Advanced Scientific Computing Research

Funding Profile by Subprogram

(dollars in thousands)

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Advanced Scientific Computing Research					
Mathematical, Information, and Computational Sciences	160,367	200,490	-1,198[a]	199,292	204,340
Laboratory Technology Research	2,818	3,000	0	3,000	0
Subtotal, Advanced Scientific Computing Research	163,185	203,490	-1,198[a]	202,292	204,340
Use of Prior Year Balances	0	-481	0	-481	0
Total, Advanced Scientific Computing Research	163,185[bcd]	203,009	-1,198[a]	201,811	204,340

Public Law Authorizations:
Public Law 95-91, “Department of Energy Organization Act”
Public Law 103-62, “Government Performance and Results Act of 1993”

Mission

In the past two decades leadership in scientific computation has become a cornerstone of the Department’s strategy to ensure the security of the nation and succeed in its science, energy, environmental quality, and national security missions. According to a number of authorities, ranging from the President’s Science Advisor and the President’s Council of Advisors on Science and Technology to the National Research Council and the Council on Competitiveness, this scientific leadership is critical to the economic health of the nation. The mission of the Advanced Scientific Computing Research (ASCR) program is to underpin DOE’s world leadership in scientific computation by supporting research in applied mathematics, computer science and high-performance networks and providing the high-performance computational and networking resources that are required for world leadership in science.

Benefits

ASCR supports DOE’s mission to provide world-class scientific research capacity through peer-reviewed scientific results in mathematics, high performance computing and advanced networks and

[a] Excludes $1,197,753 for a rescission in accordance with the Consolidated Appropriations Act, 2004, as reported in conference report H.Rpt. 108-401, dated November 25, 2003.
[b] Excludes $4,017,000 which was transferred to the SBIR program and $241,000 which was transferred to the STTR program.
[c] Excludes $1,115,315 for a rescission in accordance with the Consolidated Appropriations Resolution, FY 2003.
[d] Excludes $3,029,000 transferred for Department of Homeland Security activities in FY 2003.

through the application of terascale computing to advanced scientific applications. High-performance computing provides a new window for researchers to observe the natural world at a fidelity that could only be imagined a few years ago. Research investments in advanced scientific computing equip researchers with premier computational tools to advance knowledge and to solve the most challenging scientific problems facing the Nation.

Strategic and Program Goals

The Department's Strategic Plan identifies four strategic goals (one each for defense, energy, science, and environmental aspects of the mission plus seven general goals that tie to the strategic goals. The ASCR program supports the following goals:

Science Strategic Goal
General Goal 5, World-Class Scientific Research Capacity: Provide world-class scientific research capacity needed to ensure the success of Department missions in national and energy security, to advance the frontiers of knowledge in physical sciences and areas of biological, medical, environmental, and computational sciences, and to provide world-class research facilities for the Nation's science enterprise.

The ASCR program has one program goal which contributes to General Goal 5 in the "goal cascade":

Program Goal 05.23.00.00: Deliver forefront computational and networking capabilities - Deliver forefront computational and networking capabilities to scientists nationwide that enable them to extend the frontiers of science, answering critical questions that range from the function of living cells to the power of fusion energy.

Contribution to Program Goal 05.23.00.00 (Deliver forefront computational and networking capabilities)

Within the ASCR program, the Mathematical, Information and Computational Sciences subprogram contributes to Program Goal 05.23.00.00 by: delivering the fundamental mathematical and computer science research that enables the simulation and prediction of complex physical and biological systems; providing the advanced computing capabilities needed by researchers to take advantage of this understanding; and delivering the fundamental networking research and facilities that link scientists across the nation to the computing and experimental facilities and their colleagues to enable scientific discovery. This subprogram supports fundamental research in applied mathematics, computer science, computer networks, and tools for electronic collaboration; integrates the results of these basic research efforts into tools and software that can be used by scientists in other disciplines, especially through efforts such as Scientific Disovery through Advanced Computing (SciDAC); and provides the advanced computing and network resources that enable scientists to use these tools to deliver extraordinary science. Applied Mathematics enables scientists to translate the world into a computer with extraordinary fidelity, and provides the algorithms the computer requires to manipulate that representation of the world effectively, exposing the underlying structure. Computer science research provides the link between the mathematics and the actual computer systems. Finally, scientific discovery results from simulations conducted on the advanced computers themselves, including experimental computers with hardware designs optimized to enable particular types of scientific applications, and the largest computing capabilities available to the general scientific community. All of these elements are critical to advance the frontiers of simulation. Shrinking the distance between scientists and the resources they need is also critical to the Office of Science (SC). The challenges that

SC faces require teams of scientists distributed across the country as well as the full national portfolio of experimental and computational tools. High performance networks and network research provide the capability to move the millions of gigabytes that these resources generate to the scientists' desktops. The collaboratory activity, which is one component of the integrated ASCR Network Environment, provides the tools that enable scientists to discover, coordinate, and safely use the resources on the network.

Therefore, the ASCR program contributes to General Goal 5 by enabling research programs across SC, as well as other elements of the Department, to succeed. The following indicators establish specific long term (10 years) goals in Scientific Advancement that the ASCR program is committed to, and progress can be measured against.

- Develop multiscale mathematics, numerical algorithms, and software that enable effective models of systems such as the Earth's climate, the behavior of materials, or the behavior of living cells that involve the interaction of complex processes taking place on vastly different time and/or length scales.
- Develop, through the Genomics: GTL partnership with the Biological and Environmental Research (BER) program, the computational science capability to model a complete microbe and a simple microbial community. This capability will provide the science base to enable the development of novel clean-up technologies, bio-energy sources, and technologies for carbon sequestration.

Annual Performance Results and Targets

FY 2000 Results	FY 2001 Results	FY 2002 Results	FY 2003 Results	FY 2004 Targets	FY 2005 Targets
05.23.00.00 Deliver forefront computational and networking capabilities					
Mathematical, Information and Computational Sciences					
			Completed the definitive analysis of the advantages and issues associated with lightweight kernel operating systems rather than full kernels for the compute nodes of extreme-scale scientific computers, resolving a critical issue for the future of high performance computers in the U.S. [Met]		
			Began installation of next generation National Energy Research Scientific Computing Center (NERSC) computer, NERSC-4, that will at least double the capability available in FY 2002 to solve leading edge scientific problems. [Not Met]	Maintain Procurement Baselines. Percentages within (1) original baseline cost for completed procurements of major computer systems or network services, and (2) original performance baseline versus integrated performance over the life of the contracts - FY04 – <10%	Maintain Procurement Baselines. Percentages within (1) original baseline cost for completed procurements of major computer systems or network services, and (2) original performance baseline versus integrated performance over the life of the contracts - FY05 – <10%
			Initiated at least 5 competitively selected interdisciplinary research teams to provide computational science and applied mathematics advances that will accelerate biological discovery in microbial systems and develop the next generation of computational tools required for nanoscale science based on peer review, in partnership with the Biological and	Improve Computational Science Capabilities. Average annual percentage increase in the computational effectiveness (either by simulating the same problem in less time or simulating a larger problem in the same time) of a subset of application codes within the Scientific Discovery through Advanced Computing (SciDAC) effort. FY04 – >50%	Improve Computational Science Capabilities. Average annual percentage increase in the computational effectiveness (either by simulating the same problem in less time or simulating a larger problem in the same time) of a subset of application codes within the Scientific Discovery through Advanced Computing (SciDAC) effort. FY05 – >50%

FY 2000 Results	FY 2001 Results	FY 2002 Results	FY 2003 Results	FY 2004 Targets	FY 2005 Targets
			Environmental Research and Basic Energy Sciences programs, respectively, of submitted proposals. [Met]		
			Maintained and operated facilities, including NERSC and ESnet, so the unscheduled downtime on average is less than 10 percent of the total scheduled operating time. [Met]	Focus usage of the primary supercomputer at the National Energy Research Scientific Computing Center (NERSC) on capability computing. Percentage of the computing time used that is accounted for by computations that require at least 1/8 of the total resource - FY04 – 50%	Focus usage of the primary supercomputer at the National Energy Research Scientific Computing Center (NERSC) on capability computing. Percentage of the computing time used that is accounted for by computations that require at least 1/8 of the total resource - FY05 – 50%
	Initiated project to understand the advantages and issues associated with lightweight kernel operating systems rather than full kernels for the compute nodes of extreme-scale scientific computers. [Met]	Completed the development of the Cougar lightweight kernel for clusters of Alpha processor-based computers and began the assessment of scalability and performance for selected applications. [Met]			
Developed advanced computing capabilities, computational algorithms, models, methods, libraries, and advanced visualization and data management systems that enabled new computing applications to science. [Met]	Continued to fabricate, assemble, and operate premier supercomputer and networking facilities that served researchers at national laboratories, universities and within industry, enabling understanding of complex problems and effective integration of geographically distributed teams in national collaborations. [Met]	Achieved operation of the IBM-SP computer at 5.0 teraflop "peak" performance. These computational resources were integrated by a common high performance file storage system that facilitates interdisciplinary collaborations. Transferred the users with largest data processing and storage needs to the IBM-SP from the previous generation Cray T3E. [Met]			

Means and Strategies

The ASCR program will use various means and strategies to achieve its goals. However, various external factors may impact the ability to achieve these goals.

The ASCR program will support fundamental, innovative, peer-reviewed research to create new knowledge in areas of advanced computing research that are important to DOE. In addition, the ASCR program will plan, fabricate, assemble, and operate premier supercomputer and networking facilities that serve researchers at national laboratories, universities, and industry, thus enabling new understanding through analysis, modeling, and simulation for complex problems, and effective integration of geographically distributed teams through national laboratories. Finally, the program will continue its leadership of the SC-wide Scientific Discovery through Advanced Computing (SciDAC) initiative with Basic Energy Sciences (BES) and Biological and Environmental Research (BER) in the areas of nanotechnology and Genomics: GTL. All research projects undergo regular peer review and merit evaluation based on procedures set down in 10 CFR 605 for the extramural grant program, and under a similar process for the laboratory programs and scientific user facilities. All new projects are selected through peer review and merit evaluation.

External factors that affect the programs and performance include: (1) mission needs as described by the DOE and SC mission statements and strategic plans; (2) evolving scientific opportunities, which sometimes emerge in a way that revolutionizes disciplines; (3) results of external program reviews and international benchmarking activities of entire fields or subfields, such as those performed by the National Academy of Sciences; (4) unanticipated failures, for example, in the evaluation of new computer architectures for science, that cannot be mitigated in a timely manner; (5) strategic and programmatic decisions made by other (non-DOE) Federal agencies and by international entities; and (6) the evolution of the commercial market for high performance computing and networking hardware and software.

The fundamental research program and facilities are closely coordinated with the information technology research activities of other Federal Agencies (DARPA, EPA, NASA, NIH, NSA, and NSF) through the Computing Information and Communications R&D subcommittee of the National Science and Technology Council (NSTC), under the auspices of the Office of Science and Technology Policy. This coordination is periodically reviewed by the President’s Information Technology Advisory Committee (PITAC). In addition to this interagency coordination, ASCR has a number of partnerships with other programs in SC and other parts of the Department, focused on advanced application testbeds to apply the results of ASCR research. Finally, ASCR has a significant ongoing coordination effort with the National Nuclear Security Administration’s (NNSA) Advanced Science Computing (ASC) Campaign to ensure maximum effectiveness of both computational science research efforts.

Validation and Verification

Progress against established plans is evaluated by periodic internal and external performance reviews. These reviews provide an opportunity to verify and validate performance. Quarterly, semiannual, and annual reviews consistent with specific program management plans are held to ensure technical progress, cost and schedule adherence, and responsiveness to program requirements.

Program Assessment Rating Tool (PART) Assessment

In the PART review, OMB gave the Advanced Scientific Computing Research (ASCR) program a relatively high score of 84% overall which corresponds to a rating of “Moderately Effective.” OMB found that the program supports world-class scientific user facilities, has demonstrated an improved level of interagency communication and cooperation, is in the process of drafting a long-term strategic vision, and has been very successful with a major effort in interdisciplinary software. Although ASCR is establishing a Committee of Visitors (COV), to provide outside expert validation of the program's merit-based review processes for impact on quality, relevance, and performance, this committee has not yet met. Once the COV issues a report, ASCR will develop an action plan to respond to the findings and recommendations within 30 days. The assessment found that ASCR has developed a limited number of adequate performance measures. However, OMB noted concerns regarding the collection and reporting of performance data. To address these concerns, ASCR will work with its Advisory Committee to develop research milestones for the long-term performance goals, will include the long term research goals in grant solicitations, will work to improve performance reporting by grantees and contractors, and will work with the CFO to improve ASCR sections of the Department's performance documents. OMB also found that the ASCR Advisory Committee is underutilized. ASCR will meaningfully engage the Advisory Committee in thorough assessments of research performance and in regularly revisiting the strategic priorities for the program. ASCR's role in providing scientific research facilities is strongly supported by the Administration. Funding is provided in FY 2005 to operate the program's facilities at maximum capacity.

Funding by General and Program Goal

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
General Goal 5, World-Class Scientific Research Capacity					
Program Goal 05.23.00.00, Deliver forefront computational and networking capabilities					
Mathematical, Information and Computational Sciences	160,367	199,292	204,340	+5,048	+2.5%
Laboratory Technology Research	2,818	3,000	0	-3,000	-100.0%
Total, Program Goal 05.23.00.00, Deliver forefront computational and networking capabilities	163,185	202,292	204,340	+2,048	+1.0%
Use of Prior-Year Balances	0	-481	0	+481	+100.0%
Total, Advanced Scientific Computing Research	163,185	201,811	204,340	+2,529	+1.3%

Overview

Computational modeling and simulation are among the most significant developments in the practice of scientific inquiry in the 20th Century. Scientific computing is particularly important for the solution of research problems that are insoluble by traditional theoretical and experimental approaches, hazardous to study in the laboratory, or time-consuming or expensive to solve by traditional means. All of the research programs in DOE's Office of Science—Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, and High Energy and Nuclear Physics—have identified major scientific challenges that can only be addressed through advances in scientific computing.

ASCR research underpins the efforts of the other programs in the Office of Science. The applied mathematics research activity produces the fundamental mathematical methods to model complex physical and biological systems. The computer science research efforts enable scientists to efficiently perform scientific computations on the highest performance computers available and to store, manage, analyze, and visualize the massive amounts of data that result. The networking research activity provides the techniques to link the data producers, e.g., supercomputers and large experimental facilities with scientists who need access to the data.

ASCR's other principal responsibility is to provide the high-performance computational and networking resources that are required for world leadership in science. Recent dramatic advances in scientific computation by researchers and computer companies underscore the importance of strengthening our position in computational sciences in strategic areas. In March 2002, Japan's NEC Earth Simulator became operational. With a peak speed of 40 teraflops and a demonstrated sustained capability of over 25 teraflops, it is faster by approximately a factor of 50 than the most advanced supercomputer for civilian science in the United States. The potential long-term implications of the Earth Simulator on DOE's computational sciences capability was the principal message of the report on this subject delivered to the Director of the Office of Science by the Advanced Scientific Computing Advisory Committee. To strengthen the program's position in this area, the ASCR program is proposing a new effort in Next Generation Computer Architecture (NGA) to identify and address major bottlenecks in the performance of existing and planned DOE science applications.

How We Work

The ASCR program uses a variety of mechanisms for conducting, coordinating, and funding research in applied mathematics, network and computer sciences, and in advanced computing software tools. The program is responsible for planning and prioritizing all aspects of supported research, conducting ongoing assessments to ensure a comprehensive and balanced portfolio, regularly seeking advice from stakeholders, supporting core university and national laboratory programs, and maintaining a strong infrastructure to support research in applied mathematics, network and computer science, and advanced computing software tools. The quality of the research supported by the ASCR program is continuously evaluated through the use of merit-based peer review, scientific advisory committees, and interagency coordinating bodies.

Advisory and Consultative Activities

The ***Advanced Scientific Computing Advisory Committee (ASCAC),*** established on August 12, 1999, provides valuable, independent advice to the Department of Energy on a variety of complex scientific and technical issues related to the ASCR program. The ASCAC is charged with providing advice on: promising future directions for advanced scientific computing research; strategies to couple advanced scientific computing research to other disciplines; and the relationship of the DOE program to other Federal investments in information technology research. ASCAC's recommendations include advice on long-range plans, priorities, and strategies to address more effectively the scientific aspects of advanced scientific computing including the relationship of advanced scientific computing to other scientific disciplines, and maintaining appropriate balance among elements of the program. This advisory committee plays a key role in assessing the scientific and programmatic merit of presently funded activities and in evaluating plans for the future. The Committee formally reports to the Director, Office of Science and includes representatives from universities, national laboratories, and industries who are involved in advanced computing research. Particular attention is paid to obtaining a diverse membership with a balance among scientific disciplines, institutions, and geographic regions. ASCAC operates in accordance with the Federal Advisory Committee Act (FACA, Public Law 92-463; 92nd Congress, H.R. 4383; October 6, 1972) and all applicable FACA Amendments, Federal Regulations and Executive Orders.

The activities funded by the ASCR program are coordinated with other Federal efforts through the *Interagency Principals Group*, chaired by the President's Science Advisor, and the *Information Technology Working Group (ITWG).* The ITWG evolved through an interagency coordination process that began under the 1991 High Performance Computing Act as the High Performance Computing, Communications, and Information Technology (HPCCIT) Committee. The Federal IT R&D agencies have established a 10-year record of highly successful collaborative accomplishments in multiagency projects and in partnerships with industry and academic researchers. The multiagency approach leverages the expertise and perspectives of scientists and technology users from many agencies who are working on a broad range of IT research questions across the spectrum of human uses of information technology. DOE has been an active participant in these coordination groups and committees since their inception and the ASCR program will continue to coordinate its activities through these mechanisms including an active role in implementing the Federal IT R&D FY 2002-2006 Strategic Plan under the auspices of the National Science and Technology Council and the President's Science Advisor.

ASCR is a participant in the Interagency Committee for Extramural Mathematics Programs (ICEMAP), a coordinating committee with representatives from Federal agencies that manage programs in mathematical research, including the National Science Foundation, DOE (through ASCR), the National Aeronautics and Space Administration, the National Institute for Standards and Technology, the Air Force Office of Scientific Research, the Army Research Office, and the Office of Naval Research. Meetings are held to coordinate activities across mathematical research programs, ensuring that the Federal agencies coordinate their investments in basic mathematical research. The ASCR program regards ICEMAP as an important component in their efforts to maintain coordination with other Federal agencies.

In addition, ASCR, both through ASCAC and independently, supported a number of workshops to support its planning. These include:

- Blueprint for Future Science Middleware and Grid Research and Infrastructure, August 2002 (http://www.nsf-middleware.org/MAGIC/default.htm);
- DOE Science Network Meeting, June 2003 (http://gate.hep.anl.gov/may/ScienceNetworkingWorkshop/);
- DOE Science Computing Conference, June 2003 (http://www.doe-sci-comp.info);
- Science Case for Large Scale Simulation, June 2003 (http://www.pnl.gov/scales/);
- Workshop on the Road Map for the Revitalization of High End Computing (http://www.cra.org/Activities/workshops/nitrd/);
- Cyber infrastructure Report (http://www.cise.nsf.gov/evnt/reports/toc.htm); and
- ASCR Strategic Planning Workshop (http://www.fp-mcs.anl.gov/ascr-july03spw).

Facility Operations Reviews

The ASCR program has undertaken a series of operations reviews of the National Energy Research Scientific Computing Center (NERSC), the Energy Sciences Network (ESnet), and the Advanced Computing Research Testbeds (ACRTs).

NERSC, operated by the Lawrence Berkeley National Laboratory, annually serves about 2,000 scientists throughout the United States. These researchers work at DOE laboratories, universities, industrial laboratories and other Federal agencies. Allocations of computer time and archival storage at NERSC are awarded to research groups based on a review of submitted proposals. As proposals are submitted, they are subjected to peer review to evaluate the quality of science, the relevance of the proposed research to Office of Science goals and objectives and the readiness of the proposed application to fully utilize the computing resources being requested.

The ESnet, managed and operated by the Lawrence Berkeley National Laboratory, is a high-speed network serving thousands of Department of Energy scientists and collaborators worldwide. A pioneer in providing DOE mission oriented high-bandwidth, reliable connections, ESnet enables researchers at national laboratories, universities and other institutions to communicate with each other using the leading edge collaborative capabilities, not available in the commercial world that are needed to address some of the world's most important scientific challenges. The ESnet Steering Committee (ESSC) was established in 1985 to ensure that ESnet meets the needs of the Office of Science programs. All program offices in the Office of Science appoint members, who represent their scientific communities, to serve on the ESSC. The ESSC is responsible for reviewing and prioritizing network requirements, for establishing performance objectives, and for proposing innovative techniques for enhancing ESnet capabilities. In addition to the ongoing oversight from the ESSC, ASCR conducts external peer reviews of ESnet performance on a three year interval. The last such review was chaired by a member of ASCAC and took place in September 2001.

Advanced Computing Research Testbeds (ACRTs) play a critical role in testing and evaluating new computing hardware and software. Current testbeds are located at Oak Ridge National Laboratory (IBM Power-4 Technology and CRAY X1 technology). In FY 2002, ASCAC conducted a review of NERSC and the ACRTs. The charge to ASCAC, posed the following questions:

- What is the overall quality of these activities relative to the best-in-class in the U.S. and internationally?
- How do these activities relate and contribute to Departmental mission needs?
- How might the roles of these activities evolve to serve the missions of the Office of Science over the next three to five years?

The essential finding of the Subcommittee was that NERSC and the ACRTs are among the best worldwide in their respective categories. It was the opinion of the Subcommittee that these ASCR activities and the related spin-off research efforts contribute significantly to the mission needs of the DOE, and profoundly and positively impact high performance computing activities worldwide. The complete report is available on the web. ***(http://www.science.doe.gov/ascr/ASCAC-sub.doc)***

In FY 2001, ASCR conducted a peer review of the Center for Computational Sciences (CCS) at the Oak Ridge National Laboratory. The findings from this review validated the contributions that the CCS made to the Advanced Computing Research Testbed activity within the ASCR program.

Program Reviews

The ASCR program conducts frequent and comprehensive evaluations of every component of the program. Results of these evaluations are used to modify program management as appropriate.

In FY 2003, ASCR conducted a peer review of the Numerical Linear Algebra, Optimization, and Predictability Analysis areas within the Applied Mathematics activity. These areas represent 33 percent of this activity. In FY 2004, ASCR will conduct a peer review of the Differential Equations and Advanced Numerical Methods for High Performance Computing areas within the Applied Mathematics activity, representing an additional 33 percent of this activity. In FY 2005, ASCR will conduct a peer review of the remaining 34 percent of the Applied Mathematics activity, which consists of Computational Fluid Dynamics and Meshing Techniques. Also in FY 2003, ASCR completed reviews of all of the SciDAC Integrated Software Infrastructure Centers (ISICs). There are a total of seven such centers (three with a mathematics focus and four with a computer science focus), and this represents over 50 percent of the ASCR SciDAC budget. In FY 2004, ASCR will initiate a comprehensive review of the Computer Science base research activity.

In FY 2003, ASCR also conducted peer reviews of all the SciDAC Collaboratory Pilot and Middleware Projects. These reviews focused on accessing progress and the possible need for mid-course corrections.

In FY 2002, following a comprehensive peer review, the ASCR program approved a proposal from the Lawrence Berkeley National Laboratory (LBNL) to manage and operate the National Energy Research Scientific Computing Center for FY 2002 – FY 2006.

Planning and Priority Setting

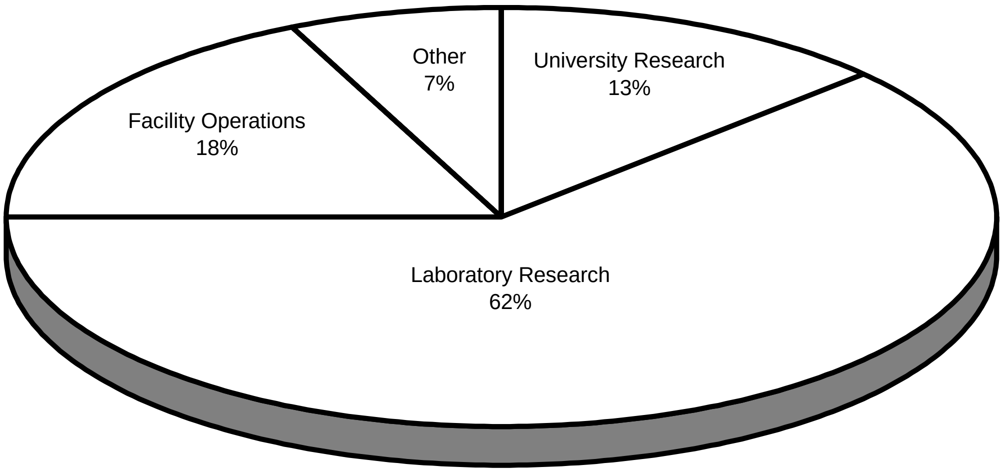
The ASCR program must coordinate and prioritize a large number of goals from agency and interagency strategic plans. One of the most important activities of ASCAC is the development of a framework for the coordinated advancement and application of network and computer science and applied mathematics. This framework must be sufficiently flexible to rapidly respond to developments in a fast paced area of research. The key planning elements for this program are:

- The Department and Office of Science Strategic Plan, as updated through program collaborations and joint advisory committee meetings. (***http://www.science.doe.gov/production/bes/strat_pln.htm)***;
- Scientific Discovery through Advanced Computing (SciDAC) plan delivered to Congress in March 2000. (***http://www.science.doe.gov/scidac/)***;
- The Interagency Working group for Information Technology Five Year Plan – FY 2002-FY 2006 (with key appendixes); and
- ASCAC report on the Japanese Earth Simulator. (***http://www.sc.doe.gov/ascr/ascac.reports.htm)***

How We Spend Our Budget

The ASCR program budget has two subprograms: Mathematical, Information and Computational Sciences (MICS) and Laboratory Technology Research (LTR). The MICS subprogram has two major components: research and facility testbed and network operations. The FY 2005 budget request continues the core and SciDAC research efforts and strengthens the research partnerships with other SC offices. The testbed and network operations expenditures account for 37 percent of the National Laboratory Research, or 24 percent of the total ASCR budget. The LTR subprogram will be brought to a successful completion in FY 2004.

Advanced Scientific Computing Research Budget Allocation FY 2005



Research

Over 74 percent of the ASCR program's FY 2005 funding will be provided to scientists at universities and laboratories to conceive and carry out the research or to fund advanced computing testbeds and network operations. National laboratory research scientists work together with the other programs of the Office of Science to develop the tools and techniques that allow those programs to take advantage of terascale computing for scientific research. The laboratories provide state-of-the-art resources for testbeds and novel applications. The division of support between national laboratories and universities is adjusted to maximize scientific productivity.

