safety upgrades, environmental compliance projects, and near-term infrastructure improvements. These funds are dedicated to upgrading and renovating the physical plant, beyond the routine maintenance and repair to keep the plant and equipment operating. GPP funds do not directly support specific R&D and demonstration programs and equipment. Argonne-West needs $10 million for FY 2003-FY 2009 to support top-priority GPP projects. Three salient top-priority projects are as follows:

- *Industrial Waste Pond.* The Record of Decision (ROD) signed by DOE, the Environmental Protection Agency, and the state of Idaho includes a commitment to remediate the Industrial Waste Pond, starting in FY 2003-FY 2004. DOE-EM, which has provided the funding for the previous six Argonne-West remediation activities, wishes to turn over the two remaining sites (Industrial Waste Pond and Sanitary Sewage Lagoons) to DOE-Nuclear Energy, which funds programmatic work at Argonne-West. Currently, no funding is available in FY 2003 for these remediation activities. The agreements and commitments in the ROD are legal and binding, with fines and penalties levied for noncompliance. Argonne-West's failure to comply with the provisions of the ROD will constitute violation of the ROD and subject the Laboratory to the fines (up to $10,000 per week) outlined in the *INEEL Federal Facility Agreement and Consent Order*. The total estimated cost for remediation is $1.6 million.

- *Electrical Switchgear Upgrade — Phases I-II.* This project will upgrade critical portions of the sitewide electrical power distribution system to meet current safety standards, improve the system's reliability and performance, and reduce costs of maintenance and repair. Existing 2.4-kV and 13.8-kV switchgear will be replaced with new equipment that contains modern metering and protection devices; associated feeder cables will also be replaced. The present switchgear is over 40 years old, and replacement parts are typically nonexistent. Failure of either the 2.4-kV or 13.8-kV system would severely affect overall site safety and operations. The total estimated cost is $1.62 million.

• *Steam and Condensate System Component Replacement.* This project will replace and upgrade the 30-year-old sitewide steam and condensate system, which has experienced increasingly frequent failures over the past few years. Most operational facilities and office space are heated by the centralized steam plant; heat is distributed through the steam and condensate system. Steam is also used by several R&D programs for process applications. This project will replace old piping and install cathodic protection to minimize corrosion. The steam and condensate system is critical to site operations, and its failure would severely affect overall site safety and operations. The total estimated cost is $1.215 million.

• *Fuel Conditioning Facility Hot Cell Shield Window Refurbishment.* The shielding windows in Fuel Conditioning Facility are 40 years old, and 16 of the 27 windows require refurbishment. Most of the windows have experienced multiple oil leaks and show signs of optical degradation. Window refurbishment is critical to treating EBR-II spent fuel for final disposal. The total estimated cost is $2.982 million.

b. General Purpose Equipment

Argonne-West GPE funds are used to replace worn-out and obsolete general purpose equipment that supports activities such as (1) environmental monitoring and control of effluents; (2) facility maintenance and monitoring; (3) materials handling and operations with heavy equipment; and (4) technical support, including computing, electronic data communications, machine shop, and electronics. Argonne-West requested $197,000 in GPE funding for FY 2003 and $1,234,900 for FY 2003-FY 2009. No funding was provided in FY 2003, and none is anticipated in FY 2004. Continued underfunding of GPE will increase the cost of corrective maintenance and increase the down time of facilities and support functions.

c. Line-Item Construction Projects

Argonne-West has identified two LICPs. The Remote Treatment Facility (RTF) is an $80 million project that needs LICP funding beginning in FY 2004. The second LICP is an $8 million office facility scheduled for later years. Details are as follows:

• *Remote Treatment Facility.* The RTF project is required to maintain compliance with the Idaho National Engineering and Environmental Laboratory (INEEL) *Site Treatment Plan* and the *State of Idaho Settlement Agreement*. The RTF will segregate, characterize, treat, and repackage remotely handled mixed transuranic waste that has accumulated at Argonne-West and INEEL over the past several decades. The project includes the design and construction of the RTF, which will be located adjacent to the existing Hot Fuel Examination Facility and connected to it through a transfer tunnel to facilitate transfers and use of some common support systems. Failure to proceed with this LICP in FY 2004 could result in administrative and judicial actions, including fines and penalties, and in suspension of spent fuel shipments to Argonne-West and INEEL.

• *Multiprogram Office Building.* This project includes the design and construction of a multiprogram office building (40,000 square feet) that will replace the eight remaining temporary office buildings at Argonne-West. Plans call for LICP funding of $8 million for FY 2010-FY 2012.

F. Assets Management, Space Management, and Inactive Surplus Facilities

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

Under the current *Prime Contract* for operation of Argonne, management of site, facilities, and assets at Argonne-East continues to determine 5% of the fee received by the contractor.

1. Assets Management

Argonne's assets are acquired, rehabilitated, and upgraded to support the Laboratory's mission. DOE executes all real estate acquisitions through a Department-certified real estate specialist. All modifications and improvements are designed and constructed in compliance with applicable state, regional, and national building codes. The principles and practices of Integrated Safety Management are fully integrated into the Life Cycle Asset Management processes by which Argonne implements site improvements. The result is a safe work environment achieved through safe work practices.

The DOE corporate physical assets database — FIMS — includes a current inventory of the Laboratory's physical assets. Periodically, this inventory is systematically reviewed, and the condition of the assets is assessed. Backlogs associated with maintenance, as well as with repairs and capital improvements, are managed through a systematic prioritization process. Integrity of all physical assets and systems is ensured through a configuration management process.

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

Retirement of surplus equipment is largely constrained by the backlog of GPE needs. Divestiture is usually limited to equipment still in use well beyond its original estimated service life. This equipment generally has little salvage value. Divestiture of surplus equipment and excess materials follows DOE guidelines.

2. Space Management

Argonne-East has long used a system of space charges that facilitates the allocation of annual infrastructure costs among various users. Occupants are assessed for costs on the basis of their use of assignable building space (which does not include general passageways, docks, or space for building equipment and mechanical systems). Space charges include recovery of sitewide expenditures for grounds, road repairs, snow-plowing, and other general utility and maintenance services. Building-specific charges reflect historical levels of maintenance for each particular building, custodial costs, and expenses for services such as sewer, water, electricity, and steam. Within buildings, services to production facilities, dedicated scientific and research apparatus, and other special-purpose equipment are metered separately for direct billing to users.

For the past decade, space utilization at Argonne-East has approached practical limits. Overall vacancy rates have averaged less than 2%, and they now approach 1.3%. Vacancy rates for office space are less than 0.5%. Moreover, available space is usually in isolated small pockets that cannot be economically consolidated to house an additional work group (such as a group now working off-site).

3. Inactive Surplus Facilities

Inactive surplus facilities present significantly different challenges for the two Argonne sites.

a. Argonne-East

The DOE-EM funding for D&D of Argonne-East facilities no longer in use ended in April 2002, after completion of more than 70% of the D&D work identified in the DOE-EM baseline for Argonne-East.

The D&D of the JANUS reactor (Building 202) and the Argonne Thermal Source Reactor (Building 316) was completed, and those facilities are now available for reuse. Argonne was in a position to complete, by the end of FY 2003, all D&D activities identified in the approved baseline, if specified funding had continued to be provided.

The site's two remaining contaminated surplus facilities (Buildings 330 and 301) continue to be candidates for future DOE-EM funding that ultimately would support demolition. Two additional facilities, neither yet surplus, have been documented to DOE as requiring future D&D: (1) the M-Wing hot cells in Building 200 (a partial facility), for which DOE-EM funding had been sought, and (2) the instrument calibration facility in Building 40 (the last remaining original building in the east area).

Candidates not yet formally identified for future DOE-EM support include parts of buildings, such as the M-Wing hot cells in Building 200 (which will become surplus by the time the transfer to DOE-EM begins) and the H-Wing high bay areas in Building 205.

Surplus facilities that are not contaminated have also been a long-standing concern at Argonne-East. Removal of facilities from the old 800 area is complete. Removal of Building 207 has facilitated planning for proposed expansion of the ATLAS complex. Following removal of Building 40, emphasis will shift to the selective removal of permanent, single-purpose buildings that can no longer function efficiently. The Laboratory will continue to remove abandoned or disconnected equipment, such as chillers.

The large majority of funding from the DOE-SC Excess Facilities Disposition Program is devoted to removal of excess equipment and broader mission support through risk reduction (e.g., removal of hazards), footprint reduction, cost savings (e.g., by elimination of surveillance and maintenance), and provision of building space and land for new research activities. In the middle years of the ten-year *Strategic Facilities Plan*, replacement facilities constructed with GPP funding will enable decontamination and disposal of several obsolete waste storage facilities (Buildings 325C, 329, and 374A), as well as replacement of the Emergency Services Department fire station (Building 333).