- ***University Research***: University researchers play a critical role in the nation's research effort and in the training of graduate students. During FY 2002, the ASCR program supported over 150 grants to the nation's university researchers and graduate students engaged in civilian applied mathematics, large-scale network and computer science research. In addition, ASCR supports a Computational Science Graduate Fellowship and an Early Career Principal Investigator activity in Applied Mathematics, Computer Science and High-Performance Networks. In FY 2002, ASCR selected 24 new graduate fellows representing 17 universities and 13 states and expects to make up to forty awards to early career principal investigators. Approximately one-half of those who received Ph.D.'s in the Computational Sciences Graduate Fellowship program between 1991 and 2001 are pursuing careers outside universities or national labs. ASCR also provides support to other Office of Science research programs.

  The university grants program is proposal driven, similar to the computer science and applied mathematics programs at NSF. However, ASCR grant solicitation notices are focused on topics that have been identified as important for DOE missions. ASCR funds the best among the ideas submitted in response to grant solicitation notices (**http://www.science.doe.gov/production/grants/**). Proposals are reviewed by external scientific peers and competitively awarded according to the guidelines published in 10 CFR 605 (**http://www.science.doe.gov/production/grants/605index.html**).

- ***National Laboratory Research***: ASCR supports national laboratory-based research groups at Ames, Argonne, Brookhaven, Los Alamos, Lawrence Berkeley, Lawrence Livermore, Oak Ridge, Pacific Northwest, and Sandia National Laboratories. The directions of laboratory research programs are driven by the needs of the Department and the unique capabilities of the laboratories to support large scale, multidisciplinary, collaborative research activities. In addition, laboratory-based research groups are highly tailored to the major scientific programs at the individual laboratories and the computational research needs of the Office of Science. Laboratory researchers collaborate with laboratory and academic researchers, and are important for developing and maintaining testbeds and novel applications of high performance computing and networking in Office of Science research. At Los Alamos, Livermore and Sandia, ASCR funding plays an important role in supporting basic research that can improve the applied programs, such as the Accelerated Strategic Computing Initiative (ASCI) and the Science Stockpile Stewardship program.

ASCR funds field work proposals from the national laboratories. Proposals are reviewed by external scientific peers and awarded using procedures that are equivalent to the 10 CFR 605 guidelines used for the grants program. Performance of the laboratory groups is reviewed by ASCR staff annually to examine the quality of their research and identify needed changes, corrective actions or redirection of effort. Individual laboratory groups have special capabilities or access to laboratory resources that can be profitably utilized in the development of the research program.

Significant Program Shifts

The ASCR program advances mathematics and computer science, and develops the specialized algorithms, the scientific software tools, and the software libraries needed by DOE researchers to effectively use high-performance computing and networking hardware for scientific discovery. The ASCR program has been a leader in the computational sciences for several decades and has been acknowledged for pioneering accomplishments.

Research efforts initiated in FY 2001 in Scientific Discovery through Advanced Computing (SciDAC) will be continued, as planned. In FY 2005, ASCR will continue efforts initiated in FY 2004 to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures. The near term activities are represented by enhancements to NERSC while the longer term activities are a part of the Next Generation Computer Architecture (NGA). This effort will continue to increase the delivered computing capability available to address the Office of Science mission through optimization of computer architectures to meet the special requirements of scientific problems. This investment positions the nation to realize extraordinary scientific opportunities in computing for science and enable new classes of scientific problems to be addressed. The NGA effort complements SciDAC and integrates advanced computer architecture researchers and engineers, application scientists, computer scientists, and applied mathematicians. The NGA efforts, as well as the enhancement of NERSC are aligned with the plan developed by the High End Computing Revitalization Task Force (HECRTF) established by the Office of Science and Technology Policy. These efforts will play a critical role in enabling potential future Leadership Class Machines, which could lead to solutions for scientific and industrial problems beyond what would be attainable through a continued simple extrapolation of current computational capabilities.

The FY 2005 budget request includes $7,500,000 for continued support of the Genomics: GTL research program, in partnership with the Biological and Environmental Research program; and $2,600,000 for the Nanoscale Science, Engineering and Technology initiative led by the Basic Energy Sciences program. ASCR's contributions to these partnerships will consist of advancing the mathematics and developing new mathematical algorithms to simulate biological systems and physical systems at the nanoscale. In addition to this continued partnership support, the FY 2005 request includes $1,350,000 to expand SciDAC partnerships with the Fusion Energy Sciences Program to lay the groundwork for the Fusion Simulation Project (FSP). The FSP will be a focused, interdisciplinary effort, whose objective is to develop the capability to predict reliably the behavior of fusion plasmas.

The FY 2005 budget also includes $8,500,000 for the new "Atomic to Macroscopic Mathematics" (AMM) research support in applied mathematics needed to break through the current barriers in our understanding of complex physics processes that occur on a wide range of interacting length- and time-scales. Achieving this basic mathematical understanding will provide enabling technology to virtually every challenging computational problem faced by the Office of Science.

In FY 2005, the Mathematical, Information and Computational Sciences subprogram will continue to support core research activities in applied mathematics, computer science, network research, collaboratory tools and collaboratory pilot projects at current levels.

The Laboratory Technology Research subprogram was brought to a successful conclusion in FY 2004 as planned with orderly completion of all existing CRADAs. This does not mean that technology transfer activities have ended; rather, these activities are now institutionalized as a part of the process of doing research at DOE sites.

Interagency Environment

The activities funded by the MICS subprogram are coordinated with other Federal efforts through the Interagency Principals Group, chaired by the President's Science Advisor, and the Information Technology Working Group (ITWG). The ITWG evolved through an interagency coordination process that began under the 1991 High Performance Computing Act as the High Performance Computing, Communications, and Information Technology (HPCCIT) Committee. DOE has been an active participant in these coordination groups and committees since their inception. The MICS subprogram will continue to coordinate its activities through these mechanisms and will lead the development of new coordinating mechanisms as needs arise. The DOE program solves mission critical problems in scientific computing. In addition, results from the DOE program benefit the Nation's Information Technology Basic Research effort. The FY 2005 program positions DOE to make additional contributions to this effort. In the area of high performance computing and computation, ASCR has extensive partnerships with other Federal agencies and the NNSA. Examples include: participating in the program review team for the DARPA High Productivity Computing Systems program; serving on the planning group for the Congressionally mandated DOD plan for high performance computing to serve the national security mission; serving on the OSTP High End Computing Revitalization Task Force; and extensive collaboration with NNSA-Advanced Simulation Computing.

Scientific Discovery through Advanced Computing

The Scientific Discovery through Advanced Computing (SciDAC) program is a set of coordinated investments across all Office of Science mission areas with the goal of achieving breakthrough scientific advances via computer simulation that were impossible using theoretical or laboratory studies alone. The power of computers and networks is increasing exponentially. Advances in high-end computing technology, together with innovative algorithms and software, are being exploited as intrinsic tools for scientific discovery. SciDAC has also pioneered an effective new model of multidisciplinary collaboration among discipline-specific scientists, computer scientists, computational scientists, and mathematicians. The product of this collaborative approach is a new generation of scientific simulation codes that can productively exploit terascale computing and networking resources. The program is bringing computation and simulation to parity with experiment and theory in the scientific research enterprise as demonstrated by major advances in climate modeling and prediction, plasma physics, particle physics, accelerator design, astrophysics, chemically reacting flows, and computational nanoscience.

The research focus of ASCR SciDAC activities includes Integrated Software Infrastructure Centers (ISICs) and collaboratories. ISICs are partnerships between DOE national laboratories and universities focused on research, development, and deployment of software to accelerate the development of SciDAC application codes. Progress to date includes significant improvements in performance modeling and analysis capabilities that have led to doubling the performance on 64 processors of the Community Atmosphere Model component of the SciDAC climate modeling activity. Collaboratories address complex science projects undertaken in the SciDAC program that involve geographically distributed computing resources, research teams, and science. Progress includes development of GridFTP, a high-performance data transport program that has become the de facto standard for data transport on the Grid. In high-energy physics, collaboratory technology enabled a single job to generate 1.5 million simulated events for the Compact Muon Solenoid. The three Mathematics ISICs, now 1.5 years into their 3-5 year life, are bringing a new level of mathematical sophistication to computational problems throughout the Office of Science. One of these, the Terascale Optimal Partial Differential Equations (PDE) Simulations (TOPS) Center, is combining the Hyper and Portable Extensible Tool kit for Scientific Computation (PETSc) libraries, together with newly developed algebraic multigrid solvers, to create fast algorithms for a variety of tough and important problems, including biochemical reaction diffusion equations, advection equations for combustion simulation, and so forth. The Terascale Simulation Tools and Technologies Center is working to develop a framework for coupling different types of grids together in a single application. For example, in a simulation of engine combustion, one might want an unstructured grid for the complex geometry around the valves, but a regular grid in the rest of the cylinder. Finally, the Applied Partial Differential Equations Center is focused on using structured adaptive grids for simulation in a variety of application domains, including ground water flow, combustion chemistry, and magneto-hydrodynamics. Given the difficulty of magneto-hydrodynamic simulation, this center is having a strong impact on the design of new particle accelerators.

Next Generation Computer Architecture for Science and Industry

The Next Generation Computer Architecture for Science and Industry (NGA) research activity is an integral part of an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures. Total funding for the NGA was $38,268,000 in FY 2004 and $38,212,000 in FY 2005. The goal of the NGA is to identify and address major architectural bottlenecks, such as internal data movement in very large systems, in the performance of existing and planned DOE science applications. Emphasis will be placed on understanding the impact of alternative computer architectures on application performance with particular attention paid to data movement from memory to processor and between processors in highly parallel systems. Software research will be initiated to improve application performance and system reliability through innovative approaches to next generation operating systems. Emphasis will also be placed on hardware evaluation testbeds of sufficient size to understand key issues impacting application performance scalability and portability. These testbeds will also enable significant scientific progress by delivering significant increases in performance to critical DOE mission applications. These testbeds will also enable industrial researchers to find opportunities for virtual prototypes and simulation of industrial processes that result in enhanced competitive position because of sharply reduced 'time to market.' The NGA activity is coordinated with other Federal agencies to gain additional insight into research directions, optimize the utilization of resources, and establish the framework for a national effort. This effort is aligned with the HECRTF plan.

Scientific Facilities Utilization

The ASCR program request includes support to the National Energy Research Scientific Computing Center (NERSC), a component of the Office of Science-wide Facilities Optimization effort. This investment will provide computer resources for about 2,000 scientists in universities, DOE laboratories, Federal agencies, and U.S. companies. The proposed funding will enable NERSC to maintain its role as one of the Nation's premier unclassified computing centers, a critical element for success of many Office of Science research programs.

	FY 2001	FY 2002	FY 2003	FY 2004 Est.	FY 2005 Est.
Maximum Hours – NERSC	8,760	8,760	8,760	8,760	8,760
Scheduled Hours – NERSC....................	8,497	8,585	8,585	8,585	8,585
Unscheduled Downtime – NERSC	1%	1%	1%	1%	1%

Workforce Development

The R&D Workforce Development mission is to ensure the supply of computational and computer science and Ph.D. level scientists for the Department and the Nation through graduate student and postdoctoral research support. In FY 2005, this program will support approximately 800 graduate students and post doctoral investigators, of which 500 will be supported at Office of Science user facilities.

ASCR will continue the Computational Science Graduate Fellowship Program with the successful appointment of 20 new students to support the next generation of leaders in computational science.

	FY 2001	FY 2002	FY 2003	FY 2004 est.	FY 2005 est.
# University Grants...........	170	163	144	140	142
Size, Duration...................	$157,000/yr-3yrs	$157,000/yr-3yrs	$197,000/yr-3yrs	$197,000/yr-3yrs	$197,000/yr-3yrs
# Lab Groups....................	226	209	165	165	165
# Grad Students	370	354	354	354	354
# PhD's Awarded.............	660	604	675	675	675

Mathematical, Information, and Computational Sciences

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
Mathematical, Information, and Computational Sciences					
Mathematical, Computational, and Computer Sciences Research	68,748	83,301	86,405	+3,104	+3.7%
Advanced Computation, Communications Research and Associated Activities	91,619	110,553	112,389	+1,836	+1.7%
SBIR/STTR	0	5,438	5,546	+108	+2.0%
Total, Mathematical, Information, and Computational Sciences	160,367	199,292	204,340	+5,048	+2.5%

Description

The Mathematical, Information, and Computational Sciences (MICS) subprogram is responsible for carrying out the mission of the ASCR program: discovering, developing, and deploying advanced scientific computing and communications tools and operating the high performance computing and network facilities that researchers need to analyze, model, simulate, and — most importantly — predict the behavior of complex natural and engineered systems of importance to the Office of Science and to the Department of Energy.

Benefits

MICS supports ASCR's contribution to DOE's mission to provide world-class scientific research capacity by providing world-class, peer-reviewed scientific results in mathematics, high performance computing and advanced networks and applying the potential of Terascale computing to advanced scientific applications. High-performance computing provides a new window for researchers to observe the natural world at a fidelity that could only be imagined a few years ago. Research investments in advanced scientific computing equip researchers with premier computational tools to advance knowledge and to solve the most challenging scientific problems facing the Nation.

Supporting Information

The computing and the networking required to meet Office of Science needs exceed the state-of-the-art by a wide margin. Furthermore, the algorithms, software tools, the software libraries and the software environments needed to accelerate scientific discovery through modeling and simulation are beyond the realm of commercial interest. To establish and maintain DOE's modeling and simulation leadership in scientific areas that are important to its mission, the MICS subprogram employs a broad, but integrated research strategy. The MICS subprogram's basic research portfolio in applied mathematics and computer science provides the foundation for enabling research activities, which includes efforts to advance networking, to develop software tools, software libraries and software environments. Results from enabling research supported by the MICS subprogram are used by computational scientists supported by other Office of Science and other DOE programs. This link to other DOE programs provides a tangible assessment of the value of the MICS subprogram for advancing scientific discovery and technology development through simulations.

In addition to its research activities, the MICS subprogram plans, develops, and operates supercomputer and network facilities that are available to researchers working on problems relevant to DOE's scientific missions 24 hours a day, 365 days a year.

The Early Career Principal Investigator (ECPI) activity was initiated in FY 2002 for scientists and engineers in tenure track positions at U.S. universities. Seventeen (17) awards were made in FY 2002. Additional awards will be made in FY 2003 for this activity pending peer reviews of applications. The goal of the ECPI activity is to support Office of Science mission-related research in applied Mathematics, computer science and high-performance networks performed by exceptionally talented university investigators, who are at an early stage in their professional careers.

Accomplishments

- *New Robust WAN File Replication and Movement Available for Large Scientific Data* - Terascale computing and large scientific experiments produce enormous quantities of data that require effective and efficient management for large scientific collaborations dispersed across wide-area networks. Using storage resource management (SRM) technology developed at Lawrence Berkeley Laboratory, it is now possible to achieve continuous replication of hundreds of files with a single request with no further human intervention. The SciDAC funded Earth System Grid is using this technology for a generalized data access for climatologists. The technology also provides an important feature--interoperability of archival systems at DOE laboratories and the National Center for Atmospheric Research. The replication process relies on GridFTP, developed at Argonne National Laboratory as part of the Globus Toolkit® for the reliable, secure and policy-aware large-scale data movement. GridFTP servers are used to stage input data and move results to mass storage systems. This software has become the de facto standard worldwide for the movement of large data.
- *Commodity Grid Kits Make Grids Easy to Program and Use* - Many scientific applications, including climate modeling, astrophysics, high energy physics, structural biology, and chemistry need numerous distributed resources to make advances in multidisciplinary scientific research. The Grid provides an infrastructure that can be used to accomplish this. Work at Argonne National Laboratory and Lawrence Berkeley National Laboratory has built on commodity technologies (Java and Python) already in use by thousands of scientists to access the Grid from higher level programming frameworks. These frameworks form the basis for scientific portals promoting collaboration between large scientific teams and allow the harnessing of distributed resources that are needed as part of the scientific problem solving process. The new Commodity Grid (CoG) Kit technology has been used while building a number of scientific portals to the Grid. Indeed, it already has become the de facto community standard for developing Grid portal applications. Examples of applications relying on this technology include the SciDAC funded Particle Physics Data Grid and Earth System Grid projects, portals for astrophysical black-hole simulations, and portals for structural biology.
- *Increased Scientific Productivity through Advanced Collaborative Environments* - The SciDAC funded National Fusion Collaboratory Project has deployed a production computational and data grid that is accelerating scientific understanding and innovation towards the design of an attractive new fusion energy source. The design of this persistent infrastructure to enable scientific

collaboration is being put forth by the U.S. as the design template for ITER, the International Thermonuclear Experimental Reactor that is planned as the one next generation experimental device for the worldwide magnetic fusion community.

- *ParamBench demonstrates the significant impact of concurrent memory accesses* - Computer scientists at the Lawrence Livermore National Laboratory, in collaboration with researchers at the University of Utah and North Carolina State University have implemented ParamBench, low-level benchmarks of memory performance in symmetric multiprocessors (SMPs). These benchmarks measure the raw memory performance of SMPs, including the effect of multiple processors accessing the memory system concurrently. Results with this benchmark suite demonstrate that standard latency-hiding techniques, such as hardware prefetching, are less effective in SMPs, even with a crossbar-based memory interconnection.
- *New Analysis Tools for Innovative Materials* - Mathematicians at the Oak Ridge National Laboratory have extended the class of materials science problems that can be solved by a powerful technique known as the "Boundary Element Method." This numerical method significantly reduces the number of operations that are needed to solve materials science problems, but has traditionally been applicable only to homogeneous materials. The researchers derived the fundamental solution to a set of integral equations for "Functionally Graded Materials," an important class of materials that are not homogeneous, but whose properties vary smoothly. These materials already play an important role in many applications, including coatings for protecting turbine blades, special optical materials, and dental implants and other bio-materials.
- *Scientific Data Objects: A Common Language for Exchanging Parallel Data* - Arrays, or matrices, are one of the basic data structures of scientific computing. In large-scale simulations, arrays are often so large that they must be distributed across many processors. In order for different software modules to work together on a distributed array, a method must exist to precisely describe the distribution of the data. As part of the SciDAC Center for Component Technology for Simulation Software, researchers at the Oak Ridge National Laboratory developed such a description, thus greatly simplifying the development of components that need to exchange distributed array data objects with other components. The new interface specification is capable of describing the layouts used by a wide range of distributed array tools, including CUMULVS (ORNL), Global Arrays (PNNL), High Performance Fortran, A++/P++ (LLNL), and others.
- *New Scientific Data Index Performs 100 Times Faster Than Commercial Database Systems* - Terascale computing and large scientific experiments produce enormous quantities of data that require effective and efficient management. The task of managing scientific data is overwhelming. Researchers at the Lawrence Berkeley National Laboratory have developed a specialized index for accessing very large datasets that contain a large number of attributes that may be queried. This new index performs 12 times faster than the previous best-known method, and 100 times faster than conventional indexing methods in commercial database systems. The prototype index is being used by researchers in high energy physics and combustion modeling.
- *Faster Reconstruction Methods are Making Waves* - Mathematicians at the Lawrence Berkeley National Laboratory have developed efficient and fast techniques for solving the problem of multiple arrivals; that is, detecting and separating the arrival of waves that have taken differing paths through a medium. Example applications include geophysical analysis, which is important for oil exploration, and antenna design. The methods are fast enough that they can be embedded inside

"inverse solvers," computer codes that use information about the arriving waves to deduce the characteristics of an unknown body between the source and detector. This will result in new computational tools to examine hidden objects, accurately reconstruct inaccessible regions, and rapidly test proposed models.

- *Increasing Scientific Productivity through Automated Optimization* - Many complex problems in science, engineering and business require the solution of optimization problems, but the conventional approach to solving such problems can be extremely time-consuming and difficult to apply. Researchers at Argonne National Laboratory have developed the Network-Enabled Optimization System (NEOS) that allows users to solve optimization problems over the Internet with state-of-the-art software and without tedious downloading and linking of specialized optimization code. Because of its ease of use, the NEOS server has gained widespread popularity with more than 5,000 job requests each month from users around the world. Recent NEOS applications include circuit simulation, protein folding, circuit design, brain modeling, airport crew scheduling, and modeling of electricity markets.
- *Open Source Cluster Application Resources (OSCAR) Cluster Software Distribution A Big "Hit" Worldwide* - The Open Source Cluster Application Resources package, OSCAR, is a collection of software tools for managing Linux-based computer clusters developed by a consortium of academic, research, and industry members led by scientists at the Oak Ridge National Laboratory. According to the Top 500 Clusters web site, OSCAR has become the most used cluster computing distribution available today. OSCAR is also used as the core cluster base package in the MacNeil Schwindler (MSC) Linux commercial cluster distribution as well as the NCSA "in-a-box" series of cluster computing solutions. OSCAR has a "market share" of over 30% according to the poll – more than twice its nearest competitor. OSCAR has been downloaded over 53,000 times and has received over 140,000 web page hits during the past year.
- *Tiled Displays: Automatic Calibration of Scalable Display Systems* - Today's scientific simulations and rich multimedia collaborative environments can easily produce tens of millions of pixels for display. Tiled display systems built by combining the images from arrays of projectors can provide massive numbers of pixel elements to visually represent large amounts of information. Multiprojector tiled arrays can be a cost-effective way to create these displays, and they may be the only practical way to create large information dense displays. But, it is difficult to create the illusion of a unified seamless display for a variety of reasons, including projector-to-projector color and luminosity differences, variation of luminosity across the image from a single projector, and optical distortion of the individual projector images caused by imperfections in the lenses and misalignment of projectors. Researchers at Argonne National Laboratory have developed methods to attack these fundamental issues providing an efficient and optimized measurement process using inexpensive components that is tolerant of a wide range of imperfections in components and measurement setup such as lighting conditions and camera optics.
- *Center for Computational Sciences (CCS) Deploys CrayX1 Computer System* - The Center for Computational Sciences at ORNL has acquired and begun deployment of a CrayX1 system to test its effectiveness in solving scientific problems of national scale in climate, biology, nanoscale materials, fusion, and astrophysics. "This partnership with Cray is one of the first steps in the initiative to explore computational architecture essential to 21st century scientific leadership," said the Director of the Office of Science. The Cray X1 is the first U.S. computer to offer vector processing and

massively parallel processing capabilities in a single architecture. The system has been specifically designed for scientific applications. Preliminary results on climate applications show the potential for significant improvements in performance over current generation computers.

- *NERSC Improves Supercomputer Performance* **-** The Department of Energy's National Energy Research Scientific Computing Center (NERSC) at the Lawrence Berkeley National Laboratory has doubled the peak performance of its IBM RS/6000 SP supercomputer. The 10 teraflop/s (10 trillion calculations per second) NERSC-3E (enhanced) is now the most powerful computer for unclassified research in the United States. The supercomputer named *Seaborg* has 6,656 processors and has the largest aggregate memory of any unclassified computer in the U.S. – 7.8 terabytes (trillion bytes) – with 44 terabytes of disk storage.
- *Supernova Factory Makes Rapid Discoveries* - At the January 2003 meeting of the American Astronomical Society in Seattle, the Nearby Supernova Factory (SNfactory) based at Lawrence Berkeley National Laboratory announced that it had discovered 34 supernovae during its first year of operation — all but two of them in the last four months alone. This discovery rate of eight per month had been achieved by other supernova search projects only after years of work. The SNfactory processed a quarter-million images in its first year and archived 6 terabytes (trillion bytes) of compressed data at the National Energy Research Scientific Computing Center (NERSC) at Berkeley Lab — one of the few centers with an archive large enough to store this much data.
- *Computational Simulation Finds Correct Theoretical Model* - After three decades of uncertainty, the origins of at least some gamma-ray bursts (GRBs) are being revealed, thanks to a new generation of orbiting detectors, fast responses from ground-based robotic telescopes, and a new generation of computers and astrophysics software. A GRB detected on March 29, 2003 has provided enough information to eliminate all but one of the theoretical explanations of its origin. Computational simulations based on that model were already being developed at the National Energy Research Scientific Computing (NERSC) Center at Lawrence Berkeley National Laboratory when the discovery was made.
- *Improved Algorithm Speeds Up Fusion Code by a Factor of 5* - The NIMROD project, funded by the DOE Office of Fusion Energy Sciences and the SciDAC Center for Extended Magneto-hydrodynamic Modeling, is developing a modern computer code suitable for the study of long-wavelength, low-frequency, nonlinear phenomena in fusion reactor plasmas. The project's primary high-end computing resource is the 10 teraflop/s IBM SP (Seaborg) at the National Energy Research Scientific Computing (NERSC) Center at Lawrence Berkeley National Laboratory. Through a collaboration with members of the SciDAC Terascale Optimal PDE Simulations (TOPS) Center to implement the SuperLU linear solver software within NIMROD it now runs four to five times faster for cutting-edge simulations of tokamak plasmas, with a corresponding increase in scientific productivity.
- *ESnet deploys next general protocol* – ESnet has deployed Internet Protocol Version 6 (IPv6) on its production network. Enabling IPv6 on the network brings a new level of security (e.g. packet encryption and source authentication) and supports real-time traffic, such as video conferencing. IPv6 is expected to become the protocol of choice throughout the Internet.
- *ESnet deploys global Public Key Infrastructure (PKI)* – ESnet has played a key role in coordination and deployment of a Public Key Infrastructure for use by the new computational grids being developed around the world. ESnet is actively working with the Global Grid Forum, the European

Data Grid and Cross Grid Certificate Authority to ensure that the service has the widest possible acceptance.

Awards

Lovelace Medal Awarded to ANL Scientist - An Argonne National Laboratory scientist and colleague of the Information Sciences Institute at the University of Southern California were named as recipients of the prestigious Lovelace Medal, given by the British Computer Society (BCS). BCS cited "their work with the Globus Project and Grid computing," in giving the award for contributions with major significance in the advancement or development of information systems. This is the first time that this award has been given to a DOE-funded researcher. Previous recipients include the developer of the computer mouse and graphic interface; and the developer of the Linux operating system.

Sidney Fernbach Award goes to ORNL Scientist - An internationally recognized quantum chemist from ORNL, who is the principal architect of the Northwest Computational Chemistry Software (NWChem), was named the 2002 recipient of the IEEE Computer Society's Sidney Fernbach Award. The Sidney Fernbach Award was established by the IEEE Computer Society in 1992 and is awarded for outstanding contributions in the application of high performance computers using innovative approaches.

Scientific Computing Research Investments

High-performance computing hardware is important for meeting DOE's modeling and simulation needs. However, computer hardware can only enable scientific advances when the appropriate algorithms, scientific software tools, libraries, software environments, and the networking infrastructure are easy to use and are readily available to the users. The MICS subprogram differs from high performance computing efforts in other Federal agencies because of its management focus to integrate research investments to enable new science. Desktop systems realize advances in computing power primarily through increases in the processor's clock speed. High performance computers employ a different strategy for achieving performance, complicating the architecture and placing stringent requirements on software. The MICS subprogram supports software research over a broad range, but that research is tailored to DOE's science needs. Research is underway to improve the performance of simulations on high-end computers, to remove constraints on the human-computer interface and to discover the specialized information management and analysis techniques that scientists need to manage, analyze and visualize extremely large data sets.

Technology trends and business forces in the U.S. computer industry over the past decade caused most domestic vendors to curtail or abandon the development of high-end systems designed to meet the most demanding requirements of scientific research. Instead, large numbers of smaller commercial systems were combined and integrated into terascale computers to achieve the peak performance levels required for agency missions in computational science. The hardware is complicated, unwieldy and not balanced for scientific applications. Enabling software has been developed for scientists to take advantage of these new computers. However, this software is extraordinarily complex and can be a barrier to scientific progress. Consequently, the DOE, primarily through the MICS subprogram, and other Federal agencies whose missions depend on high-performance computing, must make basic research investments to adapt high-performance computing and networking hardware into tools for scientific discovery.

The NGA represents the first step in the adjustment to our strategy that is required to enable future progress in computational science. Continued emphasis on developing software-based solutions to enable scientific simulations on large clusters of computers designed for mid-range applications is no longer the basis for a sustainable strategy for many high-end applications. Rather, our emphasis needs to broaden to include computer hardware technology, architecture, and design trends motivated from a scientific and industrial user perspective. This can be accomplished by making research investments that couple computational scientists, computer scientists, and industrial researchers with U.S. computer vendors to orient future computer architectures towards the needs of science and industry. Additional research investments must be made to ensure the availability of software takes full advantage of these future computer architectures. The status of the technology, the conditions of the current business market for computing, and the success of the Earth Simulator supercomputer in Japan are strong indicators that this strategy can provide tangible near-term benefits for scientific simulation. While NGA will be instrumental in removing some architectural bottlenecks to performance on actual scientific simulations, others will remain and possibly become persistent obstacles in the future.

To illustrate the complexities involved, think of a high-performance computer as a large number of conference rooms distributed around a region. Each conference room is connected through the region's transportation and communications infrastructure. Now, the task of a successful scientific application is analogous to getting everyone in the region to a pre-assigned conference room on time. Instructions are given to each participant (systems software). Results from each conference (calculations) will be documented (stored in memory) for distribution. New conferences are convened, new instructions are given and new decisions are made. Now repeat this process trillions of times, as occurs in a scientific simulation! As one can appreciate, this process can only work if the region's infrastructure is properly configured and operating efficiently. That is, the buses, subways, taxicabs, roads, elevators and telephones can efficiently handle the demand. Most of the systems available from computer vendors are analogous to small regions, a limited number of conference rooms and an inefficient infrastructure. Computers for scientific simulation on the other hand, must be analogous to large cities, large numbers of conference rooms, and an efficient infrastructure, with alternative modes of transportation and communication.

Advances in *computer science* research can enable scientists to overcome these remaining barriers. For example:

- efficient, high-performance operating systems, compilers, and communications libraries for high-end computers;
- software to enable scientists to store, manage, analyze, visualize, and extract scientific understanding from the enormous (terabyte to petabyte) data archives that these computers will generate;
- software frameworks that enable scientists to reuse most of their intellectual investment when moving from one computer to another and make use of lower-level components, such as runtime services and mathematical libraries, that have been optimized for the particular architecture;
- scalable resource management and scheduling software for computers with thousands of processors;
- performance monitoring tools to enable scientists to understand how to achieve high performance with their codes; and
- computational scientists with tools, options, and strategies to obtain the maximum scientific benefit from their computations.

Research advances in computer science do not provide the full range of capabilities that computational scientists need, especially for the complex problems faced by the Office of Science. Significant efforts in the applied mathematical research activity will be required for the Department to satisfy its mission requirements for computational science. Historically, improvements in mathematical algorithms have yielded at least as much increase in performance as have improvements in hardware. A large proportion of these advances resulted from the MICS subprogram applied mathematics research activity. The requirements of scientific domains for new algorithms that can scale to work effectively across thousands of processors and produce the most science in the fewest number of computer operations drives the need for improved mathematical algorithms and the supporting software libraries that must be made available for ready use by scientists. In this area of research, the MICS applied mathematics activity is the core of the nationwide effort.

The MICS subprogram research activities that respond to these challenges are described below in the Detailed Program Justification section of the MICS subprogram budget under the headings:

- Applied Mathematics
- Computer Science
- Advanced Computing Software Tools

High Performance Networking, Middleware and Collaboratory Research Investments

Advances in network capabilities and network-enabled technologies now make it possible for large geographically distributed teams to effectively collaborate on solutions to complex problems. It is now becoming possible to harness and integrate the collective capabilities of large geographically distributed data archives, research teams, and computational resources. This collective capability is especially important for the teams using the major experimental facilities, computational resources, and data resources supported by DOE because all of the necessary resources are not available at one location. To successfully realize the potential of this collective research capability, additional research is needed to bring network, data, and computational resources to the members of a distributed team in a manner that is easy to use and guarantees end-to-end performance. For example:

- Significant research is needed to augment the capability of the Internet to support distributed high-end data-intensive applications and to secure large-scale scientific collaborations. The requirements of high-performance networks that support distributed data-intensive computing and scientific collaborations on a national and international scale are very different than the requirements of the current commercial networks where millions of users are moving small web pages. The MICS-supported research on high-performance networks includes research on high-performance protocols, network-aware operating system services, advanced network coprocessors, network measurement and analysis.
- Research is also needed for the development and testing of high-performance middleware needed to seamlessly couple scientific applications to the underlying transport networks. These include high-performance middleware such as advanced security services for grid computing, ultra-high-speed data transfer services, services to guarantee Quality of Service (QoS) for delay sensitive applications, and grid resources discovery. This high-performance middleware provides the scalable software components needed to integrate data, visualization, computation and high-speed networks into a scalable and secure scientific collaborative environment.

The MICS subprogram will address these challenges through fundamental research in networking; software tools that integrate networking and computer science to enable scientific collaboration (collaboratory tools); partnerships with key scientific disciplines; and advanced network testbeds.

Specific responses to these challenges are described in the Detailed Program Justification section of the MICS subprogram budget under the headings:

- Networking
- Collaboratory Tools
- National Collaboratory Pilot Projects

Enhancements to High Performance Computing and Networking Facilities

To realize the scientific opportunities offered by advanced computing, enhancements to the Office of Science's computing and networking facilities are also required. The MICS subprogram supports a suite of high-end computing resources and networking resources for the Office of Science:

- *Production High Performance Computing Facilities.* The National Energy Research Scientific Computing Center (NERSC) provides high performance computing for investigators supported by the Office of Science. NERSC provides a spectrum of supercomputers offering a range of high performance computing resources and associated software support.
- *Energy Sciences Network (ESnet).* ESnet provides worldwide access to Office of Science facilities, including light sources, neutron sources, particle accelerators, fusion reactors, spectrometers, high-end computing facilities, massive data resources and other leading-edge instruments and facilities.
- *Advanced Computing Research Testbeds.* The Advanced Computing Research Testbeds (ACRTs) consist of high performance, advanced architecture computing platforms for testing and evaluation to ascertain the prospects for meeting future general, or specialized, computational science needs of the Office of Science. In FY 2005, the ACRTs will provide hardware resources for the NGA activity. Two types of computing platforms will be evaluated - early systems from vendors, and experimental systems. Based on an analysis of vendor offerings and a peer review of the potential that such offerings can meet Office of Science computational needs, hardware will be acquired at sufficient scale to address key performance and software scaling issues. The evaluation process will include computer science studies and tests of leading-edge Office of Science computational science applications, such as those being developed under SciDAC. In addition, the ACRTs will provide computing resources to SciDAC teams.
- *Trends for Future Supercomputing and Networking Resources.* The need for high performance computational resources will increase in future years as applications transition from the software development and testing phase to using the software to generate new science. As the peak performance of the computers increase, the amount of data produced in a simulation increases as well. Therefore, focused enhancements to the Office of Science's network infrastructure are required to enable scientists to access and understand the data generated by their software and by large-scale science experiments.

The MICS subprogram activities that respond to these challenges are described later in the Detailed Program Justification section of the MICS subprogram budget under the headings:

- National Energy Research Scientific Computing Center (NERSC)
- Advanced Computing Research Testbeds
- Energy Sciences Network (ESnet)

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Mathematical, Computational, and Computer Sciences Research	**68,748**	**83,301**	**86,405**
▪ **Applied Mathematics**...	**21,332**	**22,635**	**29,363**

This activity supports research on the underlying mathematical understanding of physical, chemical and biological systems, and on advanced numerical algorithms that enable effective description and prediction of such systems on terascale computing systems. Research in Applied Mathematics supported by MICS underpins computational science throughout DOE. Historically, the numerical algorithms developed under this activity have produced more scientific advances through simulation than improvements in computer hardware. This activity supports research at DOE laboratories, universities, and private companies. Many of the projects supported by this activity involve research partnerships between DOE's national laboratories and universities. The activity supports research in a wide variety of areas of mathematics, including: ordinary and partial differential equations and solutions methods, including techniques to convert equations into discrete elements and boundary integral methods, advanced treatment of interfaces and boundaries, (fast marching and level set methods, and front tracking); numerical linear algebra (advanced iterative methods, general and problem-specific preconditioners, sparse solvers, and dense solvers); fluid dynamics (compressible, incompressible and reacting flows, turbulence modeling, and multiphase flows); optimization (linear and nonlinear programming, interior-point methods, and discrete and integer programming); mathematical physics; control theory (differential-algebraic systems, order reduction, and queuing theory); accurate treatment of shock waves; "fast" methods (fast multipole and fast wavelet transforms); mixed elliptic-hyperbolic systems; dynamical systems (chaos theory, optimal control theory, and bifurcation theory); and automated reasoning systems.

The FY 2005 budget continues the Computational Sciences Graduate Fellowship program at the current level of $3,500,000.

The FY 2005 budget also includes $8,500,000, for the new "Atomic to Macroscopic Mathematics" (AMM) research effort to provide the research support in applied mathematics needed to break through the current barriers in our understanding of complex physical processes that occur on a wide range of interacting length- and time-scales. The current state-of-the-art in the theory and modeling of complex physical systems generally requires that the physical phenomena being modeled either occur at a single scale, or widely separated scales with little or no interaction. Complex physical systems frequently involve highly nonlinear interactions among many

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

phenomena at many different scales. Increases in computational power over the last decade have enabled scientists to begin the process of creating sophisticated models with fewer simplifying assumptions. These new models cannot succeed without a deeper understanding of the mathematics of phenomena at multiple scales and how they interact, from the atomic scale through the mesoscopic to the macroscopic. Achieving this basic mathematical understanding will provide enabling technology to virtually every challenging computational problem faced by the Office of Science.

Progress in AMM will best be achieved through a combination of investments, including (1) funds for innovative approaches to multiscale mathematics at universities throughout the country, (2) investments in partnerships between university researchers and investigators at the national laboratories, and (3) additional investments in multidisciplinary teams at the national laboratories. Category (1) represents investment in relatively high-risk / high-payoff approaches. Categories (2) and (3) follow the SciDAC model of building teams that involve national laboratory researchers in various critical applications. AMM research will support the development of new high-fidelity simulations that are crucial to our improved understanding of important problems across the Office of Science, including fuel cell design, understanding of microbial cells and communities, accelerator design and optimization, combustion processes including clean and efficient engine design, fusion reactor design and optimization, design of materials atom-by-atom, and many more.

	FY 2003	FY 2004	FY 2005
▪ **Computer Science**	**17,489**	**23,680**	**23,680**

This activity supports research in computer science to enable researchers to effectively utilize high-performance computers to advance science in areas important to the DOE mission. DOE has unique requirements for high performance computing that significantly exceed the capability of software products from computer vendors. This activity supports computer science research in two general areas: the underlying software to enable applications to make effective use of computers with hundreds or thousands of processors as well as computers that are located at different sites; and large scale data management and visualization under circumstances where the underlying resources and users are geographically distributed. The first area includes research in protocols and tools for interprocessor communication and parallel input/output (I/O) as well as tools to monitor the performance of scientific applications and advanced techniques for visualizing very large-scale scientific data. Researchers at DOE laboratories and universities, often working together in partnerships, propose and conduct this research.

Beginning in FY 2004, this activity incorporates the software research component of NGA to improve application performance and system reliability through innovative approaches to next generation operating systems. In FY 2005, NGA effort in this activity also includes $2,000,000 transferred from Scientific Applications Partnerships for applications teams working in close partnership with systems evaluation teams. Total funding for the NGA software research component research is $6,659,000.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
▪ **Advanced Computing Software Tools**	**19,362**	**20,256**	**19,362**

This activity supports research that builds on the results from research in applied mathematics and computer science to develop integrated software tools that computational scientists can use to develop high performance applications (such as characterizing and predicting phase changes in materials). These tools, which enable improved performance on high-end systems, are critical to the ability of scientists to attack the complex scientific and engineering problems that can only be solved with high-end computing systems.

In FY 2005, this activity will continue to support the Integrated Software Infrastructure Centers (ISICs), a SciDAC activity, competitively selected in FY 2001. The ISICs funded under this activity focus on: structured and unstructured mesh generation for large simulations and high performance tools for solving partial differential equations on parallel computers; tools for analyzing the performance of scientific simulation software that uses thousands of processors; the development of data management and visualization software capable of handling terabyte scale data sets extracted from petabyte scale data archives, and software for managing computers with thousands of processors; and software component technology to enable rapid development of efficient, portable, high performance parallel simulation software.

These Integrated Software Infrastructure Centers are a critical component in DOE's SciDAC strategy. The ISICs are responsible for the entire lifecycle of the software that they develop. These software tools must be reliable, understandable and well documented. Also, the scientific user community needs these tools to be maintained, bug-free and upgraded, as necessary. Software tools for high performance scientific simulations have no commercial market. The Integrated Software Infrastructure Centers initiated in FY 2001 provide the only means for developing and deploying these tools to the scientific community.

There is a decrease of $894,000 in the last year of the SciDAC program for ISICs resulting from accelerated rampdown of selected efforts. This decrease is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.

▪ **Scientific Applications Partnerships**	**10,565**	**16,730**	**14,000**

This activity, formerly titled Scientific Application Pilot Projects, supports collaborative research with computational scientists in other disciplines to apply the computational techniques and tools developed by other MICS activities to address problems relevant to the mission of SC. This effort tests the usefulness of advances in computing research, transfers the results of this research to the scientific disciplines, and helps define opportunities for future research. The FY 2005 funding for this activity will allow the continuation of the multidisciplinary partnerships that were competitively selected in FY 2001. These projects are part of the SciDAC activity and are coupled to the Integrated Software Infrastructure Centers. Areas under investigation include design of particle accelerators with the High Energy Physics (HEP) and Nuclear Physics (NP) programs; plasma turbulence in tokamaks with the Fusion Energy Sciences (FES) program; global climate

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

change with the Biological and Environmental Research (BER) program; and combustion chemistry with the Basic Energy Sciences (BES) program.

The FY 2005 request includes funds to continue at a reduced level the partnership with the Biological and Environmental Research Genomics: GTL and the partnership with the Basic Energy Sciences program in nanoscale science. The FY 2005 request also includes $1,350,000 to expand SciDAC partnerships with the Fusion Energy Sciences program to lay the groundwork for the Fusion Simulation Project (FSP). The FSP will be a focused, interdisciplinary effort, whose objective is to develop the capability to predict reliably the behavior of fusion plasma. The NGA effort ($2,000,000) for applications teams working in close partnership with systems evaluation teams is shifted to the Computer Science activity FY 2005.

	FY 2003	FY 2004	FY 2005
Advanced Computation, Communications Research, and Associated Activities...	**91,619**	**110, 553**	**112,389**
▪ **Networking**	**8,736**	**7,066**	**5,784**

The DOE national laboratories, the unique instruments and facilities at those laboratories, and the university community contributing to the DOE missions create a complex, distributed system that is conducting scientific research on a wide range of problems that depend, increasingly, on high-performance network infrastructure. This program activity is one component of an integrated ASCR effort to develop and deploy a scalable, secure, integrated environment to support these network-intensive science applications, a Network Environment. The components of this effort are the MICS activities: Network Research, Collaboratory Tools, and Collaboratory Pilots. Together, these activities support research and development in high performance networking and middleware along with collaboratory pilots and testbeds that are largely partnerships with other program offices to test, demonstrate, and validate the technologies that derive from that research.

This activity advances the Network Environment vision by supporting research and development in high-performance networks needed to develop and deploy advanced networking capabilities to address challenging issues such as ultra-high-speed data transfers, remote visualization, real-time remote instrumentation, and large-scale scientific collaboration. Networking research is carried out at national laboratories and universities and consists of two major elements:

Network R&D – to address the fundamental issues of high-performance networks to support access to the next generation of scientific facilities, terascale computing resources and distributed petabyte-scale data archives. Network R&D focuses on leading-edge networking technologies such as ultra optical transport protocols and services for ultra high-speed data transfers; techniques and tools for ultra high-speed network measurement and analysis; advanced network tools and services to enable network-aware, high-end scientific applications; and scalable cyber-security technologies for open science environment.

Advanced experimental networking – to accelerate the adoption of emerging networking technologies and to transfer networking R&D results into production networks that support science applications. It includes activities such as experimental networking testbeds, advanced deployment and evaluation of new networking technologies, and exploration of advanced

	(dollars in thousands)	
FY 2003	FY 2004	FY 2005

networking concepts. A rapid adoption of emerging network capabilities into production networks will enable scientists pushing the limits of today's networks capabilities to use networking technologies to conduct far-reaching experiments.

There is a decrease of $1,282,000 in the level of support for network research activities in FY 2005. This will reduce research activities at universities and laboratories in high performance network protocols and optical networks. This decrease is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.

	FY 2003	FY 2004	FY 2005
▪ **Collaboratory Tools**	**7,403**	**5,527**	**5,527**

The DOE national laboratories, the unique instruments and facilities at those laboratories, and the university community contributing to the DOE missions create a complex, distributed system that is conducting scientific research on a wide range of problems that depend, increasingly, on high-performance network infrastructure. This program activity is one component of an integrated ASCR effort to develop and deploy a scalable, secure, integrated environment to support these network-intensive science applications, a Network Environment. The components of this effort are the MICS activities: Network Research, Collaboratory Tools, and Collaboratory Pilots. Together, these activities support research and development in high performance networking and middleware along with collaboratory pilots and testbeds that are largely partnerships with other program offices to test, demonstrate, and validate the technologies that derive from that research.

This activity advances the network environment vision by supporting research that builds on results of fundamental research in computer science and networking to develop an integrated set of software tools to support scientific collaborations. These tools provide a new way of organizing and performing scientific work that offers the potential for increased productivity and efficiency and will also enable broader access to important DOE facilities and data resources by scientists and educators throughout the country. It is particularly important to provide for efficient, high-performance, reliable, secure, and policy-aware management of large-scale data movement. This research includes an effort to develop a set of essential middleware services required to support large-scale data-intensive collaboratory applications. This research also includes an effort to research, develop, and integrate the tools required to support a flexible, secure, seamless collaboration environment that supports the entire continuum of interactions between collaborators. The goal is to seamlessly allow collaborators to locate each other; use asynchronous and synchronous messaging; share documents, progress, results, and applications; and hold videoconferences. There is also research for developing and demonstrating an open, scalable approach to application-level security in widely distributed, open network environments that can be used by all the collaboratory tools as well as by the advanced computing software tools whenever access control and authentication are issues.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
▪ **National Collaboratory Pilot Projects**....................	**9,380**	**10,857**	**8,013**

The DOE national laboratories, the unique instruments and facilities at those laboratories, and the university community contributing to the DOE missions create a complex, distributed system that is conducting scientific research on a wide range of problems that depend, increasingly, on high-performance network infrastructure. This program activity is one component of an integrated ASCR effort to develop and deploy a scalable, secure, integrated environment to support these network-intensive science applications, a Network Environment. The components of this effort are the MICS activities: Network Research, Collaboratory Tools, and Collaboratory Pilots. Together, these activities support research and development in high performance networking and middleware along with collaboratory pilots and testbeds that are largely partnerships with other program offices to test, demonstrate, and validate the technologies that derive from that research.

This activity advances the Network Environment vision by supporting research that tests, validates, and applies collaboratory tools in real-world situations in partnership with other DOE programs. The competitively selected partnerships involve national laboratories, universities, and U.S. industry. It is important to demonstrate and test the benefits of collaboratory tools' evolving technology in order to promote their widespread use and enable more effective access to the wide range of resources within the Department, from light sources to terascale computers to petabyte data storage systems. The partnerships that were initiated in FY 2001 focus on developing user environments where collaboration is ubiquitous and distributed computing is seamless and transparent for DOE mission applications. The Particle Physics Data Grid is developing middleware infrastructure to support High Energy Physics (HEP) and Nuclear Physics (NP) communities, and to enable grid-enabled data-management ("manipulation") and analysis capabilities "at the desk of every physicist." It is building one unified system that will be capable of handling the capture, storage, retrieval and analysis of particle physics experiments at the five most critical research facilities, a key collaboratory issue being the highly distributed access to, and processing of, the resulting data by a worldwide research community. In another scientific community, the Earth System Grid II is developing a virtual collaborative environment linking distributed centers, models, data, and users that will facilitate exchange among climatologists all over the world and provide a needed platform for the management of the massive amounts of global climate data that are being generated. Development of this and similar concepts is essential for rapid, precise, and convincing analysis of short- and long-term weather patterns, particularly in the period when increasing pollution introduces changes that may affect us for generations to come. The National Fusion Collaboratory is centered on the integration of collaborative technologies appropriate for widely dispersed experimental environments and includes elements of security, distributed systems, and visualization. All three of these pilot collaboratories will rely on the DOE Science Grid to provide the underpinnings for the software environment, the persistent grid services that make it possible to pursue innovative approaches to scientific computing through secure remote access to online facilities, distance collaboration, shared petabyte datasets and large-scale distributed computation.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

There is a decrease of $2,844,000 in the level of support for National Collaboratory Pilot projects due to the accelerated rampdown of selected efforts. This decrease is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.

▪ **National Energy Research Scientific Computing Center (NERSC)**...	**22,515**	**31,906**	**37,868**

Located in a single facility at the Lawrence Berkeley National Laboratory (LBNL), NERSC delivers high-end capability computing services and support to the entire DOE Office of Science (SC) research community. NERSC provides these services to the DOE community, to the other DOE laboratories, and to major universities performing work relevant to DOE missions. NERSC provides the majority of resources and services that are used to support the Office of Science SciDAC program. The Center serves 2,000 users working on about 700 projects; 35 percent of users are university based, 61 percent are in National Laboratories, 3 percent are in industry, and 1 percent in other government laboratories. The major computational resource at NERSC is an IBM SP computer. The initial installation of hardware, which was completed in FY 2001 following a fully competitive process, provided a peak performance of 5 trillion floating point operations per second (teraflops) to its users. The capability of this system was increased to 10 teraflops following the acquisition of additional computer hardware in FY 2003. The FY 2005 funding will support the continued operation of the IBM SP computer at 10 teraflops peak performance. These computational resources are integrated by a common high performance file storage system that facilitates interdisciplinary collaborations. Related requirements for capital equipment, such as high-speed disk storage systems, archival data storage systems, and high performance visualization hardware, and general plant projects (GPP) funding are also supported. FY 2005 capital equipment requirements for these types of capital equipment remain at the same level as in FY 2004.

In FY 2004 and FY 2005, the NERSC budget is increased as a part of an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures. This enhancement will enable NERSC to competitively procure a significant new high performance computer to support the missions of the Office of Science. The enhancement at NERSC will deliver an increase of approximately 30% in the high performance computing resources available to scientists as well as associated improvements in storage and network systems to enable scientists to most effectively use NERSC resources.

▪ **Advanced Computing Research Testbeds (ACRTs)**	**25,934**	**36,909**	**36,909**

This activity supports the acquisition, testing and evaluation of advanced computer hardware testbeds to assess the prospects for meeting future computational needs of the Office of Science, such as SciDAC and special purpose applications. The ACRT activity will provide two types of

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

computer testbeds for evaluation - early systems and experimental systems. Each testbed will involve significant research and architecture design activities. These research and evaluation (R&E) prototypes have been identified as a critical element in the HECRTF plan because they enable early partnership with vendors to tailor architectures to scientific requirements. The results from these partnerships also play a key role in the choice of both high performance production systems and potential leadership class systems government-wide.

The FY 2005 request continues an enhanced scope for the hardware evaluation testbed in the Next Generation Architecture (NGA) research activity as a part of an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures. A goal of these testbeds is to identify and address major architectural bottlenecks, such as: internal data movement in very large systems, to the performance of existing and planned DOE science applications. Total funding for the testbed activities in the NGA is $31,553,000. Emphasis will be placed on understanding the impact of alternative computer architectures on application performance with particular attention paid to data movement from memory to processor and between processors in highly parallel systems. The enhanced scope in the hardware evaluation testbed will improve our ability to understand key issues impacting application performance scalability. The NGA activity will be coordinated with other Federal agencies to gain additional insight into research directions, optimize the utilization of resources, and establish the framework for a national effort and is aligned with the goals of the HECRTF plan. Funding for these testbeds will be allocated through peer reviewed competition. These testbeds, coupled with the NGA software research, play a critical role in enabling potential future leadership class scientific computing facilities for open science.

▪ **Energy Sciences Network (ESnet)**	**17,651**	**18,288**	**18,288**

ESnet is a Wide Area Network (WAN) project that supports the scientific research mission of the Department of Energy. The ESnet project/investment supports the agency's mission and strategic goals and objectives by providing DOE with interoperable, effective, and reliable communications infrastructure and leading-edge network services in support of the agency's science research missions. ESnet supplies the DOE science community with capabilities not available through commercial networks or the commercial Internet. ESnet provides national and international high-speed access to DOE and Office of Science researchers and research facilities, including: light sources; neutron sources; particle accelerators; fusion reactors; spectrometers; supercomputers; and other high impact scientific instruments. ESnet provides the communications fabric that interconnects geographically distributed research facilities and large-scale scientific collaborations. ESnet supplies the critical infrastructure that links DOE researchers worldwide and forms the basis for advanced experimental research in networking, collaboratory tools, and distributed data-intensive scientific applications testbeds such as the national collaboratory pilot projects. ESnet provides network services through contracts with commercial vendors for advanced communications services including Asynchronous Transfer Mode (ATM), Synchronous Optical Networks (SONET) and Dense Wave Division Multiplexing (DWDM). ESnet provides interfaces between the network fabric it provides and peering arrangements with other Federal,

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

education and commercial networks, international research network connections, and the University Corporation for Advanced Internet Development (UCAID) Abilene network that provides high performance connections to many research universities.