Resource requirements for elimination of surplus facilities (both contaminated and uncontaminated, including D&D, surveillance, and maintenance of facilities pending disposal) total $41 million through FY 2009. In addition, environmental management and long-term stewardship of the site's natural assets and ecosystems will continue through the planning horizon. Wetlands management will be funded through operating funds, as will continued maintenance of formerly contaminated sites; funding required for these activities will total $16 million through FY 2009.

b. Argonne-West

Currently, all major facilities at Argonne-West are actively used, including many EBR-II systems that provide power switching, site monitoring, cooling water, compressed air, and other services to the entire site. Currently, TREAT, ZPPR, and the Sodium Processing Facility are in standby status and not operating. However, these unique scientific and engineering assets could be extremely valuable in supporting future DOE programs, such as the Generation IV Nuclear Energy program, the Advanced Fuel Cycle Initiative, and the Space Nuclear Power program. In addition, the closed EBR-II facility has unique scientific and engineering attributes and unique materials that can be applied to future DOE programs. (The EBR-II Plant Closure Project was completed in FY 2002, and the recently issued EBR-II RCRA Part B Permit requires that EBR-II be "RCRA clean closed" within the next 20 years.)

G. Energy Management and Sustainable Design

Energy efficiency and conservation are strong priorities at Argonne. The Laboratory benefits from continued participation in the demand-side load management program of its local electric distribution company, Commonwealth Edison. The Laboratory also pursues funding for energy conservation projects from the Federal Energy Management Program, and it assists DOE in (1) the development and implementation of facility retrofitting projects using energy savings performance contracts involving third-party financing and (2) the competitive procurement of electricity.

Argonne-East remains on track in achieving the 30% reduction in energy usage by FY 2005 that is mandated by DOE order. However, for a second consecutive year the Laboratory is encountering continuing delays in obtaining DOE approvals for both its first proposed project (under the Super Energy Savings Contract program) and its second proposed project (under the Utility Energy Savings Contract program). The combined total estimated cost of these two projects exceeds $3 million.

The current electric utility contract for Argonne-East is between DOE's Argonne Area Office and Commonwealth Edison. The resulting cost of electricity is the lowest available to the Laboratory. Natural gas is supplied through a supply contract and a separate delivery contract. The gas is purchased as a commodity through a Defense Logistics Agency supply and transportation contract, which assures the Laboratory of the lowest available cost. Nicor, Inc., provides distribution and storage services for the delivered gas. DOE's Argonne Area Office also holds the gas contracts for Argonne-East. The Laboratory provides technical support to DOE for evaluating and selecting the site's utility contracts.

The Laboratory continues to develop concepts for reducing the cost of the basic energy commodities it purchases. Argonne-East has reduced the cost of natural gas for its boiler plant by taking advantage of its physical location along interstate gas pipelines and the resulting opportunity to bypass service from the local distribution company. The Laboratory is now in its third three-year, special-rate delivery service contract with Nicor, Inc. The Laboratory agrees not to bypass the Nicor system in exchange for a reduced rate for natural gas distribution. Argonne-East also saves on coal purchases by making an annual lump sum bid. Coal is then trucked to the site as needed.

It is a formal Argonne policy to incorporate strategies for sustainable design and pollution prevention into all design and construction projects. Sustainable design strategies are integrated at the initial stages of new projects through use of the Environmental Evaluation Notification Form, which considers both sustainable design and pollution prevention. The Laboratory also provides training, resources, and support for sustainable design and pollution prevention to managers of projects throughout design, construction, and demolition.

H. Third-Party Financing

Argonne-East remains a leader in the use of third-party financing to develop needed facilities. A prominent recent example is funding by the state of Illinois for the design and 1997 construction of the APS housing complex (Building 460), a facility providing 124,000 square feet of space. The state has also contributed $3.6 million for development of the master plan for the Rare Isotope Accelerator (RIA) and for design of the Illinois Science Center, whose construction the state is considering funding as part of RIA construction at Argonne. The state is also supporting construction of the building for the Center for Nanoscale Materials. In FY 2002 and FY 2003 the state contributed $19 million toward this $36 million project. We anticipate that the remaining $17 million will be included in the state's FY 2004 budget. In the future we plan to consider collaborative funding for science facilities that would serve two other major Laboratory initiatives discussed in Chapter III: a computer and computational science building and a genomics building at the APS.