In FY 2005, funds will be used to operate ESnet and to continue support for upgrading the capability of the ESnet backbone to 10,000 million bits per sec (Mbps) from its current capability of 155 Mbps. Remaining funds will be used to upgrade networking hardware and services at high priority ESnet sites to exploit the enhanced performance capabilities of the backbone. FY 2005 capital equipment requirements remain at the same level as in FY 2004.

	FY 2003	FY 2004	FY 2005
SBIR/STTR	**0**	**5,438**	**5,546**

In FY 2003, $3,942,000 and $236,000 were transferred to the SBIR and STTR programs, respectively. The FY 2004 and FY 2005 amounts are the estimated requirement for the continuation of the SBIR and STTR program.

	FY 2003	FY 2004	FY 2005
Total, Mathematical, Information, and Computational Sciences	**160,367**	**199,292**	**204,340**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Mathematical, Computational, and Computer Sciences Research	
▪ **Applied Mathematics**. Provides an increase to support initiation of Atomic to Macroscopic Mathematics research effort ($+8,500,000). The increase is offset by a decrease of $1,772,000 from the existing program.	+6,728
▪ **Computer Science.** Core research is decreased $2,000,000 to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures. This decrease is offset by NGA funding of $2,000,000 transferred from Scientific Application Partnerships.	0
▪ **Advanced Computing Software Tools.** Decrease in last year of SciDAC program for ISICs resulting from rampdown of selected efforts. This decrease is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.	-894

	FY 2005 vs. FY 2004 ($000)
▪ **Scientific Application Partnerships.** The change in this activity includes reductions in partnerships with BER ($-367,000) and BES ($-472,000) and an increase of $1,350,000 to expand SciDAC partnerships with the Fusion Energy Sciences program to lay the groundwork for the Fusion Simulation Project (FSP). The NGA effort for applications teams working in close partnership with systems evaluations teams is shifted to the Computer Science activity in FY 2005 ($-2,000,000). A decrease in core research ($-1,241,000) is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.	-2,730
Advanced Computation, Communications Research, and Associated Activities	
▪ **Network Research**. Decrease in level of support for network research activities. This will reduce research activities at universities and laboratories in high performance network protocols and optical networks. This decrease is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.	-1,282
▪ **National Collaboratory Pilots.** Decrease in the level of support for National Collaboratory Pilot projects because of accelerated rampdown of selected efforts. This decrease is required to support an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.	-2,844
▪ **National Energy Research Scientific Computing Center.** Provides an increase to enable installation of a major new resource for computational scientists with an architecture different from the current NERSC resource. This increase supports an Office of Science strategy to acquire additional advanced computing capability to support existing users in the near term and to initiate longer-term research and development on next generation computer architectures.	+5,962
SBIR/STTR	
▪ Increase in SBIR/STTR due to increase in operating expenses.	+108
Total Funding Change, Mathematical, Information, and Computational Sciences	**+5,048**

Laboratory Technology Research

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
Laboratory Technology Research	2,818	2,916	0	-2,916	-100%
SBIR/STTR	0	84	0	-84	-100%
Total, Laboratory Technology Research	2,818	3,000	0	-3,000	-100%

Description

The Laboratory Technology Research (LTR) subprogram will be brought to a successful conclusion in FY 2004 with orderly completion of all existing CRADAs. The mission of the Laboratory Technology Research subprogram was to support high-risk research that advances science and technology to enable applications that could significantly impact the Nation's energy economy. LTR fostered the production of research results motivated by a practical energy payoff through cost-shared collaborations between the Office of Science (SC) laboratories and industry. The termination of the LTR subprogram does not mean that technology transfer activities have ended; rather, due to the impact of this subprogram, these activities are now institutionalized as a part of the process of doing research at DOE sites.

Benefits

LTR supported ASCR's contribution to DOE's mission of world-class scientific research capacity by promoting the transfer of these research results to the private sector. The success of this program has institutionalized these processes in all of the programs within the Office of Science; therefore these processes are now integrated into the other programs and the LTR subprogram is no longer needed.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Laboratory Technology Research	**2,818**	**2,916**	**0**

This activity supported research to advance the fundamental science at the Office of Science (SC) laboratories toward innovative energy applications. Through CRADAs, the SC laboratories entered into cost-shared research partnerships with industry, typically for a period of three years, to explore energy applications of research advances in areas of mission relevance to both parties. The existence of the LTR subprogram fostered the institutionalization of technology transfer activities at DOE sites. Now that these activities are institutionalized, a separate program to fund them is no longer necessary.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
SBIR/STTR	**0**	**84**	**0**

In FY 2003, $75,000 and $5,000 were transferred to the SBIR and STTR programs, respectively. The FY 2004 amount is the estimated requirement for the continuation of the SBIR and STTR program.

	FY 2003	FY 2004	FY 2005
Total, Laboratory Technology Research	**2,818**	**3,000**	**0**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Laboratory Technology Research	
▪ The Laboratory Technology Research subprogram will be brought to a successful completion in FY 2004, as planned.	-2,916
SBIR/STTR	
▪ Decrease in SBIR/STTR due to completion of the LTR subprogram.	-84
Total Funding Change, Laboratory Technology Research	**-3,000**

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Capital Equipment (total).........................	3,962	6,290	6,250	-40	-0.6%

Science Laboratories Infrastructure

Funding Profile by Subprogram

(dollars in thousands)

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Science Laboratories Infrastructure					
Laboratories Facilities Support	32,194	33,456	-186[a]	33,270	17,911
Excess Facilities Disposition	7,900	6,055	-35[a]	6,020	6,100
Oak Ridge Landlord	5,015	5,079	-30[a]	5,049	5,079
Health & Safety Improvements	0	10,000	-59[a]	9,941	0
Subtotal, Science Laboratories Infrastructure	45,109	54,590	-310[a]	54,280	29,090
Use of Prior Year Balances	0	-1,998	0	-1,998	0
Total, Science Laboratories Infrastructure	45,109[b]	52,592	-310[a]	52,282	29,090

Public Law Authorizations:
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance and Results Act of 1993"

Mission

The mission of the Science Laboratories Infrastructure (SLI) program is to enable the conduct of Departmental research missions at the ten Office of Science (SC) laboratories and the Oak Ridge Institute for Science and Education (ORISE) by funding line item construction to maintain the general purpose infrastructure (GPI) and the clean-up and removal of excess facilities. The program also supports SC landlord responsibilities for the 36,000 acre Oak Ridge Reservation; provides Payments in Lieu of Taxes (PILT) to local communities around Argonne National Laboratory-East (ANL-E), Brookhaven National Laboratory (BNL), and Oak Ridge National Laboratory (ORNL); and provides for the correction of Occupational Safety & Health Administration (OSHA) and Nuclear Regulatory Commission (NRC) identified deficiencies and implementation of recommendations for improved health and safety practices at SC laboratories.

Benefits

This program supports the conduct of Departmental research missions at the ten SC laboratories and the Oak Ridge Reservation, including the Federal facilities in the town of Oak Ridge, primarily by addressing general purpose facilities and infrastructures needs.

[a] Excludes $310,110 for a rescission in accordance with the Consolidated Appropriations Act, 2004, as reported in conference report H.Rpt. 108-401, dated November 25, 2003.

[b] Excludes $296,000 for a rescission in accordance with the Consolidated Appropriations Resolution, FY 2003.

Significant Program Shifts

Progress in Line Item Projects – One project was completed in FY 2003: ORNL Electrical Systems Upgrades. Six projects are scheduled for completion in FY 2004: BNL Groundwater and Surface Water Protection Upgrades; BNL Electrical Systems Modifications, Phase II; LBNL Site-wide Water Distribution System Upgrades; ORNL Laboratory Facilities HVAC Upgrade; ORNL Fire Protection System Upgrades; and the ANL-E Fire Safety Improvements, Phase IV. In FY 2005, two projects are scheduled for completion: ORNL Research Support Center; and the ANL-E Mechanical and Control Systems Upgrades-PH I.

In FY 2004, Congress appropriated $10,000,000 to address the OSHA and NRC identified health and safety deficiencies and recommendations for improved health and safety practices at SC laboratories. This $10,000,000 is sufficient to address the most significant health and safety issues at the laboratories. If the Administration determines that health and safety issues remain, resources will be requested in future years as necessary.

Laboratories Facilities Support

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
Laboratory Facilities Support					
General Purpose Facilities	18,868	24,619	9,283	-15,336	-62.3%
Environment, Safety and Health	12,319	7,140	7,108	-32	-0.5%
Payment in Lieu of Taxes (PILT)	1,007	1,511	1,520	+9	+0.6%
Total, Laboratories Facilities Support	32,194	33,270	17,911	-15,359	-46.2%

Description

The Laboratories Facilities Support (LFS) subprogram improves the mission readiness of Office of Science (SC) laboratories by funding line item construction projects to refurbish or replace general purpose facilities and the site-wide infrastructure.

Benefits

This subprogram improves the mission readiness of SC laboratories by funding line item construction projects to refurbish or replace general purpose facilities and site-wide infrastructure. The subprogram also provides Payments in Lieu of Taxes (PILT) assistance as required by law for communities surrounding Brookhaven National Laboratory and Argonne National Laboratory –East.

Supporting Information

General purpose and site-wide infrastructure includes administrative, research laboratory, user support and testing space as well as cafeterias, power plants, fire stations, electrical, gas and other utility distribution systems, sanitary sewers, roads, and other associated structures. The 10 SC laboratories have over 2,400 buildings (including 787 trailers and 150 excess buildings) with a total square footage of over 21,000,000 square feet. The LFS subprogram also provides Payments in Lieu of Taxes (PILT) assistance for communities surrounding Brookhaven National Laboratory and Argonne National Laboratory-East.

Capital investment requirements for SC laboratories are identified in laboratory Strategic Facilities Plans. These plans assume the full modernization/revitalization of the infrastructure of the laboratories will be completed over a ten-year period and include priority lists of proposed facilities and infrastructure needs. The backlog of line item construction modernization needs as summarized in SC's 2003 Update of the "*Infrastructure Frontier Report: A Quick Look Survey of the Office of Science Laboratory Infrastructure*," is on the order of $1 billion. Nearly 85% of this total is to rehabilitate or replace buildings.

The large backlog of line item construction needs is attributable to:

- the age of the facilities (over 69% of the buildings are 30 years old or older, and 43% are 40 years old or older);

- the use of wood and other non-permanent building materials in the original construction of the laboratories in the 40's and 50's;
- changing research needs that require:
  - different kinds of space (e.g., nuclear facilities including hot cells are in less demand while facilities that foster interaction and team-based research are in high demand); and
  - higher quality of space (e.g., reduced vibration sensitivity and temperature variability, and increased air quality and power demand for computers and other electronic equipment);
- obsolescence of existing building systems and components and changing technology (e.g., digital controls for heating and ventilation systems, fire alarms, security);
- increased requirements for continuity of utility operations to support large user population at SC user research facilities; and
- changing environmental, safety and health regulations and security needs.

For each budget, all candidate construction projects for funding by the LFS subprogram are scored using the DOE Life Cycle Asset Management (LCAM) Cost-Risk-Impact Matrix that takes into account risk, impacts, and mission need. The projects that have ES&H as the principal driver are further prioritized using the Risk Prioritization Model from the DOE ES&H and Infrastructure Management Plan process. Based on these scores, the LFS subprogram prioritizes the projects. The prioritized list is further evaluated for SC science program mission impact by an integrated infrastructure management team composed of the LFS subprogram and SC research program offices. Projects are then proposed from this list consistent with budget availability.

The LFS subprogram ensures that the funded projects are managed effectively and completed within the established cost, scope and schedule baselines. Performance will be measured by the number of all SLI projects completed within the approved baseline for cost (at or below the appropriated Total Estimated Cost), scope (within 10%), and schedule (within six months). One project scheduled for completion in FY 2003 was completed within the approved baselines for cost, scope, and schedule.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
General Purpose Facilities	**18,868**	**24,619**	**9,283**

Provides funding to support the continuation of two FY 2003 subprojects under the Science Laboratories Infrastructure (MEL-001) Project Engineering and Design (PED) and construction project data sheets. These are summarized below. More details are provided in the data sheets presented later.

Ongoing :

- LBNL Building 77 Rehabilitation of Structures and Systems, Phase II ($4,825,000)
- BNL Research Support Building, Phase I ($4,458,000)

	FY 2003	FY 2004	FY 2005
	(dollars in thousands)		
Environment, Safety and Health	**12,319**	**7,140**	**7,108**

Provides funding to support the continuation of one FY 2004 subproject under the Science Laboratories Infrastructure (MEL-001) construction project data sheet. It is summarized below. More details are provided in the data sheet presented later.

Ongoing:

- SLAC Safety and Operational Reliability Improvements ($7,108,000)

	FY 2003	FY 2004	FY 2005
PILT	**1,007**	**1,511**	**1,520**

Provide Payments in Lieu of Taxes (PILT) to support assistance requirements for communities surrounding Brookhaven National Laboratory and Argonne National Laboratory-East. PILT payments are negotiated between the Department and local governments based on land values and tax rates.

	FY 2003	FY 2004	FY 2005
Total, Laboratories Facilities Support	**32,194**	**33,270**	**17,911**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
General Purpose Facilities (GPF)	
▪ Reduction in the General Purpose Facilities (GPF) area reflects the cancellation of the PNNL Laboratory Systems Upgrades subproject. The facilities to be rehabilitated under this subproject are now scheduled for removal under the River Corridor clean-up project and further investment is unnecessary. The remaining funds are redirected to two ongoing subprojects: TJNAF CEBAF Center Addition – Phase I and the BNL Research Support Building – Phase I, in FY 2004. This reduced the funding required for FY 2005 mortgages for these projects. Also, funding for two on-going subprojects, the BNL Research Support Building and the LBNL Building 77 Rehab, is reduced, extending funding schedules for both into FY 2006.	-15,336
Environmental Safety & Health (ES&H)	
▪ Reduction in the ES&H area reflects the completion of several ES&H projects resulting from significant past ES&H investment and shifting of SC program priorities. Funding is included for the SLAC Safety and Operational Reliability Improvements project.	-32

	FY 2005 vs. FY 2004 ($000)
PILT	
▪ PILT is continued close to the FY 2004 level.	+9
Total Funding Change, Laboratories Facilities Support	**-15,359**

Excess Facilities Disposition

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
Excess Facilities Disposition	7,900	6,020	6,100	+80	+1.3%

Description

The Excess Facilities Disposition (EFD) subprogram removes excess facilities at the SC laboratories to reduce long-term costs and liabilities in support of programmatic initiatives (e.g., making land available for new programs). In addition to removal of excess facilities, the subprogram will also clean-up facilities for reuse where such reuse is economical and can provide needed functionality.

Benefits

This subprogram reduces the long-term costs, risks and liabilities at the SC laboratories associated with excess facilities by removing them and cleaning them up for reuse or transfer. It also supports programmatic initiatives by making land available for new programs and reducing expenditures on surveillance and maintenance of excess facilities.

Supporting Information

The EFD subprogram evaluates and prioritizes the backlog based on footprint reduction, risk reduction (e.g., removal of hazards), availability of space/land for research activities, and cost savings (e.g., elimination of surveillance and maintenance costs). The prioritized list is further evaluated for mission impact by an integrated infrastructure management team composed of the EFD subprogram and SC research program offices. The estimated backlog of non-contaminated or slightly contaminated facilities at the beginning of FY 2005 will be approximately $12,000,000.

The EFD subprogram does not fund projects that replace currently active and occupied buildings (e.g., old, deteriorated and marginally functional ones that are still used but are to be replaced by new modern buildings). Such building replacement projects are funded under the previously described LFS subprogram and would include removal of the old buildings as part of the justification for the project.

It should be noted that the EFD subprogram does not include projects involving cleanout and stabilization of contaminated facilities proposed for transfer to the Office of Environmental Management (EM) for ultimate disposition. At issue are 29 process-contaminated facilities at SC laboratories with an estimated decontamination and decommissioning (D&D) cost of $175,000,000. The Department is currently reviewing its existing facility transfer policies.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Excess Facilities Disposition..	**7,900**	**6,020**	**6,100**

In FY 2003, funding of $7,900,000 supports the 8 projects listed below and allows for the clean-up/removal of an estimated 460,000 square feet of space:

- ANL-E ($1,100,000) – Decontamination of Building 306 C132A&B; Decontamination of Building 306 Room D-001 and D-002 Cell; Partial Disposal of Building 202 (Kennels) (approximately 9,000 sq. ft.)
- BNL ($1,025,000) – Demolition of Buildings 89, 90, 91, 158, 184 and 206 (approximately 57,000 sq. ft.)
- FNAL ($362,000) – Demolition of four muon enclosures, Laser Building and Laboratory G trailer and slab, and Shed B at Site 50 (approximately 7,800 sq. ft.)
- LBNL ($2,450,000) – Removal of B51A beamline and demolition of Structure 51B External Proton Beam (EPB) Hall (approximately 48,000 sq. ft.) which are part of the retired Bevatron accelerator complex.
- LLNL ($250,000) – Demolition of the Magnetic Fusion Energy bridge and utility lines (approximately 1,000 sq. ft.)
- ORNL ($2,155,000) – Cleanout of Buildings 9204-1, 9999-3, 2011 and 9204-1 Scrap Yard; Demolition of Buildings 0961, 2093 and 3013 (approximately 270,000 sq. ft.)
- SLAC ($13,000) – Cleanout of Lauritsen Laboratory at California Institute of Technology (approximately 55,000 sq. ft.)
- PPPL ($545,000) – Removal of Princeton Beta Experiment Modification (PBX) Princeton Large Torus (PLT) control room and initial subsystems (approximately 12,000 sq. ft.)

In FY 2004, funding of $6,020,000 will support the 9 projects listed below and allows for the clean-up/removal of an estimated 84,000 square feet of space:

- Ames ($150,000) - Waste Handling Facility Closeout and Demolition, Phase 1
- ANL-E ($749,000) – Building 202 (N&P Kennels) Partial Disposal, Building 202,D-149 Lead Vault Demolition, and Building 205 G101 Junior Cave Remediation (approximately 4,400 sq. ft.)
- BNL ($725,000) – Demolition of Buildings 206/207/208/457/458 (approximately 34,000 sq. ft.)
- FNAL ($233,000) – Bubble Chamber Demolition (approximately 3,000 sq. ft.)
- LBNL ($500,000) – Remove Upper Layer Roof Concrete Shielding Blocks & Beamline Components from Building 51 of the retired Bevatron accelerator complex.
- LLNL ($250,000) – Demolition of Magnetic Fusion Energy Legacy Facilities at Building 445, Phase I (approximately 8,000 sq. ft.)

	(dollars in thousands)	
FY 2003	FY 2004	FY 2005

- ORNL ($760,000) – Demolition of Buildings 2069 and 7009 (approximately 17,000 sq. ft.)
- PPPL ($980,000) – Princeton Beta Experiment Modification (PBX)/Princeton Large Torus (PLT) final subsystem removals and cooling tower demolition (approximately 18,200 sq. ft.)
- SLAC ($150,000) - Demolish Portion of Sector 17 "Boneyard" (approximately 4 acres)
- Unallocated ($1,523,000) – To be allocated to other priority projects in FY 2004. $1,000,000 of the reserve is designated for the 88" cyclotron at LBNL in accordance with the FY 2004 appropriation committee report language. Because the 88" cyclotron will continue to operate in FY 2004 and FY 2005, a request has been submitted to Congress to apply these funds for the continued clean-out of retired Bevatron accelerator complex at LBNL.

In FY 2005, funding of $6,100,000 will support at least the 9 projects listed below and allow for the clean-up/removal of more than 61,000 square feet of space:

- Ames ($150,000) - Waste Handling Facility Closeout and Demolition, Phase 2 (approximately 9,000 sq. ft.)
- ANL-E ($2,120,000) - Building 40 (Instrument Calibration) Disposal and Partial Facility Demolitions (approximately 8,000 sq. ft.)
- BNL ($300,000) - Demolition of Buildings 428 and 492, and partial demolition of Buildings 197 and 244 (approximately 6,000 sq. ft.)
- FNAL ($125,000) – Demolition of two muon enclosures (approximately 2,000 sq. ft.)
- LBNL ($1,360,000) - Removal of portions of the retired Bevatron accelerator complex including a trailer, small building and injector (approximately 7,000 sq. ft.)
- LLNL ($300,000) - Demolition of Magnetic Fusion Energy Legacy Facilities at Building 445, Phase 2 (approximately 7,000 sq. ft.)
- ORISE ($565,000) – Demolition of Building SC-2, Isotope Laboratory (approximately 550 sq. ft.)
- ORNL ($780,000) - Demolition of Buildings 5000, 2018, 7010, 2016, 3008 and 3111 (approximately 19,000 sq. ft.)
- SLAC - ($400,000) – Demolition of HRS Detector in Building 660 (approximately 2,000 sq. ft.)

Individual projects and amounts are subject to revision based on evolving program priorities including risk reduction (e.g., removal of hazards), footprint reduction, cost savings (e.g., elimination of surveillance and maintenance costs), and availability of space/land for new research activities.

	FY 2003	FY 2004	FY 2005
Total, Excess Facilities Disposition	**7,900**	**6,020**	**6,100**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Excess Facilities Disposition	
▪ Excess Facilities Disposition is continued close to the FY 2004 level.	+80

Oak Ridge Landlord

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Oak Ridge Landlord	5,015	5,049	5,079	+30	+0.6%

Description

The Oak Ridge Landlord subprogram supports activities to maintain continuity of operations at the Oak Ridge Reservation (ORR) and the Oak Ridge Operations Office (ORO).

Benefits

This subprogram maintains continuity of operations at the Oak Ridge Reservation and the Oak Ridge Operations Office by minimizing interruptions due to infrastructure and/or other systems failures. The subprogram also provides Payments in Lieu of Taxes (PILT) assistance as required by law for communities surrounding Oak Ridge.

Supporting Information

The subprogram supports landlord responsibilities, including infrastructure for the 24,000 acres of the ORR outside of the Y-12 plant, ORNL, and the East Tennessee Technology Park, plus DOE facilities in the town of Oak Ridge. This includes roads and grounds and other infrastructure maintenance, Environment, Safety and Health (ES&H) support and improvements, PILT for Oak Ridge communities, and other needs related to landlord requirements. These activities maintain continuity of operations at the Oak Ridge Reservation and the ORO and minimize interruptions due to infrastructure and/or other systems failures.

Detailed Justification

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
Roads, Grounds and Other Infrastructure and ES&H Support and Improvements	**2,424**	**2,458**	**1,602**
Road maintenance, reservation mowing, bridge inspections, and records management.			
General Purpose Equipment	**0**	**0**	**150**
Replacement of two aging high maintenance fuel tanker trucks.			
General Plant Projects	**0**	**0**	**736**
Major road repair and renovation of the Federal Building including electrical systems, restrooms, and exterior shell.			
Payments in Lieu of Taxes (PILT)	**2,300**	**2,300**	**2,300**
Payments in Lieu of Taxes (PILT) to the City of Oak Ridge, and Anderson and Roane Counties.			

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Reservation Technical Support..	**291**	**291**	**291**
Includes recurring activities such as site mapping, National Archives Records Administration, support for legacy legal cases, and real estate activities.			
Total, Oak Ridge Landlord	**5,015**	**5,049**	**5,079**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Oak Ridge Landlord	
▪ Landlord activities are continued close to the FY 2004 level.	+30

Health and Safety Improvement

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
Health and Safety Improvement..................	0	9,941	0	-9,941	-100%

Description

The Health and Safety Improvements subprogram corrects health and safety deficiencies at SC laboratories to ensure consistency with Occupational Safety and Health Administration (OSHA) and Nuclear Regulatory Commission (NRC) requirements.

Benefits

This subprogram improves health and safety practices at SC laboratories to ensure consistency with Occupational Safety and Health Administration and Nuclear Regulatory Commission safety requirements.

In FY 2003, Congress directed the OSHA and NRC to perform inspections at the 10 SC laboratories. The purpose of these inspections was to document those deficiencies that would be identified if the Department were regulated by the OSHA and NRC, and to provide recommendations for improved health and safety practices.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Health and Safety Improvements	**0**	**9,941**	**0**

The deficiencies include: electrical hazards, machine guarding, legacy material removal, material handling, ladder compliance, inadequate building egress, crane hazards, exhaust ventilation, and eyewash station availability and operability.

Explanation of Funding Change

	FY 2005 vs. FY 2004 ($000)
Health and Safety Improvements	
It is expected that the FY 2004 funding will address the most significant health and safety issues at the laboratories. If the Administration determines that health and safety issues remain, resources will be requested in future years as necessary.	-9,941

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
General Plant Projects (ORO Landlord)	0	0	736	+736	--
Capital Equipment (ORO Landlord)	0	0	150	+150	--
Capital Equipment (Excess Facilities Disposition)	75	0	0	0	--
Total, Capital Operating Expenses...................	75	0	886	+886	--

Construction Projects

	(dollars in thousands)					
	Total Estimated Cost (TEC)	Prior Year Approp- riations	FY 2003	FY 2004	FY 2005	Unapprop. Balance
Project – 03-SC-001 Laboratories Facilities Support Project						
FY 2003 PED Datasheet.......................	N/A	N/A	3,313	0	0	0
Project – 04-SC-001 Laboratories Facilities Support Project						
FY 2004 PED Datasheet.......................	N/A	N/A	0	1,988	0	0
Project - MEL-001 Laboratories Facilities Support Project						
FY 2005 Construction Datasheet	N/A	N/A	27,874	29,771	16,391	15,869
Total, LFS Construction...............................	N/A	N/A	31,187	31,759	16,391	15,869

MEL-001 – Science Laboratories Infrastructure Project, Various Locations

(Changes from FY 2004 Congressional Budget Request are denoted with a vertical line in the left margin.)

Significant Changes

Subproject 18 – Laboratory Systems Upgrades (PNNL) is cancelled. The buildings that were to be rehabilitated under this project will be removed under the Office of Environmental Management funded Corridor Clean-up project at the Hanford Site.

1. Construction Schedule History

Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		

N/A -- See subproject details

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Project Engineering & Design (PED)			
Prior Years	3,183[a]	3,183	1,374
FY 2003	3,313[b]	3,313	2,663
FY 2004	1,988[c]	1,988	3,259
FY 2005	0	0	1,188
Construction			
Prior Years	21,111	21,111	12,162
FY 2003	27,874	23,924	20,733
FY 2004	29,771	31,742	28,682
FY 2005	16,391	16,391	23,945
FY 2006	15,869	15,869	16,015
FY 2007	0	0	7,500

[a] Title I and Title II Design funding of $880,000 (Subproject 18); $803,000 (Subproject 17); and $1,500,000 (Subproject 25) provided under PED Project No. 02-SC-001.

[b] Title I and Title II Design funding of $1,679,000 (Subproject 27); $1,089,000 (Subproject 28); $545,000 (Subproject 33) requested under PED Project No. 03-SC-001.

[c] Title I and Title II Design funding of $1,988,000 requested under PED Project No. 04-SC-001.

3. Project Description, Justification and Scope

This project funds two types of subprojects:

- Projects that renovate or replace inefficient and unreliable general purpose facilities (GPF) including general use, service and user support facilities such as administrative space, cafeterias, utility systems, and roads; and
- Projects to correct Environment, Safety, and Health (ES&H) deficiencies including deteriorated steam lines, environmental insult, fire safety improvements, sanitary system upgrades and electrical system replacements.

General Purpose Facilities Projects:

a. Subproject 15 – Laboratory Facilities HVAC Upgrade (ORNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
7,055	3,500	3,555	0	0	0	3Q 2002 – 2Q 2004

This project will provide improvements to aging (average 38 years old) HVAC systems located throughout the 13 buildings which comprise ORNL's central research complex, thereby improving the research environment and reducing operations and maintenance costs. Work will include: 1) installation of a primary/secondary Central Chilled Water Plant pumping system by replacing existing inefficient primary and booster pumps with a variable volume distribution system and 2-way chilled water control valves; 2) installation of a chilled water cross-tie to Buildings 4501/4505 from the underground tie-line between Buildings 4500N and 4509 to address low capacity problems; 3) upgrading of a corroded hot water reheat distribution system which supplies reheat water for zone control of the primary air handlers; 4) upgrade of deteriorated air handlers in selected buildings with new filters, steam and chilled water coils, and controls; 5) installation of new chilled water coils and chilled water supply piping for the east wing of Building 3500 to replace the refrigerant system that has high maintenance requirements; and 6) replacement of control valves in various buildings to improve system efficiency.

b. Subproject 18 – Laboratory Systems Upgrades (PNNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
880	880 [a]	0 [b]	0 [b]	0	0	Project Cancelled [b]

This project will upgrade or replace 20-50 year old mechanical system components in eight high

[a] Title I and Title II Design funding provided under PED Project No. 02-SC-001.

[b] Project cancelled. The buildings that were to be rehabilitated under this project will be removed under the Office of Environmental Management funded River Corridor Clean-up project at the Hanford Site. FY 2003 Unobligated balances of $3,950,000 and $2,141,000 of FY 2004 Construction funds have been redirected in FY 2004 as follows: $5,105,000 to complete CEBAF center addition subproject MEL-001-33 and $986,000 to Research Support building MEL-001-27.

occupancy facilities, replacing them with more efficient and better performing systems to enhance the quality of science while reducing maintenance and energy costs. This upgrade will include: replacement of HVAC supply and exhaust fans; replacement, rehabilitation or modification of numerous chemical exhaust fume hoods; and installation of computerized, remote, digital controls on various systems to improve operations.

c. Subproject 25 – Research Support Center (ORNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
16,041	1,500 [a]	4,941	9,600	0	0	2Q 2003 – 2Q 2005

This project will construct a 50,000 sq. ft. facility to house the core support service facilities and serve as the cornerstone and focal point of the East Research Campus envisioned in the ORNL Facility Revitalization Project. This building will include an auditorium and conference center (currently there is no adequate auditorium/conference space available at ORNL), cafeteria, visitor reception and control area, and offices for support staff. It will facilitate consolidation of functions, which are presently scattered throughout the Laboratory complex in facilities that are old (30-50 years), undersized, poorly located, or scheduled for surplus. The facility will serve as a modern center for meeting, collaborating, and exchanging scientific ideas for ORNL staff and nearly 30,000 visitors, guests, and collaborators that use ORNL facilities each year. The new cafeteria will replace the existing cafeteria, which was constructed in 1953. The existing cafeteria is poorly located to serve the current staff and is adjacent to the original production area of the laboratory now undergoing decontamination. The estimated simple payback is seven years.

d. Subproject 27 – Research Support Building, Phase I (BNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
18,200	0	3,206 [b]	5,971	4,458	4,565	2Q 2004 – 3Q 2007

This 70,000 sq. ft. facility is intended to consolidate Staff Services, Public Affairs, Human Resources, Credit Union, Library and other support functions in a central quadrangle to provide staff and visiting scientists with convenient and efficient support. This facility, the first of four phases in the BNL Master Revitalization Plan, will include a lobby with a visitor information center to assist visiting scientists, and a coordinated office layout of related support services. After completion of this project, 21,100 sq. ft. of World War II era structures will be torn down. Based on total life-cycle costs, productivity gains, avoided energy and maintenance costs, the Research Support Building will provide a return on investment of 10% and a simple payback of 8.4 years.

[a] Title I and Title II Design funding of $1,500,000 provided under PED Project No. 02-SC-001.
[b] Title I and Title II Design funding of $1,679,000 requested under PED Project No. 03-SC-001.

e. Subproject 28 – Building 77 Rehabilitation of Structures and Systems, Phase II (LBNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
13,360	0	1,735 [a]	2,000	4,825	4,800	3Q 2004 – 2Q 2007

This project will provide for rehabilitation to correct mechanical, electrical and architectural deficiencies in Buildings 77 (a 39 year old, 68,000 sq. ft. high-bay industrial facility) and 77A (a 14 year old, 10,000 sq. ft. industrial facility). Both buildings house machine shop and assembly operations in which production of highly sophisticated research components for a variety of DOE research projects is performed. Current work includes precision machining, fabrication and assembly of components for the Advanced Light Source, the Dual-Axis Radiographic Hydrodynamic Test Facility (DAHRT) project, the Spallation Neutron Source, and the ATLAS Detector. Infrastructure systems installed by this project will include HVAC, power distribution, lighting, and noise absorption materials. The improvements are necessary to satisfy urgent demands for high levels of cleanliness, temperature and humidity control, and OSHA and reliability requirements. This is the second of two projects; the first project, funded in FY 1999 and completed in FY 2002, corrected structural deficiencies in Bldg. 77.

f. Subproject 33 – Continuous Electron Beam Accelerator Facility (CEBAF) Center Addition, Phase I (TJNAF)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
10,500	0	1,481 [b]	9,019 [c]	0	0	2Q 2005 – 2Q 2007

This project is Phase I of three phases to provide for additions to the CEBAF Center office building. The purpose of the three phases is to provide additional critical computer center space and to eliminate off-site leases and existing trailers to collocate staff for enhanced productivity. This first addition will add 59,000 sq. ft. of computer center (7,600 sq. ft.) and office space, and eliminate 22,000 sq. ft. of aging trailers with a 7.4-year simple payback and a 10% rate of return. Phase I will provide additional space for 182 users and 50 staff personnel.

<u>ES&H Projects</u>:

a. Subproject 12 - Site-wide Water Distribution System Upgrade (LBNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
8,264	5,400	2,864	0	0	0	2Q 2002 –1Q 2004

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[a] Title I and Title II Design funding of $1,089,000 requested under PED Project No. 03-SC-001.

[b] Title I and Title II Design funding of $545,000 requested under PED Project No. 03-SC-001.

[c] Includes $3,950,000 of FY 2003 unobligated balances and $1,155,000 of planned FY 2004 funds redirected from subproject MEL-001-018.

This project will rehabilitate the Laboratory's High Pressure Water (HPW) System that supplies over 100 facilities at LBNL. The HPW System provides domestic water, fire water, treated water, cooling tower water and low conductivity water. It consists of 9.6 km of pipe (1.4 km of cast iron pipe, 6.3 km of ductile iron pipe, and 1.9 km of cement lined coated steel pipe), associated valves, pumps, fittings etc. and two 200,000 gallon emergency fire water tanks. This project will: replace all cast iron pipe, which is in imminent danger of failing, with ductile iron pipe; electrically isolate pipe and provide cathodic protection; replace leaking valves and add pressure reducing stations to prevent excessive system pressure at lower laboratory elevations; add an emergency fire water tank to serve the East Canyon; and provide the two current emergency fire water tanks with new liners and seismic upgrades.

b. Subproject 13 - Groundwater and Surface Water Protection Upgrades (BNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
6,033	4,652	1,381	0	0	0	2Q 2002 - 1Q 2004

This project will implement a backlog of ground and surface water protection projects that are commitments to regulators. These include: proper closure of inactive supply and injection wells; runoff control for the surplus material storage yard; containment and runoff control for the radioactive material storage yard; replacement of 12 hydraulic elevator cylinders; removal of 22 underground fuel oil tanks; and other Suffolk County Article 12 upgrades.

c. Subproject 14 - Fire Protection Systems Upgrades (ORNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
5,892	3,704	2,188	0	0	0	3Q 2002 – 4Q 2004

This project will upgrade the 36 year-old fire protection system with improved, more reliable fire alarm capabilities by: replacing deteriorated, obsolete systems; replacing the single 16-inch water main in the east central section of ORNL with a looped system (4,000 lf of 16 inch pipe); and by extending coverage of automatic alarm systems to areas not previously served. New fire alarm equipment will provide emergency responders with greatly improved annunciation of the causes and locations of alarms and will provide code compliant occupant notification evacuation alarms for enhanced life safety. It will also include timesaving, automatic diagnostic capabilities that will reduce maintenance costs. The new occupant notification systems will comply with the Americans with Disabilities Act. The fire alarm receiving equipment at the site fire department headquarters will be upgraded to ensure its reliability, modernize its technology, and meet the demands of an expanded fire alarm system network.

d. Subproject 16 – Electrical Systems Modifications, Phase II (BNL)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
6,734	3,855	2,879	0	0	0	2Q 2002 – 1Q 2004

This project is the second phase of the modernization and refurbishment of the Laboratory's deteriorating 50 year-old electrical infrastructure. The project includes: installation of two new 13.8 kV feeders to provide alternate sources to existing, aged feeders; installation of additional underground ductbanks to support a new 13.8 kV feeder; replacement of 24 kV switchgear to increase system reliability/safety; reconditioning of 50 480-volt circuit breakers including replacing obsolete trip units with modern, solid-state trip devices; and the retrofit of 10 13.8 kV air breakers with new vacuum technology.

e. Subproject 17 – Mechanical and Control Systems Upgrade, Phase I (ANL-E)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
8,962	803[a]	3,007	5,152	0	0	3Q 2003 – 3Q 2005

This project will upgrade and replace 30-40 year old mechanical system components in various facilities. It will optimize capacity, enhance system reliability and performance, improve safety, and reduce maintenance and repair costs of primary building mechanical equipment and control systems. The mechanical systems designated for replacement are no longer adequate, reliable, or efficient, and do not meet current ES&H standards (i.e. failure of laboratory exhaust systems could lead to the release of radioactive material). Specifically, this project will: upgrade HVAC systems in Buildings 221 and 362, including heating and cooling coils, fans, filter systems, ductwork, controls, and variable frequency drive fans; upgrade lab exhaust systems in Buildings 202 and 306, including new fans, ductwork, and controls; upgrade corroded drainage systems in Buildings 200, 205 and 350; and upgrade steam and condensate return systems in 12 facilities in the 360 area. This will include high and low pressure steam supply piping and associated pressure reducing stations, valves, and accessories; and replacing condensate pumping systems including piping, valves and system controls.

f. Subproject 36 – Safety and Operational Reliability Improvements (SLAC)

TEC	Prev.	FY 2003	FY 2004	FY 2005	Outyear	Construction Start/ Completion Dates
15,600	0	0	1,988[b]	7,108	6,504	3Q 2003 – 3Q 2007

[a] Title I and Title II Design funding of $803,000 provided under PED Project No. 02-SC-001.
[b] Title I and Title II Design funding of $1,988,000 requested under PED Project No. 04-SC-001.

This project has two components:

- Underground Utility Upgrades - this component will replace deteriorated sections of cooling water, low conductivity water, drainage, natural gas, compressed air and fire protection which are critical to the operation of the linear accelerator and the B-Factory rings which produce the essential collisions needed for the Parity Violation studies (one of the pillars of the current US High Energy Physics program also carried out competitively at KEK in Japan). There have been five pipe failures over the last two years and the failure rate is expected to increase in these 35 year-old systems as they continue to age. When the pipes fail, research is slowed or halted until repairs are completed.
- Seismic Upgrades – this component will install seismic upgrades necessary to bring various building structures into compliance with the seismic standards of the Uniform Building Code. The seismic hazard in the Bay Area is high. 19 “essential” facilities, i.e., those that will minimize the time required for the Laboratory to recover from an earthquake, will be retrofitted for a total of 229,000 sq. ft.

Payback is 11.2 years for the entire project.

4. Details of Cost Estimate

N/A

5. Method of Performance

To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

6. Schedule of Project Funding

N/A

7. Related Annual Funding Requirements

N/A

Fusion Energy Sciences

Funding Profile by Subprogram

(dollars in thousands)

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Fusion Energy Sciences					
Science	136,198	150,660	0	150,660	150,815
Facility Operations	66,198	86,087	-1,555[a]	84,532	85,495
Technology	38,299	27,363	0	27,363	27,800
Subtotal, Fusion Energy Sciences	240,695	264,110	-1,555[a]	262,555	264,110
Use of Prior Year Balances	0	-529	0	-529	0
Total, Fusion Energy Sciences	240,695[bc]	263,581	-1,555[a]	262,026	264,110

Public Law Authorization:
Public Law 95-91, "Department of Energy Organization Act, 1977"
Public Law 103-62, "Government Performance and Results Act of 1993"

Mission

The Fusion Energy Sciences (FES) program is the national basic research effort to advance plasma science, fusion science, and fusion technology—the knowledge base needed for an economically and environmentally attractive fusion energy source.

Benefits

Fusion is the energy source that powers the sun and stars. In the fusion process, nuclei of light elements such as hydrogen, fuse together to make heavier elements such as helium, giving off tremendous amounts of energy. Fusion could play a key role in U.S. long-term energy plans because it offers the potential for plentiful, safe and environmentally benign energy. A fusion power plant would produce no greenhouse gas emissions, use abundant and widely distributed sources of fuel, shut down easily, require no fissionable materials, operate in a continuous mode to meet demand, and produce manageable radioactive waste. A science-based approach to fusion offers the fastest path to commercial fusion energy and is advancing our knowledge of plasma physics and associated technologies, yielding near-term benefits in a broad range of scientific disciplines. Examples include plasma processing of semiconductor chips for computers and other electronic devices, advanced video displays, innovative

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[a] Excludes $1,555,128 for a rescission in accordance with the Consolidated Appropriations Act, 2004, as reported in conference report H.Rpt. 108-401, dated November 25, 2003.

[b] Excludes $5,837,000 which was transferred to the SBIR program and $350,000 which was transferred to the STTR program.

[c] Excludes $1,615,228 for a rescission in accordance with the Consolidated Appropriations Resolution, FY 2003.

materials coatings, the efficient destruction of chemical and radioactive wastes, and more efficient space propulsion.

Strategic and Program Goals

The Department's Strategic Plan identifies four strategic goals (one each for defense, energy, science, and environmental aspects of the mission plus seven general goals that tie to the strategic goals. The FES program supports the following goals:

Energy Strategic Goal
General Goal 4, Energy Security: Enhance energy security by developing technologies that foster a diverse supply of affordable and environmentally sound energy, improving energy efficiency, providing for reliable delivery of energy, exploring advanced technologies that make a fundamental change in our mix of energy options, and guarding against energy emergencies.

Science Strategic Goal
General Goal 5, World-Class Scientific Research Capacity: Provide world-class scientific research capacity needed to ensure the success of Department missions in national and energy security, to advance the frontiers of knowledge in physical sciences and areas of biological, medical, environmental, and computational sciences, and to provide world-class research facilities for the Nation's science enterprise.

The FES program has one program goal which contributes to General Goals 4 and 5 in the "goal cascade":

Program Goal 04.24.00.00/05.24.00.00: Bring the power of the Stars to Earth — Answer the key scientific questions and overcome enormous technical challenges to harness the power that fuels a star.

Contribution to Program Goal 04.24.00.00 (Energy Security)
The Fusion Energy Sciences program contributes to this goal through participation in ITER, an experiment to demonstrate the sustained burning of fusion fuel. The next frontier in fusion science is a sustained, burning (or self-heated) plasma. In September 2002, the Fusion Energy Sciences Advisory Committee (FESAC) concluded that the fusion program is technically and scientifically ready to proceed with a burning plasma experiment and recommended joining the ongoing negotiations to construct the international burning plasma experiment, ITER. The National Research Council of the National Academy of Sciences endorsed this strategy in December 2002 (and more recently, in November 2003). Based in part on these recommendations, plus an Office of Science assessment of the cost estimate for the construction of ITER, the President decided in January 2003 that the U.S. should join the ITER negotiations. This proposed international collaboration will test the scientific and technical feasibility of fusion power. In FY 2003, DOE began leading U.S. participation in the negotiations and supporting technical activities preparing the project for construction beginning in 2006.

Contribution to Program Goal 05.24.00.00 (World-Class Scientific Research Capacity)

The Fusion Energy Sciences program contributes to this goal by managing a program of fundamental research into the nature of fusion plasmas and the means for confining plasma to yield energy. This includes: 1) exploring basic issues in plasma science; 2) developing the scientific basis and computational tools to predict the behavior of magnetically confined plasmas; 3) using the advances in tokamak research to enable the initiation of the burning plasma physics phase of the Fusion Energy

Sciences program; 4) exploring innovative confinement options that offer the potential to increase the scientific understanding of plasmas in various configurations; 5) focusing on non-neutral plasma physics and high energy density physics; 6) developing the cutting edge technologies that enable fusion facilities to achieve their scientific goals; and 7) advancing the science base for innovative materials.

These activities require operation of a set of unique and diversified experimental facilities, ranging from smaller-scale university devices to larger national facilities that require extensive collaboration. These facilities provide scientists with the means to test and extend theoretical understanding and computer models—leading ultimately to an improved predictive capability for fusion science.

The following indicators establish specific long term (10 years) goals in Scientific Advancement that the FES program is committed to and progress can be measured against.

1. **Predictive Capability for Burning Plasmas:** Develop a predictive capability for key aspects of burning plasmas using advances in theory and simulation benchmarked against a comprehensive experimental database of stability, transport, wave-particle interaction, and edge effects.
2. **Configuration Optimization:** Demonstrate enhanced fundamental understanding of magnetic confinement and improved basis for future burning plasma experiments through research on magnetic confinement configuration optimization.
3. **Inertial Fusion Energy and High Energy Density Physics**: Develop the fundamental understanding and predictability of high energy density plasmas.

Annual Performance Results and Targets

FY 2000 Results	FY 2001 Results	FY 2002 Results	FY 2003 Results	FY 2004 Targets	FY 2005 Targets
Program Goal 04.24.00.00/05.24.00.00 (Energy Security/World-Class Scientific Research Capacity)					
Facility Operations					
	Kept deviations in weeks of operation for each major facility within 10 percent of the approved plan. [met goal]	Kept deviations in weeks of operation for each major facility within 10 percent of the scheduled weeks. [met goal]	Kept deviations in weeks of operation for DIII-D and Alcator C-Mod each major facility within 10 percent of the approved plan. NSTX did not meet the target because of a coil joint failure. [Did not meet goal.]	Average achieved operational time of major national fusion facilities as a percentage of total planned operational time is greater than 90%.	Average achieved operational time of major national fusion facilities as a percentage of total planned operational time is greater than 90%.
	Kept deviations in cost and schedule for upgrades and construction of scientific user facilities within 10 percent of approved baselines; achieved planned cost and schedule performance for dismantling, packaging, and offsite shipping of the Tokamak Fusion Test Reactor (TFTR) systems. [met goal]	Kept deviations in cost and schedule for upgrades and construction of scientific user facilities within 10 percent of project baselines; successfully completed within cost and in a safe manner all TFTR decontamination and decommissioning activities. [met goal]	Kept deviations in cost and schedule for upgrades and construction of scientific user facilities within 10 percent of approved baselines. [met goal]	Cost-weighted mean percent variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects kept to less than 10%.	Cost-weighted mean percent variance from established cost and schedule baselines for major construction, upgrade, or equipment procurement projects kept to less than 10%.
			Completed the National Compact Stellarator Experiment (NCSX) Conceptual Design and began Preliminary Design. [met goal]		

Means and Strategies

The Fusion Energy Sciences program will use various means and strategies to achieve its program goals. However, various external factors may impact the ability to achieve these goals.

The science and the technology of fusion have progressed to the point that the next major research step is the exploration of the physics of a self-sustained plasma reaction in a burning plasma physics experiment. The proposed international burning plasma experiment called ITER is the focal point of burning plasma fusion research around the world, and the Administration has decided to join the negotiations to conduct this experiment. In light of this decision, many elements of the fusion program that are broadly applicable to burning plasmas will now be directed more specifically toward the needs of ITER. These elements represent areas of fusion research in which the United States has particular strengths relative to the rest of the world, such as theory, modeling, and tokamak experimental physics. Longer range technology activities have been phased out or redirected to support preparations for the realization of the burning plasma device and associated experiments. The U.S. funding commitment to ITER will increase significantly in the future as the project moves to construction and eventually to science operations.

Scientists from the United States participate in leading edge scientific experiments on fusion facilities abroad, and conduct comparative studies to supplement the scientific understanding they can obtain from domestic facilities. These include the world's highest performance tokamaks (JET in England and JT-60 in Japan), a stellarator (the Large Helical Device in Japan), a superconducting tokamak (Tore Supra in France), and several smaller devices. In addition, the United States is collaborating with South Korea on the design of diagnostics for the long-pulse, superconducting, advanced tokamak (KSTAR). These collaborations provide a valuable link with the 80 percent of the world's fusion research that is conducted outside the United States. The United States is an active participant in the International Tokamak Physics Activity (ITPA) that facilitates identification of high priority research for burning plasmas in general, and for ITER specifically, through workshops and assigned tasks. ITPA further identifies coordinated experiments on the international tokamak programs and coordinates implementation of these experiments through the International Atomic Energy Implementing Agreements on tokamaks. In FY 2004, the United States began participating in the ITER Transitional Arrangements activities preparing the project for construction beginning in 2006.

All research projects undergo regular peer review and merit evaluation based on SC-wide procedures set down in 10 CFR 605 for the extramural grant program, and under a similar modified process for the laboratory programs and scientific user facilities. All new projects are selected by peer review and merit evaluation. FES formally peer reviews their scientific user facilities to assess the scientific output, user satisfaction, and the overall cost-effectiveness of each facility's operations, and their ability to deliver the most advanced scientific capability to its user community. Major facilities are reviewed by an independent peer process on a 5-year basis as part of the grant renewal process, or an analogous process for national laboratories. Checkpoint reviews at the 3-year point provide interim assessment of program quality. Program Advisory Committees for the major facilities provide annual or semi-annual feedback on assessments of the quality of research performed at the facility; the reliability and availability of the facility; user access policies and procedures; user satisfaction; facility staffing levels; R&D activities to advance the facility; management of the facility; and long-range goals of the facility.

Facility upgrades and construction projects have a goal to stay within 10 percent, on average, of cost and schedule baselines for upgrades and construction of scientific facilities. In FES, construction of major research facilities has generally been on time and within budget. User facilities have as a goal to be operated and maintained so they operate more than 90%, on average, of total planned annual operating time. FES's operation of major scientific facilities has ensured that a growing number of U.S. scientists have reliable access to those important facilities.

External factors that affect the level of performance include:
(1) changing mission needs as described by the DOE and SC mission statements and strategic plans;
(2) scientific opportunities as determined, in part, by proposal pressure and scientific workshops; (3) the results of external program reviews and international benchmarking activities of entire fields or sub fields, such as those performed by the National Academy of Sciences (NAS); (4) unanticipated failures in critical components of scientific user facilities that cannot be mitigated in a timely manner; and
(5) strategic and programmatic decisions made by non-SC funded domestic research activities and by major international research centers.

Validation and Verification

Progress against established plans is evaluated by periodic internal and external performance reviews. These reviews provide an opportunity to verify and validate performance. Monthly, quarterly, semiannual, and annual reviews consistent with specific program management plans are held to ensure technical progress, cost and schedule adherence, and responsiveness to program requirements.

Program Assessment Rating Tool (PART) Assessment

The Department implemented a tool to evaluate selected programs. PART was developed by OMB to provide a standardized way to assess the effectiveness of the Federal Government's portfolio of programs. The structured framework of the PART provides a means through which programs can assess their activities differently than through traditional reviews. The Fusion Energy Sciences (FES) program has incorporated feedback from OMB into the FY 2005 Budget Request and has taken or will take the necessary steps to continue to improve performance.

In the PART review, OMB gave the Fusion Energy Sciences (FES) program a relatively high score of 82% overall which corresponds to a rating of "Moderately Effective". This score is attributable to the use of standard management practices in FES. Although FES is establishing a Committee of Visitors (COV) to provide outside expert validation of the program's merit-based review processes for impact on quality, relevance, and performance, and this committee has met and prepared its report, FESAC has not yet met to receive the report. Once the COV issues a report, FES will develop an action plan to respond to the findings and recommendations within 30 days. The assessment found that FES has developed a limited number of adequate performance measures. However, OMB noted concerns regarding the collection and reporting of performance data. To address these concerns, FES will work with its Advisory Committee to develop research milestones for the long-term performance goals, will include the long term research goals in grant solicitations, will work to improve performance reporting by grantees and contractors, and will work with the CFO to improve FES sections of the Department's performance documents. The Administration strongly supports efforts to explore possible U.S. participation in ITER. OMB found that the FES budget is not sufficiently aligned with scientific program goals and that a science-based strategic plan for the future of U.S. fusion research within an international context needs to be developed. FES will engage its advisory committee to prepare a top-to-bottom scientific prioritization for U.S. fusion and will then develop a strategic plan, based upon that input, by September 2005.

Funding by General and Program Goal

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
General Goal 4, Energy Security					
Program Goal 04.24.00.00, Advance Plasma Science, Fusion Science, and Fusion Technology					
Facility Operations: ITER	0	3,000[a]	7,000[b]	+4,000	+133.3%
General Goal 5, World-Class Scientific Research Capacity					
Program Goal 05.24.00.00, Advance Plasma Science, Fusion Science, and Fusion Technology					
Science	136,198	150,660	150,815	+155	+0.1%
Facility Operations: Non-ITER	66,198	81,532	78,495	-3,037	-3.7%
Technology	38,299	27,363	27,800	+437	+1.6%
Total, Program Goal 05.24.00.00, Advance Plasma Science, Fusion Science, and Fusion Technology	240,695	259,555	257,110	-2,445	-0.9%
Total, General Goal 4 and 5 (Fusion Energy Sciences)	240,695	262,555	264,110	+1,555	+0.6%
Use of Prior Year Balances	0	-529	0	+529	+100.0%
Total, Fusion Energy Sciences	240,695	262,026	264,110	+2,084	+0.8%

Overview

Fusion science is a subfield of plasma science that deals primarily with studying the fundamental processes taking place in plasmas where the temperature and density approach the conditions needed to allow the nuclei of two low-mass elements, like hydrogen isotopes, to join together, or fuse. When these nuclei fuse, a large amount of energy is released. There are two leading methods of confining the fusion plasma—magnetic, where strong magnetic fields constrain the charged plasma particles, and inertial, where laser or particle beams compress and heat the plasma during very short pulses. Most of the world's fusion energy research effort, the U.S. included, is focused on the magnetic approach. But NNSA's supports a robust program in inertial fusion for stockpile stewardship but also provides a base for Fusion Energy Science work in this area. Thus FES depends on NNSA for the physics of the target-driver interaction.