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

	TEC	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Funded Projects								
AF-01								
Office of Nuclear Energy, Science and Technology								
Nuclear Energy Research and Development								
General Plant Projects, ANL-West[b]	1.6	-	1.6	-	-	-	-	-
FS-30								
Office of Environmental Management								
Safeguards and Security — Environmental Waste Management								
General Plant Projects, ANL-West[b]	1.0	-	1.0	-	-	-	-	-
KB-04								
Office of Science								
Nuclear Physics								
Accelerator Improvements, ANL-East[b]	0.8	0.4	0.4	-	-	-	-	-
KC-02								
Office of Science								
Basic Energy Sciences								
Materials Sciences								
Advanced Photon Source								
Accelerator Improvements, ANL-East[b]	7.8	3.9	3.9	-	-	-	-	-
KC-03								
Office of Science								
Basic Energy Sciences								
Chemical Sciences								
General Plant Projects, ANL-East[b]	10.4	5.4	5.0	-	-	-	-	-
39-KG-02								
Office of Science								
Science Laboratories Infrastructure								
Environment, Safety, and Health Support, ANL-East								
Environment, Safety, and Health Compliance								
Mechanical and Control Systems Upgrade - Phase I (02-CH-056)	9.0	0.8	3.0	5.2	-	-	-	-
TOTAL FUNDED PROJECTS	30.6	10.5	14.9	5.2	0.0	0.0	0.0	0.0

Table S3.3 Major Construction Projects[a] (Cont.)

	TEC	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Budgeted Projects								
AF-01								
Office of Nuclear Energy, Science and Technology								
Nuclear Energy Research and Development								
General Plant Projects, ANL-West[b]	5.5	-	-	5.5	-	-	-	-
AF-95								
Office of Nuclear Energy, Science and Technology								
Nuclear Energy Research and Development								
General Plant Projects, ANL-West[b]	0.5	-	-	0.5	-	-	-	-
FS-30								
Office of Environmental Management[c]								
Safeguards and Security — Environmental Waste Management								
General Plant Projects, ANL-West[b]	1.0	-	-	1.0	-	-	-	-
KB-04								
Office of Science								
Nuclear Physics								
Accelerator Improvements, ANL-East[b]	0.4	-	-	0.4	-	-	-	-
KC-02								
Office of Science								
Basic Energy Sciences								
Materials Sciences								
Advanced Photon Source								
Accelerator Improvements, ANL-East[b]	3.9	-	-	3.9	-	-	-	-
KC-03								
Office of Science								
Basic Energy Sciences								
Chemical Sciences								
General Plant Projects, ANL-East[b]	14.9	-	-	14.9	-	-	-	-
TOTAL BUDGETED PROJECTS	26.2	0.0	0.0	26.2	0.0	0.0	0.0	0.0
TOTAL FUNDED AND BUDGETED PROJECTS	56.8	10.5	14.9	31.4	0.0	0.0	0.0	0.0

Table S3.3 Major Construction Projects[a] (Cont.)

	TEC	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Proposed Projects								
AF-95								
Office of Nuclear Energy, Science and Technology								
Nuclear Energy Research and Development								
General Plant Projects, ANL-West[b]	7.6	-	-	-	4.5	1.2	0.9	1.0
39-AF-95								
Office of Nuclear Energy, Science and Technology								
Nuclear Energy Research and Development								
Remote Treatment Facility	86.0	-	-	-	9.7	19.4	18.6	28.2
FS-30								
Assistant Secretary for Environmental Management[c]								
Safeguards and Security — Environmental Management								
General Plant Projects, ANL-West[b]	2.0	-	-	-	0.7	0.7	0.3	0.3
KB-04								
Office of Science								
Nuclear Physics								
Accelerator Improvements, ANL-East[b]	1.6	-	-	-	0.4	0.4	0.4	0.4
KC-02								
Office of Science								
Basic Energy Sciences								
Materials Sciences								
Advanced Photon Source								
Accelerator Improvements, ANL-East[b]	15.6	-	-	-	3.9	3.9	3.9	3.9
KC-03								
Office of Science								
Basic Energy Sciences								
Chemical Sciences								
General Plant Projects, ANL-East[b]	61.8	-	-	-	17.2	15.6	14.5	14.5
39-KG-01								
Office of Science								
Science Laboratories Infrastructure								
General Purpose Facilities								
New General Purpose Facilities								
Multiprogram Laboratory Office Building (05-CH-011)	18.0	-	-	-	1.5	8.3	8.2	-
General Purpose Laboratory Facility	6.0	-	-	-	-	-	-	1.0

Table S3.3 Major Construction Projects[a] (Cont.)