[a] Reflects $3,000,000 in direct funding for ITER preparations. An additional $5,000,000 for ITER supporting activities is reflected within goal 5, bringing the total Fusion program resources in preparation for ITER to $8,000,000 in FY 2004.

[b] Reflects $7,000,000 in direct funding for ITER preparations. An additional $31,000,000 for ITER supporting activities is reflected within goal 5, bringing the total Fusion program resources in preparation for ITER to $38,000,000 in FY 2005.

The Fusion Energy Sciences program activities are designed to address the scientific and technology issues facing fusion:

- the transport of plasma heat from the core outward to the plasma edge and to the material walls as a result of electromagnetic turbulence in the plasma (chaos, turbulence, and transport),
- the stability of the magnetic configuration and its variation in time as the plasma pressure, density, turbulence level, and population of high energy fusion products change (stability, reconnection, and dynamo),
- the role of the colder plasma at the plasma edge and its interaction with both material walls and the hot plasma core (sheaths and boundary layers),
- the interaction of electrons and ions in the plasma with high-power electromagnetic waves injected into the plasma for plasma heating, current drive and control (wave-particle interaction), and
- the development of reliable and economical superconducting magnets, plasma heating and fueling systems, vacuum chamber, and heat extraction systems and materials that can perform satisfactorily in an environment of fusion plasmas and high energy neutrons.

These issues have been codified into four thrusts that characterize the program activities:

- Burning Plasmas, that will include our efforts in support of ITER;
- Fundamental Understanding, that includes Theory and Modeling, as well as General Plasma Science;
- Configuration Optimization, that includes experiments on advanced tokamaks, magnetic alternates, and inertial fusion concepts, as well as facility operations and technology; and
- Materials, that includes fusion specific materials science closely coupled to the BES materials science program.

Progress in all of these thrust areas, in an integrated fashion, is required to achieve ultimate success.

How We Work

The primary role of the Fusion Energy Sciences (FES) program governance is the funding, management, and oversight of the program. FES has established an open process for obtaining scientific input for major decisions, such as planning, funding, evaluating and, where necessary, terminating facilities, projects, and research efforts. There are also mechanisms in place for building fusion community consensus and orchestrating international collaborations that are fully integrated with the domestic program. FES is likewise active in promoting effective outreach to and communication with related scientific and technical communities, industrial and government stakeholders, and the public.

Advisory and Consultative Activities

The Department of Energy uses a variety of external advisory entities to provide input that is used in making informed decisions on programmatic priorities and allocation of resources. The FESAC is a standing committee that provides independent advice to the Director of the Office of Science on complex scientific and technological issues that arise in the planning, implementation, and management of the fusion energy sciences program. The Committee members are drawn from universities, national laboratories, and private firms involved in fusion research or related fields. The Director of the Office of Science charges the Committee to provide advice and recommendations on various issues of concern to the fusion energy sciences program. The Committee conducts its business in public meetings, and submits reports containing its advice and recommendations to the Department.

During FY 2001 and 2002, the Department undertook a multi-step process to plan the future directions of the FES program. In October 2000, the FESAC was charged to address the scientific issues of burning plasma physics. In its September 2001 report "Review of Burning Plasma Physics" (DOE/SC-0041), FESAC stated that "*Now*" is the time to take steps leading to the expeditious construction of its finding that a burning plasma experiment would bring enormous scientific benefits and technical rewards not only to the fusion program, but to several other fields as well. FESAC also found that the present scientific understanding and technical expertise were sufficient to allow such an experiment, no matter how challenging, to succeed with a high degree of confidence.

In the summer of 2002, at a two-week workshop involving a large part of the fusion research community, a statement about the need for burning plasma research received unanimous support of the attendees. In addition, a uniform technical assessment of the three leading proposals for a burning plasma experiment was developed.

With these steps in hand, FESAC that had been charged in February 2002 to recommend a strategy for burning plasma experiments, issued its report, "A Burning Plasma Program Strategy to Advance Fusion Energy" (DOE/SC-0060) in September 2002. The report states that the world effort to develop fusion is at a threshold of a new state in its research: the investigation of burning plasmas. This investigation, at the frontier of the physics of complex systems, would be a huge step in establishing the potential of magnetic fusion to contribute to the world's energy security. The report then outlines a consistent, aggressive strategy, taking advantage of international efforts, to develop the science and technology of plasmas.

These three steps fit together with the recommendation from the NRC following its review of burning plasmas, Burning Plasma: Bringing a Star to Earth", September 2003, in which NRC recommends that the United States participate in ITER, a burning plasma experiment and one of the three approaches assessed technically during the summer workshop in 2002.

A variety of other committees and groups provide input to program planning. Ad hoc activities by fusion researchers, such as the 2002 Snowmass meeting, provide a forum for community debate and formation of consensus. The President's Committee of Advisors on Science and Technology (PCAST) has also examined the fusion program on several occasions, as has the Secretary of Energy Advisory Board. As noted, the National Research Council, who's Plasma Physics Committee serves as a continuing connection to the general plasma physics community, recently carried out an assessment of the Department of Energy's Fusion Energy Sciences' strategy for addressing the physics of burning plasmas. In addition, the extensive international collaborations carried out by U.S. fusion researchers provide informal feedback regarding the U.S. program and its role in the international fusion effort. These sources of information and advice are integrated with peer reviews of research proposals and when combined with high-level program reviews and assessments provide the basis for prioritizing program directions and allocations of funding.

Program Advisory Committees (PACs) serve an extremely important role in providing guidance to facility directors in the form of program review and advice regarding allocation of facility run time. These PACs are formed primarily from researchers from outside the host facility, including non-U.S. members. They review proposals for research to be carried out on the facility and assess support requirements, and, in conjunction with host research committees, provide peer recommendations regarding priority assignments of facility time. Because of the extensive involvement of researchers from outside the host institutions, PACs are also useful in assisting coordination of overall research programs. Interactions among PACs for major facilities assure that complementary experiments are appropriately scheduled and planned.

Facility Operations Reviews

FES program managers perform quarterly reviews of the progress in operating the major fusion facilities. In addition, a review of each of these major facilities occurs periodically by peers from the other facilities. Further, quarterly reviews of each major project are conducted by the Associate Director for Fusion Energy Sciences with the Federal Project Director in the field and other involved staff from both the Department and the performers.

Program Reviews

The peer review process is used as the primary mechanism for evaluating proposals, assessing progress and quality of work, and for initiating and terminating facilities, projects, and research programs. This policy applies to all university and industry programs funded through grants, national laboratory programs funded through Field Work Proposals (FWPs), and contracts from other performers. Peer review guidelines for FES derive from best practices of government organizations that fund science and technology research and development, such as those documented in the General Accounting Office report, "Federal Research: Peer Review Practices at Federal Science Agencies Vary" (GAO/RCED-99-99, March 1999), as well as more specifically from relevant peer review practices of other programs in the Office of Science.

Merit review in FES is based on peer evaluation of proposals and performance in a formal process using specific criteria and the review and advice of qualified peers. In addition to the review of the scientific quality of the programs provided by the peer review process, FES also reviews the programs for their balance, relevance, and standing in the broader scientific community.

Universities and most industries submit grant proposals to receive funding from FES for their proposed work. Grants typically extend for a three to five year period. The grants review process is governed by the already established SC Merit Review System. DOE national laboratories submit annual field work proposals for funding of both new and ongoing activities. These are subject to peer review according to procedures that are patterned after those given in 10 CFR Part 605 that govern the SC grant program. For the major facilities that FES funds, these extensive reviews are conducted as part of a contract or cooperative agreement renewal, with nominal five-year renewal dates. External peer reviews of laboratory programs are carried out on a periodic basis.

Another review mechanism involves charging FESAC to establish a Committee of Visitors (CoV) to review program management practices every three to four years on a rotating basis for the following program elements: theory and computation, confinement innovations, general plasma sciences, tokamak research, and enabling research and development. The CoV should not only report on process, but on how this process impacts the substance of the program quality, and perceived gaps in the overall research portfolio supported by the program under review. The CoVs should be answering questions such as: Are the best people and proposals being funded, and if not, why not?; Are the right reviewers being chosen?; Are the common variety of approaches to merit review (e.g., mail, panel, etc.) and competition being used in an appropriate manner?; Are poorly-rated proposals funded, and if so, why? The first CoV review will address the theory and computation program, reporting its result to the Department by March 2004.

Planning and Priority Setting

The FESAC carries out an invaluable role in the fusion program by identifying critical scientific issues and providing advice on medium- and long-term goals to address these issues.

The National Research Council (NRC), in its report on the Department's strategy for addressing the science of a burning plasma, recommended that a new effort be made to integrate the U.S. participation in the ITER project into the U.S. domestic program. The NRC report stated that this integration should be defined through a prioritized balancing of the content, scope, and level of the U.S. activities in fusion. The fusion community and FESAC were ready to act on this recommendation, and so the FESAC has been charged to assist the Department and the community in establishing priorities for the fusion program. The FESAC panel that will address this charge will 1) identify major program issues in science and technology that need to be addressed, 2) recommend how to organize campaigns to address those issues, and 3) recommend the priority order in which those campaigns will be pursued. FESAC's report on this activity is scheduled to be completed in July 2004.

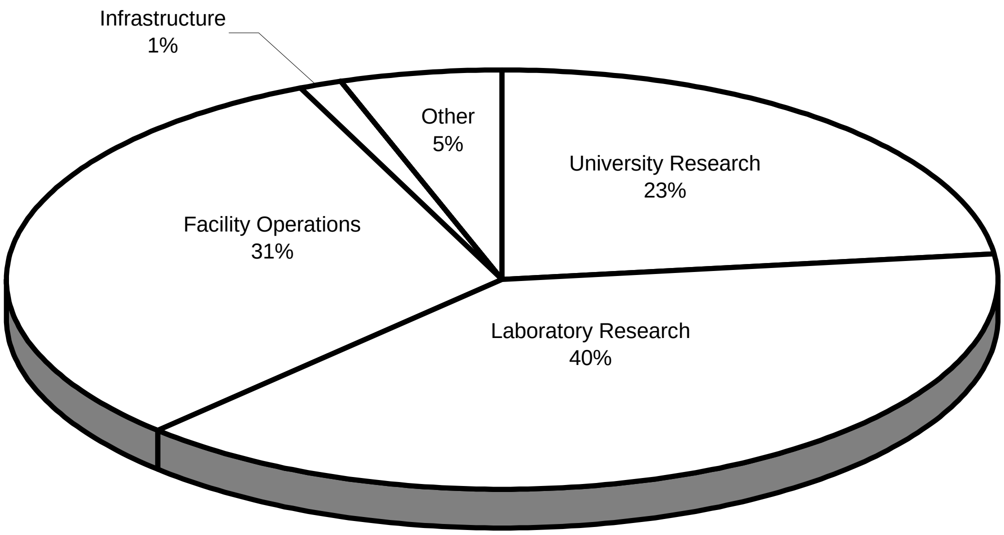
A variety of sources of information and advice, as noted above under the heading "Advisory Activities," are integrated with peer reviews of research proposals and when combined with high-level program reviews and assessments provide the basis for prioritizing program directions and allocations of funding.

How We Spend Our Budget

The FES budget has three components: Science, Facility Operations, and Technology. Research efforts are distributed across universities, laboratories, and private sector institutions. In addition to a major research facility at Massachusetts Institute of Technology (MIT), there are several smaller experimental facilities located at universities. There are two other major facilities, located at a national laboratory (Princeton Plasma Physics Laboratory), and a private sector institution (General Atomics). Technology supports and improves the technical capabilities for ongoing experiments and provides limited long-term development for future fusion power requirements.

The balance of funding levels and priorities undergoes periodic scrutiny by the FESAC. The following chart illustrates the allocation of funding to the major program elements.

Fusion Energy Sciences Budget Allocation
FY 2005



Research

The DOE fusion energy sciences program involves over 1,100 researchers and students at more than 70 U.S. academic, federal, and private sector institutions. The program funds research activities at 67 academic and private sector institutions located in 30 states and at 11 DOE and Federal laboratories in 8 states. The three major facilities are operated by the hosting institutions, but are configured with national research teams made up of local scientists and engineers, and researchers from other institutions and universities, as well as foreign collaborators.

- **University Research**

  University researchers continue to be a critically important component of the fusion research program and are responsible for training graduate students. University research is carried out on the full range of scientific and technical topics of importance to fusion. University researchers are active participants on the major fusion facilities and one of the major facilities is sited at a university (Alcator C-Mod at MIT). In addition, there are 16 smaller research and technology facilities located at universities, including a basic plasma user science facility at UCLA that is jointly funded by DOE and NSF. There are 5 universities with significant groups of theorists and modelers. About 40 Ph.D. degrees in fusion-related plasma science and engineering are awarded each year. Over the past three decades, many of these graduates have gone into the industrial sector and brought with them the technical basis for many of the plasma applications found in industry today, including the plasma processing on which today's semiconductor fabrication lines are based.

  The university grants program is proposal driven. External scientific peers review proposals submitted in response to announcements of opportunity and funding is competitively awarded according to the guidelines published in 10 CFR Part 605. Support for basic plasma physics is carried out through the NSF/DOE Partnership in Basic Plasma Science and Engineering.

- **National Laboratory and Private Sector Research**

  The Fusion Energy Sciences program supports national laboratory-based fusion research groups at the Princeton Plasma Physics Laboratory, Oak Ridge National Laboratory, Sandia National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Idaho National Engineering and Environmental Laboratory, Argonne National Laboratory, and Los Alamos National Laboratory. In addition, one of the major research facilities is located at and operated by General Atomics in San Diego, California. The laboratory programs are driven by the needs of the Department, and research and development carried out there is tailored to take specific advantage of the facilities and broadly based capabilities found at the laboratories.

  Laboratories submit field work proposals for continuation of ongoing or new work. Selected parts of proposals for continuing work are reviewed on a periodic basis, and proposals for new work are peer reviewed. FES program managers review laboratory performance on a yearly basis to examine the quality of their research and to identify needed changes, corrective actions, or redirection of effort.

Significant Program Shifts

The budget requested for FY 2005 is slightly above the FY 2004 Appropriation. The FY 2005 budget continues the redirection of the fusion program to prepare for participation in the ITER program, while also supporting many of the program priorities recommended by the Fusion Energy Sciences Advisory Committee and supported by the Secretary of Energy Advisory Board and the National Research Council (NRC).

The principal program shifts comport with the President's decision to join the ITER negotiations to build a burning plasma experimental facility. Longer range technology activities will have been phased out in FY 2004 while engineering and technology R&D activities that directly support existing and near term experiments as well as preparations for the construction of the burning plasma device will be increased. The three major fusion research facilities will be operated for 14 weeks each, 56 percent of the maximum possible single-shift operation, to advance our understanding of the key physics issues governing toroidal fusion concepts, thereby contributing to future experiments on ITER.

The FY 2005 budget will also support the continuation of the Scientific Discovery through Advanced Computing (SciDAC) program, which is being focused on burning plasma physics and ITER.

A summary of program resources to be applied to ITER in FY 2005, as well as the corresponding level for FY 2004, is shown in the following table. For the DIII-D and Alcator C-Mod research programs, the fraction of research in support of ITER needs is increased in FY 2005 despite a reduction in total weeks of facility operation. Also, Plasma Technology research in support of ITER is significantly increased in FY 2005 relative to FY 2004 when specific ITER R&D needs began to be identified by the interim ITER project team.

Fusion Program Resources in Preparation for ITER

(dollars in thousands)

	FY 2004	FY 2005
DIII-D Experimental Program	$3,000	$10,000
Alcator C-Mod Experimental Program	1,000	5,000
Fusion Plasma Theory & Computation	1,000	3,000
ITER Preparations	3,000	7,000
Plasma Technology	~ 0	13,000
Total	$8,000	$38,000

ITER negotiations are continuing in FY 2004. A comprehensive process to prepare an international agreement covering all aspects of ITER construction, operation and decommissioning is in place. This includes input on all topics by experts from each negotiating Party, discussion by representatives of each Party and resolution of differences by the negotiators. The negotiating process is aiming at a negotiated agreement in early 2004 for subsequent consideration and approval within the Parties' governmental systems. In addition, representatives of the Parties are addressing critical decisions on siting, sharing of costs and assignment of management personnel. During FY 2004 a U.S. ITER Project Office will be selected to manage the preparations in FY 2004 and FY 2005 for ITER construction starting in FY 2006.

The FY 2005 budget request is consistent with the expected cost and schedule baseline for the design and fabrication of the National Compact Stellarator Experiment (NCSX), a joint ORNL/PPPL advanced stellarator experiment at the Princeton Plasma Physics Laboratory, that is now expected to begin operation in late FY 2008/early FY 2009.

Finally, the Inertial Fusion Energy research program will be focused on the science issues of non-neutral plasmas and high energy density physics research.

Awards

- Nine fusion researchers were elected Fellows of the American Physical Society in 2002.

- A recent PhD recipient from the University of Texas won the 2003 Marshall N. Rosenbluth Outstanding Doctoral Thesis Award for his first principles theoretical analysis of a plasma thruster that models the helicon plasma source, single-pass radio frequency heating, and particle and momentum balance.
- A fusion materials scientist was elected fellow of the American Society of Materials "for outstanding contributions to our understanding of the effects of radiation on the properties of materials, and the development of new, advanced materials for service in the challenging environment of fusion reactors.
- A PPPL Nobel Prize winning scientist has been elected a Fellow of the American Association for the Advancement of Science (AAAS).
- A recent graduate of Princeton University who did his thesis research at PPPL, was named an APS Congressional Science Fellowship winner.
- A PPPL engineer was named a Fellow of the American Society of Mechanical Engineers.

Scientific Discovery through Advanced Computing (SciDAC)

The Scientific Discovery through Advanced Computing (SciDAC) activity is a set of coordinated investments across all Office of Science mission areas with the goal to achieve breakthrough scientific advances through computer simulation that were impossible using theoretical or laboratory studies alone. The power of computers and networks is increasing exponentially. By exploiting advances in computing and information technologies as tools for discovery, SciDAC encourages and enables a new model of multi-discipline collaboration among the scientific disciplines, computer scientists, and mathematicians. The product of this collaborative approach is a new generation of scientific simulation codes that can fully exploit terascale computing and networking resources. The program will bring simulation to a parity level with experiment and theory in the scientific research enterprise as demonstrated by major advances in climate prediction, plasma physics, particle physics, and astrophysics.

During the past year, multidisciplinary teams of computational plasma physicists, applied mathematicians, and computer scientists have made progress in the areas of magnetic reconnection, macroscopic stability, electromagnetic wave-plasma interaction, simulation of turbulent transport of energy and particles, and atomic physics relevant to edge plasma physics. There have been significant advances in the simulation of mode conversion in tokamak plasmas, modeling of the sawtooth instability in tokamaks with realistic plasma parameters, and understanding turbulent transport as a function of plasma size in tokamaks.

Scientific Facilities Utilization

The Fusion Energy Sciences request includes funds to operate and make use of major fusion scientific user facilities. The Department's three major fusion physics facilities are: the DIII-D Tokamak at General Atomics in San Diego, California; the Alcator C-Mod Tokamak at the Massachusetts Institute of Technology; and the National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory. These three facilities are each unique in the world's fusion program and offer opportunities to address specific fusion science issues that will contribute to the expanding knowledge base of fusion. Taken together, these facilities represent a nearly $1,000,000,000 capital investment by the U.S. Government, in current year dollars.

The funding requested will provide research time for about 465 scientists in universities, federally sponsored laboratories, and industry, and will leverage both federally and internationally sponsored research, consistent with a strategy for enhancing the U.S. National science investment.

The total number of weeks of operation at all of the major fusion facilities is shown in the following table.

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
Maximum weeks	75	75	75	75	75
Planned weeks	44	34	31	54	42
Weeks operated as % of planned weeks	100%	94%	81%	TBD	TBD

In addition to the operation of the major fusion facilities, a Major Item of Equipment project, the NCSX project at PPPL, is supported in the fusion program. Milestones for this project are shown in the following table.

FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
		Complete the NCSX Conceptual Design and begin the Preliminary Design.	Complete final design of NCSX and begin fabrication.	Award, through a competitive process, production contracts for the NCSX Modular Coil. Winding Forms and Conductor and Vacuum Vessel. Complete winding of the first Modular Coil.
.		Complete C-Mod Lower Hybrid Upgrade Project		

Workforce Development

The FES program, the Nation's primary sponsor of research in plasma physics and fusion science, supports development of the R&D workforce by funding undergraduate researchers, graduate students working toward masters and doctoral degrees, and postdoctoral associates developing their research and management skills. The R&D workforce developed as a part of this program provides new scientific talent to areas of fundamental research. It also provides talented people to a wide variety of technical and industrial fields that require finely honed thinking and problem solving abilities and computing and technical skills. Scientists trained through association with the FES program are employed in related fields such as plasma processing, space plasma physics, plasma electronics, and accelerator/beam physics as well as in other fields as diverse as biotechnology and investment and finance.

In FY 2003, the FES program supported 384 graduate students and post-doctoral investigators. Of these, approximately 50 students conducted research at the DIII-D tokamak at General Atomics, the Alcator C-Mod tokamak at MIT, and the NSTX at PPPL. A Junior Faculty development program for university plasma physics researchers and the NSF/DOE partnership in basic plasma physics and engineering focus on the academic community and student education.

	FY 2001	FY 2002	FY 2003	FY 2004, est.	FY 2005, est.
# University Grants	186	186	189	195	195
# Permanent PhD's [a]	741	731	745	775	775
# Postdocs	99	99	100	105	105
# Grad Students	266	279	284	295	295
# PhD's awarded	49	53	40	42	42

[a] Permanent PhD's includes faculty, research physicists at universities, and all PhD-level staff at national laboratories.

Science

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Science					
Tokamak Experimental Research	47,050	49,519	48,406	-1,113	-2.2%
Alternative Concept Experimental Research	52,423	54,122	55,279	+1,157	+2.1%
Theory	24,478	25,228	25,340	+112	+0.4%
SciDAC	3,256	3,320	3,300	-20	-0.6%
General Plasma Science	8,991	11,725	11,700	-25	-0.2%
SBIR/STTR	0	6,746	6,790	+44	+0.7%
Total, Science	136,198	150,660	150,815	+155	+0.1%

Description

The Science subprogram fosters fundamental research in plasma science aimed at a predictive understanding of plasmas in a broad range of plasma confinement configurations. There are two basic approaches to confining a fusion plasma and insulating it from its much colder surroundings—magnetic and inertial confinement. In the former, carefully engineered magnetic fields isolate the plasma from the walls of the surrounding vacuum chamber; while in the latter, a pellet of fusion fuel is compressed and heated so quickly that there is no time for the heat to escape. In addition, the Science subprogram supports exploratory research to combine the favorable features of and the knowledge gained from magnetic and inertial confinement, steady-state and pulsed approaches, in new, innovative fusion approaches. There has been great progress in plasma science during the past three decades, in both magnetic and inertial confinement, and today the world is at the threshold of a major advance in fusion power development--the study of burning plasmas, in which the self-heating from fusion reactions dominates the plasma behavior.

Benefits

The Science subprogram provides the fundamental understanding of plasma science needed to address and resolve critical scientific issues related to fusion burning plasmas. The Science subprogram also explores and develops diagnostic techniques and innovative concepts that optimize and improve our approach to creating fusion burning plasmas, thereby seeking to minimize the programmatic risks and costs in the development of a fusion energy source. Finally, this subprogram provides training for graduate students and post docs, thus developing the national workforce needed to advance plasma and fusion science.

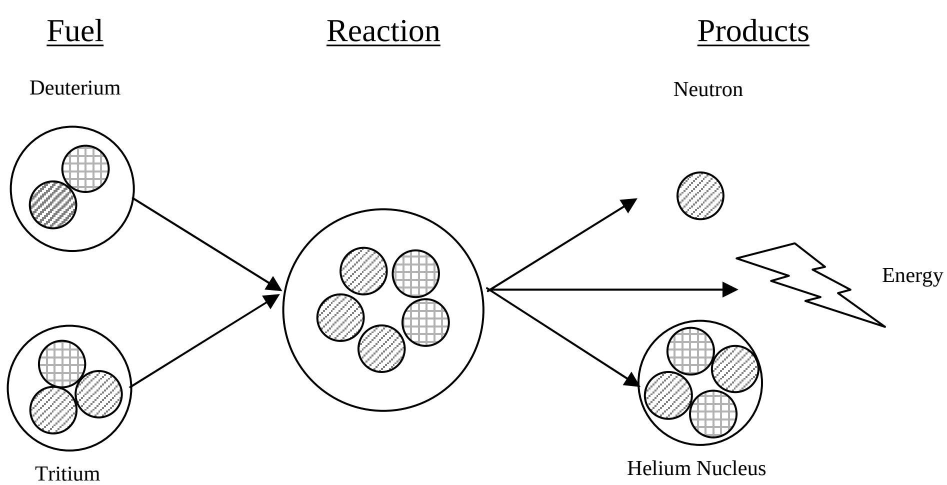
Supporting Information

Plasmas, the fourth state of matter, comprise over 99% of the visible universe and are rich in complex, collective phenomena. During the past decade there has been considerable progress in our fundamental understanding of key individual phenomena in fusion plasmas, such as transport driven by micro-turbulence, and macroscopic equilibrium and stability of magnetically confined plasmas. Over the next ten years the Science subprogram will continue to advance the understanding of plasmas through an integrated program of experiments, theory, and simulation as outlined in the ***Integrated Program Planning Activity for the Fusion Energy Sciences Program*** prepared for FES and reviewed by the Fusion Energy Sciences Advisory Committee. This integrated research program will focus on well-defined plasma scientific issues including turbulence, transport, macroscopic stability, wave particle interactions, multiphase interfaces, hydrodynamic stability, implosion dynamics, fast ignition, and heavy-ion beam transport and focusing. We expect this research program to yield new methods for sustaining and controlling high temperature, high-density plasmas, which will have a major impact on a burning plasma experiment, such as ITER, and to benefit from ignition experiments on the NNSA-sponsored National Ignition Facility (NIF).