	TEC	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Proposed Projects (Cont.)								
Building Rehabilitation and Upgrade								
Upgrade Existing Facilities								
Building Roof Replacements (05-CH-012)	15.8	-	-	-	1.1	6.0	6.0	2.7
Building Electrical Service Upgrade - Phase II (05-CH-062)	9.1	-	-	-	0.7	5.2	3.1	-
Mechanical and Control Systems Upgrade - Phase II	10.5	-	-	-	-	1.0	4.8	4.7
Laboratory Space Upgrade - Phase I	13.0	-	-	-	-	-	1.0	5.9
Building Electrical Service Upgrade - Phase III	11.0	-	-	-	-	-	-	1.0
Mechanical and Control Systems Upgrade - Phase III	11.0	-	-	-	-	-	-	1.0
Laboratory Space Upgrade - Phase II[d]	13.5	-	-	-	-	-	-	-
Building Electrical Service Upgrade - Phase IV[d]	8.0	-	-	-	-	-	-	-
Mechanical and Control Systems Upgrade - Phase IV[d]	10.0	-	-	-	-	-	-	-
Building Electrical Service Upgrade - Phase V[d]	8.0	-	-	-	-	-	-	-
Laboratory Space Upgrade - Phase IV[d]	26.0	-	-	-	-	-	-	-
Upgrade Utilities								
Roads-Parking-Walks-Street Lighting Upgrade	14.0	-	-	-	-	1.0	7.0	6.0
Central Heating Plant Auxillaries Upgrade	8.0	-	-	-	-	-	1.0	4.0
Electrical System Upgrade - Phase IV[d]	11.0	-	-	-	-	-	-	-
39-KG-02								
Office of Science								
Science Laboratories Infrastructure								
Environment, Safety, and Health Support, ANL-East								
Environment, Safety, and Health Compliance								
Fire Safety Improvements - Phase V	6.0	-	-	-	-	-	-	1.0
Building 362 Asbestos Abatement[d]	6.0	-	-	-	-	-	-	-

[a] This table excludes construction funded from non-DOE sources.

[b] General Plant Projects and Accelerator Improvements are not line-item construction projects in the President’s Budget; other projects in the table are.

[c] Safeguards and Security at Argonne-West will be funded by the Office of Nuclear Energy, Science and Technology, beginning in FY 2004.

[d] To begin after FY 2008.

Supplement 4: Other Charts and Tables

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

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

A. Science and Math Education

Table S4.1 characterizes Argonne's existing educational programs. The total number of appointments and the number of minorities and women are shown for FY 2001 and FY 2002.

B. User Facilities

Table S4.2 describes experimenters at the Argonne user facilities that have been officially designated as such by DOE. In highly abbreviated terms, these facilities provide the following important scientific capabilities:

- *Advanced Photon Source:* Became operational in 1996, providing superintense x-ray beams meeting research needs in virtually all scientific disciplines and many critical technology areas; accommodates national research centers in basic energy sciences, advanced synchrotron radiation instrumentation, and structural biology, as well as academic and industrial research teams. (Argonne manages a number of specialized user facilities at the Advanced Photon Source through the Laboratory's scientific divisions.)
- *Intense Pulsed Neutron Source:* Accelerates protons to obtain neutrons, which are particularly valuable for the study of materials through analysis of the motions and structures of atoms.
- *Argonne Tandem-Linac Accelerator System:* Accelerates ions of heavy elements for studies of their reactions, to advance basic understanding of the properties of atoms and atomic nuclei.
- *Electron Microscopy Center:* Provides transmission and scanning electron microscopy for high-spatial-resolution imaging, microanalysis, and *in situ* studies, including studies of *in situ* ion irradiation and implantation effects in metals, semiconductors, and ceramics.

C. Subcontracting and Procurement

Table S4.3 describes Argonne's subcontracts and procurements from universities. Table S4.4 describes procurements from small or disadvantaged businesses.