An additional objective of the Science subprogram is to broaden the intellectual and institutional base in fundamental plasma science. Two activities, an NSF/DOE partnership in plasma physics and engineering, and Junior Faculty development grants for members of university plasma physics faculties, will continue to contribute to this objective. A new "Centers of Excellence in Fusion Science" program will also foster fundamental understanding and connections to related sciences.

Plasma science includes not only plasma physics but also physical phenomena in a much wider class of ionized matter, in which atomic, molecular, radiative transport, excitation, and ionization processes are important. These phenomena can play significant roles in partially ionized media and in the interaction of plasmas with material walls. Plasma science contributes not only to fusion research, but also to many other fields of science and technology, such as industrial processing, national security, space propulsion, and astrophysics.

Fusion science, a major sub-field of plasma science, is focused primarily on describing the fundamental processes taking place in plasmas where the peak temperatures are greater than 100 million degrees Celsius and densities high enough that light nuclei collide and fuse together, releasing energy and producing heavier nuclei. The reaction most readily achieved in laboratory plasmas is the fusion of deuterium and tritium producing helium and a neutron.



The Fusion Process

Fusion science shares many scientific issues with plasma science. For Magnetic Fusion Energy (MFE), these include: (1) chaos, turbulence, and transport; (2) stability, magnetic reconnection, self-organization, and dynamos; (3) wave-particle interaction and plasma heating; and (4) sheaths and boundary layers. Progress in all of these fields is likely to be required for ultimate success in achieving a practical fusion source.

For Inertial Fusion Energy (IFE), the two major science issues are: (1) high energy density physics that describes intense laser-plasma and beam-plasma interactions; and (2) non-neutral plasmas, as is seen in the formation, transport, and focusing of intense heavy ion beams.

Science Accomplishments

Research funded by the Fusion Energy Sciences program in FY 2003 is focused on developing a predictive understanding of burning plasmas, finding improved magnetic confinement configurations, and exploring high energy density physics relevant to inertial fusion energy.

Predictive Capability for Burning Plasmas

Intensive efforts during the past year have produced advances in the four major topical areas of fusion science: turbulence and transport, macroscopic equilibrium and stability, wave-plasma interactions and plasma heating, and edge/boundary layer plasma physics.

Turbulent transport is the dominant mechanism for energy and particle transport in high temperature tokamak plasmas. Understanding turbulent transport is one of the great challenges of plasma science and is essential to be able to optimize a burning plasma experiment.

- For the first time, a scientific code (GYRO) developed as part of the SciDAC program has been able to correctly predict the transport of heat in the core of a turbulent plasma. The code results were compared to experimental results from the DIII-D tokamak and found to predict the correct level of transport throughout the core of the plasma. This result is a big step in understanding turbulence and transport in tokamak plasmas.
- As our understanding of transport has evolved, we have discovered techniques for reducing energy transport. Internal transport barriers have been observed on both the DIII-D tokamak and the Alcator C-Mod tokamak. A key issue in tokamaks is reducing energy transport without reducing particle transport to the point where density and impurities accumulate in the plasma. Recent experiments with Internal Thermal Barriers (ITB's) generated by off-axis radio frequency (RF) heating on C-Mod have confirmed the ability to control the density peaking, and avoid impurity accumulation, through the application of simultaneous on-axis RF heating. Modeling of these discharges with the GS2 transport code has revealed that a small-scale instability (the Trapped Electron Mode), stimulated by the increased temperature gradients which result from the on-axis heating, appear to be primarily responsible for the enhanced diffusive particle transport, which controls the density peaking and the impurity confinement.

To confine a plasma at the temperatures and densities required for fusion energy production requires either a high magnetic field or an efficient confinement configuration. Achieving the latter requires an understanding of Magnetohydrodynamic (MHD) equilibrium and stability. Since a plasma confined by a magnetic field is not in thermodynamic equilibrium, a variety of large-scale instabilities can occur.

- In a tokamak, a fast-growing instability can lead to a complete loss of magnetic confinement and a rapid transport of the plasma energy to the vacuum vessel walls. A new set of coils, controlled by a high-speed computer system, were installed inside the DIII-D vacuum vessel to stabilize the plasma at pressures that would otherwise be unstable. This active feed-back control system allowed DIII-D to operate with plasma pressures up to 40% higher than the conventional limits.

- One of the less severe but still significant instabilities in the tokamak arises from resistive diffusion of the plasma current so that it collects in clumps that form "magnetic islands" inside the plasma. These islands limit the energy content of the plasma by providing radial short circuits for heat flow across the island. Modern theory work has characterized a new form of these instabilities called Neoclassical Tearing Modes (NTMs), which are driven by a local deficit in plasma's bootstrap current, forming NTM islands. The drive for the NTM instabilities increases as the plasma pressure (or plasma density and temperature) increases. The growth of NTM islands can be arrested by providing localized current drive by microwaves. Experiments in DIII-D demonstrated the validity of the theory and the ability to stabilize these NTMs. In these experiments, conducted in several stages, radially-localized off-axis current was driven by high power microwaves, completely suppressing different modes of the NTM stability. After the islands were completely suppressed, it was possible to increase the plasma pressure with additional beam heating power.

Understanding the interaction of plasma particles with electromagnetic waves is a fundamental topic in plasma science that has practical application to plasma heating and current drive.

- Recent measurements on the Alcator C-Mod tokamak with the phase contrast imaging diagnostic show intermediate wavelength mode converted waves in the core of the plasma. Detailed modeling with the TORIC code has shown that these intermediate wavelength mode converted waves are in fact Ion Cyclotron Waves. This is the first definitive observation of these waves in a tokamak. The ion cyclotron wave propagates toward the low magnetic field region and may have favorable properties for plasma flow drive. Plasma flows are known to have a stabilizing effect on plasma turbulence.

- Electromagnetic wave current drive and/or profile modification are essential elements of all planned advanced, high-performance operating scenarios for ITER. Recent experiments on the DIII-D tokamak at General Atomics have demonstrated stationary plasma performance that projects to longer pulse length and/or higher gain operation in ITER than the present baseline scenario. The results from these experiments, that use a small amount of Ohmic heating transformer flux to support the plasma current and match ITER plasma shape, indicate that the ITER pulse length may be extended to about one hour duration (up from the 400 second baseline case) with full fusion power of about 500 MW. Alternatively, higher fusion power could be achieved for shorter pulses.

Understanding edge plasma physics is important for tokamaks because the properties of the edge plasma affect both the flux of heat and particles to the material walls around the plasma and the confinement of heat and particles in the core of the plasma.

- In High confinement discharges, an undesirable phenomenon is the formation of Edge Localized Modes (ELMs) that eject pulses of particles and energy to plasma facing components and may cause melting or erosion. Previous experiments in DIII-D discovered a new mode of operation with two radial regions of improved heat insulation (transport barriers). Recent experiments in DIII-D involve exhaust of plasma fuel particles and impurities through these barriers without generating ELMs at the plasma edge. The plasma edge in this new mode of operation is 'quiescent' with the absence of ELMs. Additional experiments and analysis during the past year showed that the quiescent double barrier mode in DIII-D resulted in high performance and could be sustained for 3.8 seconds. The conclusion is that this mode can lead to steady-state operation using external current drive. The DIII-D team worked with the ASDEX-Upgrade team in Germany to extend the DIII-D results to

ASDEX-UG, achieving quiescent plasmas (without ELMs) and further strengthening the conclusions reached in DIII-D.

- Experiments in DIII-D have revealed an alternate technique for controlling ELMs in DIII-D using ‘chaotic’ like magnetic fields in the plasma edge. An international team of scientists used a set of new internal coils to break the smooth magnetic surfaces at the narrow plasma edge into a ‘chaotic’ configuration. This chaotic edge configuration eliminated Edge Localized Modes (ELMs) that impart large transient heat loads to the plasma chamber walls and limit plasma performance.
- During the past year, NSTX scientists measured and analyzed the heat flux on the plasma facing components during high power operation. In high confinement mode operation, the dispersion of the heat flux on the divertor plates increased by a factor of three as the plasma triangularity was increased. Geometric effects accounted for less than a factor of two in the increase in the heat flux dispersion. This is a favorable result as increased triangularity is often needed to achieve high performance operation, and greater dispersion of the heat flux reduces peak heat loads on the divertor plates.

Configuration Optimization

Since the inception of this program element in 1997, significant progress has been made in many areas, such as transport in plasmas undergoing Taylor relaxation, the generation of magnetic helicity and its injection into toroidal plasma systems (including tokamaks), stability and generation of exoteric plasma configurations, and shear flow stabilization of plasmas.

- Self organization of plasma flows occurs in many of the important plasmas being studied for fusion, and plays an important role in the dynamics of these plasmas, for better or for worse. The approach to self organization in plasmas typically involves a relaxation process called Taylor relaxation. Taylor relaxation produces magnetic fluctuations that tend to degrade energy confinement. Recent research at University of Wisconsin using a small, reversed field pinch experiment, has successfully suppressed these magnetic fluctuations, leading to a ten-fold improvement in energy confinement. As a result, the plasma temperature in this experiment broke through the 10 million degree Celsius level.
- Magnetic helicity is nature’s way of “trapping” magnetic flux and electrical currents in some self-organized manner that allows magnetic and plasma energy to be transported in space and time. Injecting magnetic helicity into a tokamak, for example, is a candidate for non-inductive start-up and producing electrical currents in tokamak, that are among the most important issues in tokamaks. To that end, a major milestone was demonstrated in the past year in a small, university-scale experiment at the University of Washington. In this experiment, magnetic helicity was generated using a coaxial plasma gun and was injected into a spherical tokamak, resulting in a 30% increase in the toroidal current in the spherical tokamak. The physics underlying the generation of magnetic helicity is further elucidated by another university-scale experiment at Caltech, in which the processes leading to flux amplification are captured photographically and analyzed for the first time. In yet another small university-scale experiment at the University of California in Davis, small balls of magnetic helicity have been accelerated to 200 km/s in the past year, and are being studied as a candidate for refueling tokamaks.
- When magnetic helicity is captured in a toroidal form in a simple vacuum vessel (simply connected) instead of a toroidal chamber (doubly connected), the configuration is a spheromak. The spheromak has the potential of a magnetic toroidal confinement system without the inconvenience (and cost) of

a center stack of a tokamak. A fundamental issue in spheromak research is its sustainment, as magnetic helicity decays due to resistive dissipative processes. In the past year, an important milestone in spheromak research has been demonstrated at the Sustained Spheromak Physics Experiment (SSPX) at the LLNL. In this experiment, for the first time, short pulses of magnetic helicity were injected sequentially into a spheromak, and were successfully retained by the spheromak. Injection of helicity into a spheromak usually opens up the flux surfaces, causing sudden loss of energy confinement. Through better theoretical understanding gained from using modern diagnostics and computational modeling, researchers at LLNL learned to time the helicity injection properly to avoid significant loss of energy confinement. The overall energy confinement was improved by a factor of four, and the plasma temperature was raised from 1.4 million degrees Celsius to 2.6 million degrees Celsius.

- A potentially cost effective way to heat a plasma to fusion temperatures is to compress a magnetized plasma using a material wall, called a liner, that may be solid, liquid, or gaseous. The plasma science question that underpins the approach is the ability of extremely high magnetic field in providing thermal insulation of the material liner so that heat is not lost too rapidly to the liner during the compression of the plasma. Significant progress has been made during the past year in preparing for the feasibility experiment. A cylindrical, solid aluminum liner, 30 cm long and 10 cm in diameter, has been compressed electromagnetically achieving 13 times radial compression with velocities ~ 4 km/s. High density field reversed configurations suitable as magnetized plasmas for the compression experiment have been generated with a density of 3×10^{16} ions/cc, a temperature of 3.3 million degrees Celsius and sustainment time of 10–20 microseconds.
- In the past year, in yet another small-scale university experiment at the University of Washington, the stabilization of a magnetized plasma by a velocity shear in the plasma flow has been demonstrated. In this experiment, the growth rate of the magnetohydrodynamic instabilities was reduced by more than a factor of 700 in a long (0.5 m) Z-pinch plasma configuration.

Inertial Fusion Energy and High Energy Density Physics

The combination of high plasma density and high plasma temperature needed for inertial fusion produces plasmas with very high energy densities. Energy densities in excess of 100 billion joules per cubic meter are of interest to an emerging field of physics called High Energy Density Physics, that cuts across several fields of contemporary physics including astrophysics. Plasmas at these energy densities are characterized by having pressures exceeding a million atmospheres.

The impact of heavy ion beams with a metallic holhraum to produce highly energetic and intense x-rays to implode a material capsule has been considered an attractive approach to create fusion reactions and plasma states of high energy densities. Instead of using ions with energy in the range of 100’s of billions of electron-volts (GeV) that are very expensive to produce, ions with much lower energy (and cost) in the 10’s of million of electron-volts (MeV) may be used if the underlying plasma science issues could be understood and overcome. In the past year, significant progress has been made in understanding the plasma science of heavy ion beams, as well as in the physics of interaction of intense laser beams with materials.

- Ions have positive electrical charge and repel each other. This electrostatic repulsion creates difficulties in focusing them to achieve high energy density. One approach is to neutralize the ions electrically by passing them through a plasma, allowing the electrons in the plasma to recombine with the ions, thus converting the ions to neutral particles. The neutral particles can then be focused by arranging their ballistic trajectories to converge. This focusing mechanism was demonstrated experimentally in the Neutralized Transport Experiment (NTX) at the LBNL, in which an ion beam of approximately 10 cm in diameter was focused down to a spot of less than a few millimeters for the first time in the past year. Separately, the High Current Experiment (HCX) at LBNL is studying the key physics related to beam transport at high intensities, including the effects of imperfections in alignment and focusing fields, image charge effects from beam proximity to the conducting wall, collective oscillations and instabilities, beam halo particles and electron effects. The experiment has used beam currents up to 0.2 amperes, that is high compared to other particle accelerators, such as those used in high energy physics.

- An exciting new scientific development in recent years in the area of inertial fusion and high energy density physics is the use of petawatt (a thousand-trillion-watt) lasers to heat an already dense solid. For fusion, the concept is to use such a laser to heat and ignite a fusionable capsule that is pre-compressed by another laser, the main compression laser. When the intense laser beam impinges on the capsule, the intense radiation accelerates the electrons in the capsule to relativistic velocities. The transport of these relativistic electrons in the material governs the effectiveness of heating the capsule. In the past year, researchers at General Atomics and Lawrence Livermore National Laboratory, working with British and Japanese experimental groups and facilities, have obtained the first experimental data that will throw the first light on the transport of these relativistic electrons in the material.

Specific FY 2005 goals leading toward the long-term performance measures for Fusion Energy Sciences are:

Tokamaks

- Develop a comprehensive experimental database of tokamak stability, transport, particle interaction, and edge effects that will be used to validate predictive models for burning plasmas.

  Obtain experimental data from DIII-D, C-MOD, and NSTX on the control of current profiles by different electromagnetic waves injected into the plasma (high power Electron cyclotron waves in DIII-D, lower hybrid waves in C-MOD, fast waves in NSTX) in order to improve plasma performance and extend pulse length. Compare these results with data from international tokamaks and theoretical predictions.

Alternates

- Assess the value of alternative magnetic confinement configurations to enhance the fundamental understanding of magnetic confinement and improve the basis for future burning plasma experiments.

  For the leading magnetic alternate concept, the spherical torus, complete a preliminary determination of its attractiveness for fusion applications, assessing stability, turbulence and transport, non-inductive current drive, scrape-off layer fluxes, and integration of high plasma pressure and high confinement efficiency for several energy replacement times.

High Energy Density Physics/IFE

- Assess the new physical phenomena that result from using high energy beams and lasers to explore extreme states of matter.

  A roadmap for an interagency high energy density program will be developed jointly with NSF and NNSA, using workshops and symposia to obtain input from the research community.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Tokamak Experimental Research	**47,050**	**49,519**	**48,406**

The tokamak magnetic confinement concept has thus far been the most effective approach for confining plasmas with stellar temperatures within a laboratory environment. Many of the important issues in fusion science are being studied in coordinated programs on the two major U.S. tokamak facilities, DIII-D at General Atomics and Alcator C-Mod at the Massachusetts Institute of Technology. Both DIII-D and Alcator C-Mod are operated as national science facilities with research programs established through public research forums, program advisory committee recommendations, and peer review. There is also a very active program of collaboration with comparable facilities abroad aimed at establishing an international database of Tokamak experimental results. In association with the International Tokamak Physics Activity (ITPA), both DIII-D and Alcator C-Mod have increased their efforts on joint experiments with other major facilities in Europe and Japan in support of ITER-relevant physics issues.

Both DIII-D and Alcator C-Mod will focus on using their flexible plasma shaping and dynamic control capabilities to attain good confinement and stability by controlling the distribution of current in the plasma with electromagnetic wave current drive and the interface between the plasma edge and the material walls of the confinement vessel by means of a “magnetic divertor.” Achieving high performance regimes for longer pulse duration, approaching the steady state, will require simultaneous advances in all of the scientific issues listed above.

▪ **DIII-D Research**	**24,420**	**25,538**	**24,926**

The DIII-D tokamak is the largest magnetic fusion facility in the United States. DIII-D provides for considerable experimental flexibility and has extensive diagnostic instrumentation to measure the properties of a high temperature plasma. It also has unique capabilities to shape the plasma and provide feedback control of error fields that, in turn, affect particle transport in the plasma and the stability of the plasma. DIII-D has been a major contributor to the world fusion program over the past decade in the areas of plasma turbulence, energy and particle transport, electron-cyclotron plasma heating and current drive, plasma stability, and boundary layer physics using a “magnetic divertor” to control the magnetic field configuration at the edge of the plasma. (The divertor is produced by magnet coils that bend the magnetic field at the edge of the tokamak out into a region where plasma particles following the field are neutralized and pumped away.)

The DIII-D experimental program contributes to all four key Magnetic Fusion Energy (MFE) fusion topical science areas—energy transport, stability, plasma-wave interactions, and boundary physics, and various thrust areas that integrate across topical areas to support the goal of achieving a burning plasma. The level of effort for most physics research topics in FY 2005 decreases from FY 2004, but a larger fraction of effort will support burning plasma physics, specifically for ITER. This research elucidates the effects of plasma edge instabilities and high pressure in various plasma confinement regimes, extending the duration of stable plasma operation, and helping build cross-machine data bases using dimensionless parameter (“wind tunnel”) techniques.

The program will also continue the investigation of the scientific basis for optimization of the tokamak approach to fusion production. This research includes investigation of different modes of operation of fusion plasmas for enhancing the attractiveness of tokamak systems. In particular, the experimental program will aim at accomplishing the following related research goal in FY 2005: 1) demonstrate the technical benefits of operating plasmas with a normalized beta (a measure of plasma pressure) value above the "standard" value, made possible by feedback control of new internal wall stabilization coils installed in FY 2003. The initial experiments in FY 2003 with these coils were promising, leading to the planning of experiments in FY 2004. These will be further expanded in 2005. 2) Extend the "Negative Central Shear" mode of operation to higher performance and long pulse plasmas using the 6 MW Ion Cyclotron Radio Frequency (ICRF) system, and the 6 MW Electron Cyclotron Heating (ECH) system. The refurbishment and commissioning of the ICRF system, that was built about 4 years ago, started in FY 2003, and it will be available for these experiments in FY 2005. This system will provide additional electron heating capability and improve the current drive provided by the ECH system and further increase capability to control current profile. The activities in all these areas are interrelated, and they will improve the physics basis and demonstration of a long-pulse, high-performance AT.

	FY 2003	FY 2004	FY 2005
▪ **Alcator C-Mod Research**...	**7,123**	**8,458**	**8,500**

Alcator C-Mod is a unique, compact tokamak facility that uses intense magnetic fields to confine high-temperature, high-density plasmas in a small volume. It is also unique in the use of metal (molybdenum) walls to accommodate high power densities.

By virtue of these characteristics, Alcator C-Mod is particularly well suited to operate in plasma regimes that are relevant to future, much larger fusion tokamaks, as well as to compact, high field, high density burning plasma physics tokamaks. Burning plasmas can be achieved for short pulses in a low cost tokamak by trading high magnetic field for large size (and cost). Alcator C-Mod has made significant contributions to the world fusion program in the areas of plasma heating, stability, and confinement in high field tokamaks; these are important integrating issues related to ignition and burning of a fusion plasma. In FY 2005, compact high field tokamak regimes and operating scenarios required for ignition in compact devices will be further explored. Resources will be increasingly focused on ITER relevant topics such as understanding the physics of the plasma edge in the presence of large heat flows, measuring the effects of and mitigating disruptions in the plasma, controlling the current density profile for better stability, noninductively driving a large part of the plasma current and helping build cross-machine data bases using dimensionless parameter ("wind tunnel") techniques.

Research will also continue to examine the physics of the operational density limit, power and particle exhaust from the plasma, mechanisms of self-generation of plasma flows, and the characteristics of the operating modes achieved when currents are driven by electromagnetic waves. It will also focus on studying transport in the plasma edge at high densities and in relation to the plasma density limit. A new diagnostic neutral beam will further improve visualization of turbulence in the edge and core of high density plasmas, and beam enabled diagnostics will shed light on the physics of temperature and density profile pedestals, whose features are now thought to be the key to predicting tokamak behavior. Active MHD spectroscopy, a novel method for sensing the onset of instability, will continue in FY 2005. The new lower hybrid (microwave) current drive

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

system will be in operation, and experiments will continue using it for control of the current density profile.

▪ **International Collaborations**..	**4,696**	**4,862**	**4,900**

In addition to their work on domestic experiments, scientists from the United States participate in leading edge scientific experiments on fusion facilities abroad, and conduct comparative studies to enhance understanding of underlying physics. The Fusion Energy Sciences program has a long-standing policy of seeking collaboration internationally in the pursuit of timely scientific issues. This allows U.S. scientists to have access to the unique capabilities of facilities that exist abroad. These include the world's highest performance tokamaks (JET in England and JT-60 in Japan), a stellarator (the Large Helical Device) in Japan, a superconducting tokamak (Tore Supra) in France, and several smaller devices. In addition, the U.S. is collaborating with South Korea on the design of plasma diagnostics for the long-pulse, superconducting, advanced tokamak (KSTAR). These collaborations provide a valuable link with the 80% of the world's fusion research that is conducted outside the U.S.

International collaboration will continue on these unique facilities abroad. In FY 2005, an expansion on joint International Tokamak Physics Activity (ITPA) with Japan, Europe, and Russia will enhance collaboration on physics issues related to tokamak burning plasmas. In FY 2005, the collaborations with international programs will also focus on ways of using the unique aspects of these facilities to make progress on the four key MFE Science issues cited in the Science Subprogram description.

▪ **Experimental Plasma Research (Tokamaks)**.......................	**7,009**	**6,570**	**6,500**

Funding provided in this category, for FY 2005, will continue to support research on innovative tokamak experiments at universities and the development of diagnostic instruments.

Complementing the advanced tokamak research on DIII-D and Alcator C-Mod is the exploratory work on the High Beta Tokamak (HBT) at Columbia University. Its goal is to demonstrate the feasibility of stabilizing instabilities in a high pressure tokamak plasma using a combination of a close-fitting conducting wall, and active feedback. This work is closely coordinated with the DIII-D program, and promising results have already been achieved on DIII-D.

Support of the development of unique measurement capabilities (diagnostic systems) that provide an understanding of the plasma behavior in fusion research devices will continue at a number of institutions. This research provides the necessary information for analysis codes and theoretical interpretation. Some key areas of diagnostic research include the development of: (1) techniques to measure the cause of energy and particle loss from the core to the edge of magnetically confined plasmas, including techniques aimed at understanding how barriers to heat loss can be formed in plasmas; (2) methods to measure the production, movement, and loss/retention of the particles that are needed to ignite and sustain a burning plasma; and (3) new approaches that are required to measure plasma parameters in alternate magnetic configurations, which add unique constraints due to magnetic field configuration and strength, and limited lines of sight into the plasma. The requested funding level in FY 2005 supports research that will enhance our understanding of critical plasma phenomena and the means of affecting these phenomena to improve energy and

	(dollars in thousands)	
FY 2003	FY 2004	FY 2005

particle confinement in tokamaks and innovative confinement machines. The funding will also support development of diagnostic systems related to the processes associated with burning plasmas, on U.S. and foreign facilities. Currently supported programs will be peer reviewed prior to awarding FY 2005 funds.

	FY 2003	FY 2004	FY 2005
▪ **Other**	**3,802**	**4,091**	**3,580**

Funding for educational activities in FY 2005 will support research at historically black colleges and universities, graduate and postgraduate fellowships in fusion science and technology, summer internships for undergraduates, and outreach efforts related to fusion science and enabling R&D.

	FY 2003	FY 2004	FY 2005
Alternative Concept Experimental Research............................	**52,423**	**54,122**	**55,279**

A significant amount of research is focused on alternative concepts, aimed at extending fusion science and identifying innovative concepts that could improve the economic and environmental attractiveness of fusion, thereby lowering the overall programmatic risk and cost of the Fusion Energy Sciences program in the long term. The largest element of the alternative concepts program is the NSTX at Princeton Plasma Physics Laboratory that began operating in FY 2000. Like DIII-D and Alcator C-Mod, NSTX is also operated as a national scientific user facility. The Madison Symmetric Torus (MST) is at an intermediate stage of development between a small-scale experiment and a major facility.

	FY 2003	FY 2004	FY 2005
▪ **NSTX Research**	**13,761**	**16,251**	**16,300**

NSTX is one of the world's two largest spherical torus confinement experiments. NSTX has a unique, nearly spherical plasma shape that complements the doughnut shaped tokamak and provides a test of the theory of toroidal magnetic confinement as the spherical limit is approached. Plasmas in spherical tori have been predicted to be stable even when high ratios of plasma-to-magnetic pressure and self-driven current fraction exist simultaneously in the presence of a nearby conducting wall bounding the plasma. If these predictions are verified in detail, it would indicate that spherical tori use applied magnetic fields more efficiently than most other magnetic confinement systems and could, therefore, be expected to lead to more cost-effective fusion power systems. An associated issue for spherical torus configurations is the challenge of driving plasma current via radio-frequency waves or biased electrodes. Such current drive techniques are essential to achieving sustained operation of a spherical torus.