Table S4.1 Participation in Science and Math Educational Programs

Program	FY 2001 Total	FY 2001 Under-represented Minorities[a]	FY 2001 Women	FY 2002 Total	FY 2002 Under-represented Minorities[a]	FY 2002 Women	FY 2003 Projected Total
Students							
Instructional Laboratory[b]	3,433	830	1,323	3,474	840	1,339	3,500
Instructional Vehicle	6,374	2,714	3,284	2,502	1,065	1,289	2,500
Student Conference	284	-	284	383	-	383	400
Teachers							
Argonne Community of Teachers	32	17	25	29	15	23	30
Chemistry Workshop	21	-	16	31	-	22	-
Educational Network Consortium	5,912	-	-	5,023	-	-	5,500
Undergraduate Programs							
Summer Energy Research Participation Program	224	32	78	163	17	57	200
Semester Energy Research Participation Program	46	8	15	34	3	15	30
Community College Initiative	23	9	10	18	8	5	15
Undergraduate Research Symposium	131	-	-	179	-	-	200
Graduate Programs							
Graduate Students — Thesis and Practicum	132	4	43	174	11	55	175
Postdoctoral Fellows	190	8	46	180	10	41	185
National School on Neutron and X-ray Scattering	60	4	21	59	6	21	60
User Programs	608	-	-	817	-	-	850
Faculty Programs							
Faculty Research Participation	31	5	5	18	3	5	20
Sabbatical Leave	6	0	1	1	1	1	3
Faculty Visits	61	3	10	66	3	13	65

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

[b] Instructional laboratory numbers include all educational levels and Argonne Information Center participants.

Table S4.2 Experimenters at Designated Argonne User Facilities — FY 2002

User Affiliation	Number of Unique Individual Experimenters[a]	Number of Organizations Represented	Percent of Use[b]
Advanced Photon Source			
Argonne	246	1	26
Other DOE Laboratories	103	10	5
Non-DOE U.S. Government	58	9	4
U.S. Universities	1,338	130	36
U.S. Industry	199	50	22
Foreign Government Laboratories	34	12	1
Foreign Universities	221	72	4
Foreign Industry	9	4	1
Other	91	25	1
Total	2,299	313	100
Intense Pulsed Neutron Source[c]			
Argonne	54	6	22
Other DOE Laboratories	37	7	15
Non-DOE U.S. Government	0	0	0
U.S. Universities	111	52	46
U.S. Industry	12	5	5
Foreign Government Laboratories	0	0	0
Foreign Universities	29	15	12
Foreign Industry	0	0	0
Other	0	0	0
Total	243	85	100
Argonne Tandem-Linac Accelerator System			
Argonne	32	1	50
Other DOE Laboratories	9	4	4
Non-DOE U.S. Government	0	0	0
U.S. Universities	41	20	30
U.S. Industry	0	0	0
Foreign Government Laboratories	7	3	4
Foreign Universities	34	18	12
Foreign Industry	0	0	0
Other	0	0	0
Total	123	46	100
Electron Microscopy Center			
Argonne	55	1	64
Other DOE Laboratories	0	0	0
Non-DOE U.S. Government	0	0	0
U.S. Universities	31	10	26
U.S. Industry	0	0	0
Foreign Government Laboratories	6	5	4
Foreign Universities	10	7	6
Foreign Industry	0	0	0
Other	1	1	0
Total	103	24	100

[a] Unique individual experimenters are counted only once, even if they travel to the Argonne user facility multiple times during the year.

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

[c] For the Intense Pulsed Neutron Source, the percent of use was calculated from the numbers of individual users, not from experimental time.

Table S4.3 Total External Subcontracting and Procurement ($ in millions)

Source	FY 2002	FY 2003	FY 2004	FY 2005
Universities	12.8	12.0	12.0	12.0
All Other	117.2	120.0	120.0	120.0
Transfers to Other DOE Contractors	15.9	24.3	21.3	19.1
Total External Subcontracts and Procurement	145.9	156.3	153.3	151.1

Table S4.4 Procurement from Small or Disadvantaged Businesses ($ in millions)

Source	FY 2002	FY 2003	FY 2004	FY 2005
Procurements from Small or Disadvantaged Businesses	65.3	61.0	62.0	63.0
Percent of Annual Procurement	58.7	50.0	51.0	52.0