The spherical torus plasma, as are all high beta plasmas, is uniquely characterized by high velocity fast ions and with a large radius of gyration relative to plasma size that could potentially lead to new plasma behaviors of interest. In FY 2005, funding will allow the NSTX national team to carry out research in the areas of high-pressure stability, short wavelength turbulence, wave-particle interactions, boundary physics, and integrated operating scenarios. Several new diagnostics and control upgrades will become operational in FY 2005. Using these new diagnostics and control system enhancements, NSTX team members plan to produce and characterize plasmas near theoretically predicted limits. They will also measure short wavelength turbulence in the plasma core in a range of plasma conditions and explore its relationship to electron thermal transport. Building on experiments carried out in FY 2004, they will demonstrate full non-inductive current drive using combinations of radio frequency waves, neutral beam injection, and pressure driven currents. Further, NSTX researchers plan to characterize heat and particle fluxes in the plasma edge and explore techniques for handling the high fluxes that are produced in high performance plasmas. Finally, they will begin to explore integrated scenarios to achieve high plasma pressure and good energy confinement efficiency for pulse lengths much longer than the energy replacement time. Comparison of all these experimental results with theory will contribute to the scientific understanding of these effects needed to make a preliminary assessment of the attractiveness of the spherical torus concept in late 2006.

	FY 2003	FY 2004	FY 2005
▪ **Experimental Plasma Research (Alternatives)**	**16,910**	**18,049**	**18,100**

With the emphasis in developing the fundamental understanding of the plasma science that underpins innovative fusion concepts, this research element is a broad-based research activity, conducted in twenty five experiments and theory support projects, involving 30 principal investigators and co-principal investigators in 11 universities, 4 national laboratories and industry. Because of the small size of the experiments and the use of sophisticated technologies, the research provides excellent educational opportunities for students and post-docs, and helps to develop the next generation of fusion scientists. In order to foster a vigorous breeding ground for research, each project is competitively peer reviewed on a regular basis of three to five years, so that a portfolio of projects with meritoriously high performance is maintained.

Other current projects in the balance of the magnetic alternate program include fundamental investigations into concepts such as, advanced stellarator configurations, advanced spherical torus, the levitated dipole, field-reversed configurations (FRC), spheromaks, and magnetized target fusion.

As examples of the research being pursued in these experiments:

- Research in advanced stellarators, such as the Helically Symmetric Torus at Wisconsin explores the symmetry characteristics that make quasisymmetrical stellarators different from all other toroidal confinement systems. It is studying transport attributable to fluctuations, and exploring stability and beta limits. Such studies will be applicable to the NCSX, a proof of principle experiment currently under fabrication.
- Field-reversed configurations and spheromaks are toroidal plasma confinement configurations like the tokamak but without the need of a center pole, making them candidates for highly compact fusion reactors. In field-reversed configurations (FRC), current research is exploring an avenue to form and sustain the FRC using a rotating magnetic field (RMF). The main experimental target by FY05 is to form a clean RMF generated FRC so that detailed physics investigations of its energy confinement and transport characteristics could begin.
- Spheromaks are plasmas with self-organized internal plasma currents which generate magnetic fields that confine the plasma, eliminating the toroidal magnets and ohmic heating transformer which necessarily thread the vacuum vessel in the tokamak. Current research aims at generating, amplifying and sustaining these internal plasma currents (related to its magnetic helicity) by the use of coaxial plasma guns (known as coaxial helicity injection).
- Research in magnetized target fusion aims at combining the favorable features of both magnetic and inertial confinement to create fusion reactions at a plasma density considerably higher than

	(dollars in thousands)	
FY 2003	FY 2004	FY 2005

conventional Magnetic Fusion Energy (MFE), but using drivers considerably less powerful and cheaper than Inertial Fusion Energy (IFE). The main experimental objectives by FY 2005 are to produce magnetized plasma with three times the density and to begin exploring the problem of translating the magnetized plasma into a mock-up liner, and to resolve the issue of using a deformable liner or an alternative liner for compressing the plasma.

- The Levitated Dipole Experiment (LDX) explores plasma confinement in a novel magnetic dipole configuration similar to the magnetic field that confines the plasma in the earth's magnetosphere.

	FY 2003	FY 2004	FY 2005
▪ **Inertial Fusion Energy/High Energy Density Physics**	**12,753**	**13,877**	**13,900**

The combination of high plasma density and high plasma temperature needed for inertial fusion produces plasmas with very high energy densities. Energy densities in excess of 100 billion joules per cubic meter are of interest to an emerging field of physics called High Energy Density Physics (HEDP), which cuts across several fields of contemporary physics including astrophysics. Plasmas at these energy densities are characterized by having pressures exceeding a million atmospheres. The research activities in IFE will be redirected to encompass the emphases of a national roadmap in High Energy Density Physics currently being developed by an interagency task force jointly by NSF, DOE, NASA and NIST, following the recommendations of the two NRC reports "Frontiers in High Energy Density Physics" and "Connecting Quarks to the Cosmos." Most high energy density conditions are produced through the use of high power lasers, ion beams, or convergence of high density plasma jets. The impact of heavy ion beams with a metallic holhraum to produce highly energetic and intense x-rays to implode a material capsule has been considered an attractive approach to create fusion reactions and plasma states of high energy densities. Instead of using ions with energy in the range of 100's of billions of electron-volts (GeV) which are very expensive to produce, ions with much lower energy (and cost) in the 10's of million of electron-volts (MeV) may be used if the underlying plasma science issues could be understood and overcome. The beam science program will become part of a more broadly based high energy density science program. This high energy density plasma physics program is a new and exciting area that we will begin to fund in FY 2005. This will require modifications to the existing IFE program, but offers attractive research opportunities in the future. Another exciting development in HEDP in recent years is the science of ultra-intense ultra-fast lasers and its applications to create states of high energy densities. A phenomenon receiving world-wide scientific attention is fast ignition, in which a petawatt laser is used to heat and possibly ignite a fusionable capsule that has been compressed by another slower laser. We are beginning to explore the physics of thermal transport under these conditions.

	FY 2003	FY 2004	FY 2005
▪ **Madison Symmetrical Torus**...	**5,189**	**5,174**	**6,200**

The goal of the Madison Symmetric Torus (MST) experiment is to obtain a fundamental understanding of the physics of reversed field pinches (RFP), particularly magnetic fluctuations and their macroscopic consequences, and to use this understanding to develop the RFP fusion configuration. The plasma dynamics that limit the energy confinement, the ratio of plasma pressure to magnetic field pressure, and the sustainment of the plasma current in RFP are being investigated in the MST experiment. Magnetic fluctuations and its macroscopic consequences including transport, dynamo, stochasticity, ion heating, magnetic reconnection, and momentum transport,

	(dollars in thousands)	
FY 2003	FY 2004	FY 2005

have applications across a wide spectrum of fusion science and astrophysics, to which the MST experiment thus contributes. MST is one of the four leading experiments in RFP research in the world, and is unique in that it pioneered the reduction of magnetic fluctuations by current density profile control. This approach has led to a ten-fold increase in energy confinement. Continual developments in the experimental facility and the theory build-up in FY 2003 and FY 2004 will enable in FY 2005 productive studies of one or more of the following techniques as mechanisms for driving and controlling the current profile, as well as for heating and fueling the plasma: inductive electric field programming, electromagnetic waves, oscillating field helicity injection, neutral beams, and pellet injection. With potentially improved plasmas in MST obtained with one or more of the most highly developed of these techniques separately or in combination, the major experimental undertaking in FY 2005 will be to measure the improved confinement and sustainment in MST.

	FY 2003	FY 2004	FY 2005
▪ **National Compact Stellarator Experiment (NCSX)**	**3,810**	**771**	**779**

NCSX Research supports the research portion of the program to be executed with the NCSX Experiment at PPPL. This involves participation and a leadership role within the National Compact Stellarator Program (NCSP). PPPL and ORNL are the participants in NCSX Research that maintains U.S. contact with major stellarator experiments in Germany, Japan and Spain. The overall objective of this work is to keep planning for NCSX research abreast of developments in stellarator research both domestically and internationally, during the fabrication phase of NCSX.

	FY 2003	FY 2004	FY 2005
Theory	**24,478**	**25,228**	**25,340**

The theory and modeling program provides the conceptual underpinning for the fusion sciences program. Theory efforts meet the challenge of describing complex non-linear plasma systems at the most fundamental level. These descriptions range from analytic theory to highly sophisticated computer simulation codes, both of which are used to analyze data from current experiments, guide future experiments, design future experimental facilities, and assess projections of their performance. Analytic theory and computer codes represent a growing knowledge base that, in the end, is expected to lead to a predictive understanding of how fusion plasmas can be sustained and controlled.

The theory and modeling program is a broad-based program with researchers located at five national laboratories, over 30 universities, and three industries. Institutional diversity is a strength of the program, since theorists at different types of institutions play different roles in the program. Theorists in larger groups, that are mainly at national laboratories and industry, generally support major experiments, work on large problems requiring a team effort, or tackle complex issues requiring a multidisciplinary teams while those at universities generally support smaller, innovative experiments or work on more fundamental problems in plasma physics.

The theory program is composed of two elements—tokamak theory and alternate concept theory. The main thrust of the work in tokamak theory is aimed at developing a predictive understanding of advanced tokamak operating modes and burning plasmas, both of which are important to ITER. These tools are also being extended to innovative or alternate confinement geometries. In alternate concept theory, the emphasis is on understanding the fundamental processes determining equilibrium, stability, and confinement in each concept.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
SciDAC	**3,256**	**3,320**	**3,300**

An important element is the FES portion of the Office of Science's Scientific Discovery through Advanced Computing (SciDAC) program. Major scientific challenges exist in many areas of plasma and fusion science that can best be addressed through advances in scientific supercomputing. In FY 2004, the FES SciDAC projects are being re-competed. The selected projects will be focused on providing a fundamental understanding of plasma science issues important to a burning plasma, and laying the groundwork for the fusion simulation project. The new projects will continue to involve collaborations among physicists, applied mathematicians and computer scientists.

In FY 2005, the computation program will continue to emphasize advanced computing and will make use of rapid developments in computer hardware to attack complex problems involving a large range of scales in time and space, including plasma turbulence and transport, large scale instabilities and stability limits, boundary layer/edge plasma physics, and wave-plasma interaction. These problems were beyond the capability of computers in the past, but advancements in computation are allowing a new look at problems that once seemed almost intractable. The objective of the advanced computing activities, including the SciDAC program, is to promote the use of modern computer languages and advanced computing techniques to bring about a qualitative improvement in the development of models of plasma behavior. This will ensure that advanced modeling tools are available to support the preparations for a burning plasma experiment, a set of innovative national experiments, and fruitful collaboration on major international facilities.

General Plasma Science	**8,991**	**11,725**	**11,700**

The general plasma science program is directed toward basic plasma science and engineering research. This research strengthens the fundamental underpinnings of the discipline of plasma physics that makes contributions in many basic and applied physics areas. Principal investigators at universities, laboratories and private industry carry out the research. A critically important element is the education of plasma physicists. Continuing elements of this program are the NSF/DOE Partnership in Basic Plasma Science and Engineering, the Junior Faculty in Plasma Physics Development program and the basic and applied plasma physics program at DOE laboratories. In FY 2005, the program will continue to fund proposals that have been peer reviewed. Funding will also continue for the *"Centers of Excellence in Fusion Science"* program that was started in FY 2004, supporting one or two centers. Basic plasma physics user facilities will be supported at both universities and laboratories, cost sharing with NSF where appropriate. Atomic and molecular data for fusion will continue to be generated and distributed through openly available databases. The Office of Fusion Energy Sciences will continue to share the cost of funding the multi-institutional plasma physics frontier science center funded by NSF in FY 2003. In FY 2004 and FY 2005, the Department is planning to spend just over $2,100,000 for the work being done at these centers.

SBIR/STTR	**0**	**6,746**	**6,790**

FY 2003 excludes $5,837,000 and $350,000 that was transferred to SBIR and STTR programs, respectively. The FY 2004 and FY 2005 amounts are the estimated requirements for the continuation of these programs.

Total, Science	**136,198**	**150,660**	**150,815**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Tokamak Experimental Research	
▪ The DIII-D decrease reflects the decrease in research efforts that accompanies the reduction in experimental operations from 18 weeks to 14 weeks.	-612
▪ The Alcator C-Mod research effort is essentially the same in FY 2005 as in FY 2004. The level of scientific analysis is maintained despite the reduction in experimental operations from 18 weeks to 14 weeks.	+42
▪ Funding for International Collaboration is increased to support mutually beneficial work on unique international facilities.	+38
▪ The Experimental Plasma Research (Tokamaks) funding is reduced slightly to support higher priority research efforts elsewhere in the program.	-70
▪ The funding in the "Other" category reflects the completion of an Intergovernmental Personnel Act assignment and a shift in funding for higher priority activities in other parts of the program.	-511
Total, Tokamak Experimental Research	**-1,113**
Alternate Concept Experimental Research	
▪ A small increase in NSTX research funding will support increased analysis of experimental data.	+49
▪ The small increase in funding for Experimental Plasma Research (ALT) will be used to partially fund the increased effort directed at understanding the physics of moving metal walls in stabilizing plasmas.	+51
▪ The small increase in IFE funding will provide a slight increase in effort as the program shifts emphasis to High Energy Density Physics research.	+23
▪ The increased MST Research funding will allow the experiment to initiate systematic research on the merits of various techniques in current drives and heating in the MST's reversed field pinch plasma in FY 2005, supported with the appropriate diagnostics, as recommended by competitive peer review.	+1,026
▪ Funding for NCSX research is increased slightly to provide additional support in preparation for operation.	+8
Total, Alternative Concept Experimental Research	**+1,157**
Theory	
▪ Funding for Theory is increased to support additional students.	+112
SciDAC	
▪ Funding is decreased to support higher priority research elsewhere in the program.	-20
General Plasma Science	
▪ Funding is decreased to support higher priority research elsewhere in the program.	-25

	FY 2005 vs. FY 2004 ($000)
SBIR/STTR	
▪ Support for SBIR/STTR is provided at the mandated level.	+44
Total Funding Change, Science	**+155**

Facility Operations

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Facility Operations					
DIII-D	27,474	30,427	29,074	-1,353	-4.4%
Alcator C-Mod	12,039	13,764	13,000	-764	-5.6%
NSTX	16,367	18,427	17,300	-1,127	-6.1%
NCSX	7,897	15,921	15,921	0	0.0%
ITER	0	3,000	7,000	+4,000	+133.3%
GPP/GPE/Other	2,421	2,993	3,200	+207	+6.9%
Total, Facility Operations	66,198	84,532	85,495	+963	+1.1%

Description

The mission of the Facility Operations subprogram is to manage the operation of the major fusion research facilities and the fabrication of new projects to the highest standards of overall performance, using merit evaluation and independent peer review. The facilities will be operated in a safe and environmentally sound manner, with high efficiency relative to the planned number of weeks of operation, with maximum quantity and quality of data collection relative to the installed diagnostic capability, and in a manner responsive to the needs of the scientific users. In addition, fabrication of new projects and upgrades of major fusion facilities will be accomplished in accordance with highest standards and with minimum deviation from approved cost and schedule baselines.

Benefits

The Facility Operations subprogram operates the major facilities needed to carry out the scientific research program in a safe and reliable manner. This subprogram ensures that the facilities meet their annual targets for operating weeks and that they have state of the art, flexible systems for heating, fueling, and plasma control required to optimize plasma performance for the experimental programs. Further, this subprogram fabricates and installs the diagnostics that maximize the scientific productivity of the experiments. Finally, this sub-program provides for the construction of new facilities such as NCSX, and for participation in ITER.

Supporting Information

This activity provides for the operation, maintenance and enhancement of major fusion research facilities; namely, DIII-D at General Atomics, Alcator C-Mod at MIT, and NSTX at PPPL. These user facilities enable U.S. scientists from universities, laboratories, and industry, as well as visiting foreign scientists, to conduct world-class research funded in the Science and Technology subprograms. The facilities consist of magnetic plasma confinement devices, plasma heating and current drive systems, diagnostics and instrumentation, experimental areas, computing and computer networking facilities, and other auxiliary systems. The Facility Operations subprogram provides funds for operating and maintenance personnel, electric power, expendable supplies, replacement parts, system modifications and facility enhancements. In FY 2005, funding is requested to operate the major fusion facilities for 14 weeks.

Funding is also provided for the continuation of the National Compact Stellarator Experiment (NCSX) Major Item of Equipment project at PPPL. In FY 2005, the project will be in its third year, following the FY 2003 project start, and FY 2004 funding will support the final design activities and initial hardware procurements.

Funding is also provided for ITER transitional activities, in which U.S. scientists and engineers will be involved in various technical activities that support both ITER negotiations for a construction project as well as preparations for eventual project construction. These activities will be managed from a U.S. ITER Project Office, to be selected in FY 2004, in preparation for ITER construction starting in FY 2006.

Funding is also included in this subprogram for general plant projects (GPP) and general purpose equipment (GPE) at PPPL. The GPP and GPE funding supports essential facility renovations, and other necessary capital alterations and additions, to buildings and utility systems. Funding is also provided for the third of four years to support the move of ORNL fusion personnel and facilities to a new location at ORNL.

Facility Operations Accomplishments

In FY 2003, funding was provided to operate facilities in support of fusion research experiments and to upgrade facilities to enable further research in fusion and plasma science. Examples of accomplishments in this area include:

- Princeton Plasma Physics Laboratory (PPPL) has awarded contracts, for $600,000 each, to two industrial teams for manufacturing development of the National Compact Stellarator Experiment (NCSX) modular coil winding forms. These are steel structures that support the modular coil windings and locate them to high accuracy. The purpose of these contracts is to develop the manufacturing processes for the forms through fabrication of full-scale prototypes. The project plans to award a follow-on contract for the production order to one of these teams next year.

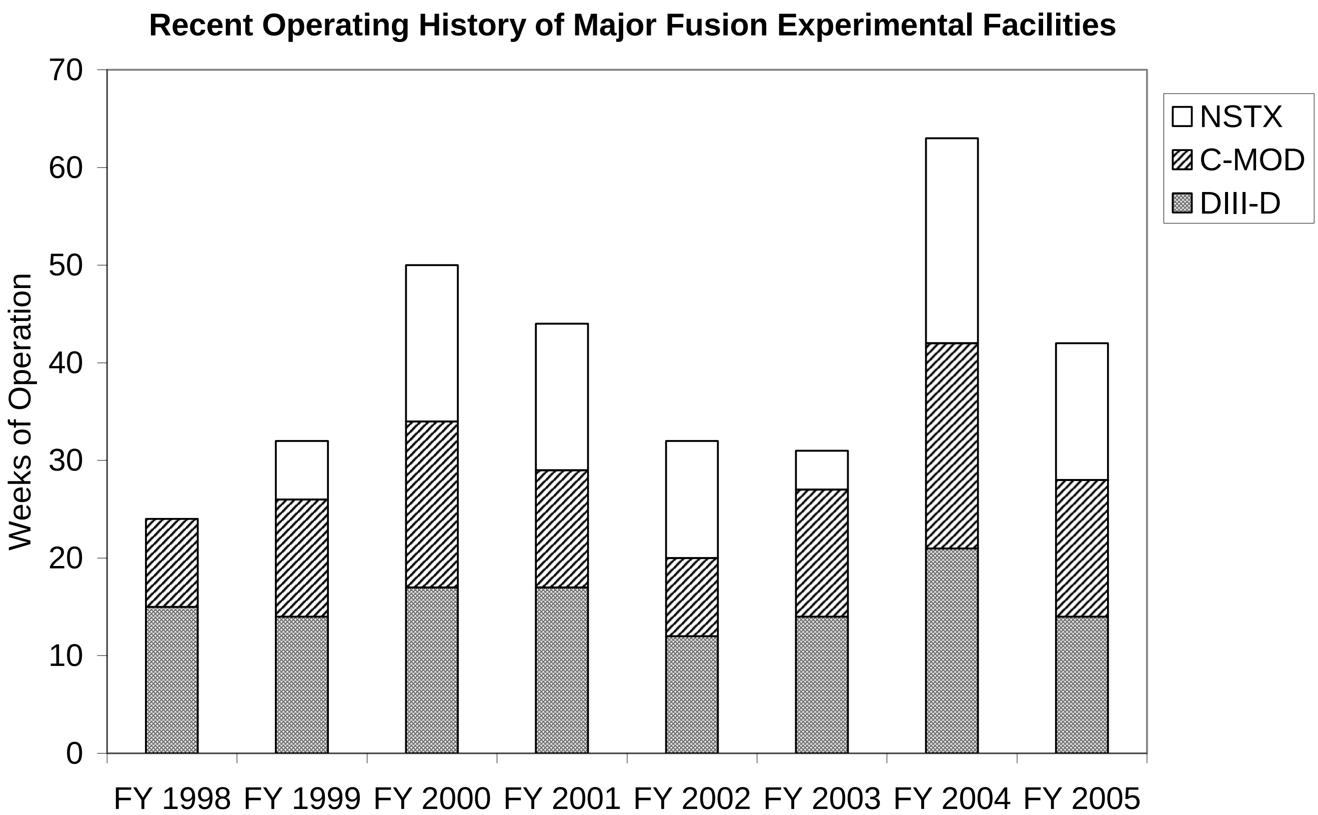
  In addition, PPPL has awarded contracts, for $400,000 each, to two industrial suppliers for manufacturing development of the NCSX vacuum vessel. The vacuum vessel is a highly shaped structure with stringent requirements on vacuum quality and magnetic permeability. The purpose of these contracts is to develop the manufacturing processes to be used in the fabrication of the vessel through fabrication of a prototype sector. Just like the modular coil winding forms, the project plans to award a follow-on contract for the production order to one of these suppliers next year.

The table and chart below summarizes the longer-term history of operation of the major fusion facilities.

Weeks of Fusion Facility Operation

(Weeks of Operations)

	FY 2003 Results	FY 2004 Target	FY 2005 Target
DIII-D	14	18	14
Alcator C-Mod	13	18	14
NSTX	4	18	14
Total	31	54	42



The specific FY 2005 goal leading toward the long-term performance measures for Fusion Energy Sciences is:

NCSX Fabrication

- Award, through a competitive process, production contracts for the following major NCSX systems: Modular Coil Winding Forms and Conductor, and Vacuum Vessel. Complete winding of the first modular coil.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
DIII-D	**27,474**	**30,427**	**29,074**

Provide support for operation, maintenance, and improvement of the DIII-D facility and its auxiliary systems. In FY 2005, these funds support 14 weeks of single shift plasma operation during which time essential scientific research will be performed as described in the science subprogram. These funds also provide for sequentially upgrading the oldest gyrotrons used in the electron cyclotron heating system to provide a uniform 10 second pulse length capability.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Alcator C-Mod	**12,039**	**13,764**	**13,000**

Provide support for operation, maintenance, and improvement of the Alcator C-Mod facility and its auxiliary systems. In FY 2005, these funds support 14 weeks of single shift plasma operation during which time essential scientific research will be performed as described in the science subprogram.

National Spherical Torus Experiment (NSTX)	**16,367**	**18,427**	**17,300**

Provide support for operation, maintenance, and minor upgrades, such as error field coils and antenna upgrades. In FY 2005, these funds support 14 weeks of single shift plasma operation to carry out the research described in the Science subprogram.

National Compact Stellarator Experiment (NCSX)	**7,897**	**15,921**	**15,921**

Funding in the amount of $15,921,000 is requested for the continuation of the NCSX Major Item of Equipment, which was initiated in FY 2003 and consists of the design and fabrication of a compact stellarator proof-of-principle class experiment. These funds will allow for the continuation of procurement of major items and fabrication of the device. This fusion confinement concept has the potential to be operated without plasma disruptions, leading to power plant designs that are simpler and more reliable than those based on the current lead concept, the tokamak. The NCSX design will allow experiments that compare confinement and stability in tokamak and stellarator configurations. The total estimated cost (TEC) of NCSX is in the range of $87,000,000-$89,000,000, with completion expected to be in the late FY 2008/early FY 2009 time frame. After the preliminary design is completed at the end of CY 2003, the cost and schedule baseline for this project will be established in early CY 2004.

ITER	**0**	**3,000**	**7,000**

Funding in the amount of $7,000,000 is provided to continue with ITER transitional activities such as safety, licensing, project management, preparation of final specifications and system integration. U.S. personnel will participate in these activities in preparation for eventual project construction. In addition, preparations will be made to qualify U.S. vendors to supply hardware and components for the project when the need arises.

General Plant Projects/General Purpose Equipment/Other	**2,421**	**2,993**	**3,200**

These funds provide primarily for general infrastructure repairs and upgrades for the PPPL site based upon quantitative analysis of safety requirements, equipment reliability and research needs. Funds also provide for the move of ORNL fusion personnel and facilities to a new location at ORNL.

Total, Facility Operations	**66,198**	**84,532**	**85,495**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
DIII-D	
▪ Funding is reduced to support higher priority activities such as ITER preparation. The number of weeks of operation, 14, is a decrease of 4 weeks from the FY 2004 planned operation..	-1,353
Alcator C-Mod	
▪ Funding is reduced to support higher priority activities such as ITER preparation. The number of weeks of operation, 14, is a decrease of 4 weeks from the FY 2004 planned operation..	-764
NSTX	
▪ Funding is reduced to support higher priority activities such as ITER preparation. The number of weeks of operation, 14, is a decrease of 4 weeks from the FY 2004 planned operation.	-1,127
ITER	
▪ Funding for direct ITER support is increased to $7M to support additional U.S. preparation for ITER construction, primarily for sending additional U.S. personnel to the interim ITER team, for broader qualification of potential U.S. suppliers of hardware, for expanded R&D preparations, and expanded project preparations in the United States.	+4,000
GPP/GPE/Other	
▪ Funding is increased to provide necessary improvements in the PPPL infrastructure and to move ORNL fusion personnel and facilities to a new location at ORNL.	+207
Total Funding Change, Facility Operations	**+963**

Technology

Funding Schedule by Activity

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
Technology					
Engineering Research	30,558	19,763	20,421	+658	+3.3%
Materials Research	7,741	7,600	7,379	-221	-2.9%
Total, Technology	38,299	27,363	27,800	+437	+1.6%

Description

The mission of the Technology subprogram is to develop the cutting edge technologies that enable both U.S. and international fusion research facilities to achieve their goals.

Benefits

The foremost benefit of this subprogram is that it enables the scientific advances in plasma physics accomplished within the Science subprogram. That is, the technology subprogram develops, and continually improves, the hardware and systems that are incorporated into existing fusion research facilities, thereby enabling these facilities to achieve higher and higher levels of performance within their inherent capability. In addition, the Technology subprogram supports the development of new hardware that is incorporated into the design of next generation facilities, thereby increasing confidence that the predicted performance of these new facilities will be achieved. Finally, there is a broader benefit beyond the fusion program in that a number of the advances in fusion technology lead directly to "spin offs" in other fields such as superconductivity, plasma processing and materials enhancements.

Supporting Information

The Engineering Research element addresses the breadth and diversity of domestic interests in technology R&D for magnetic fusion systems as well as international collaborations that support the mission and objectives of the Fusion Energy Sciences program. The activities in this element focus on critical technology needs for enabling both current and future U.S. plasma experiments to achieve their research goals and full performance potential in a safe manner, with emphasis on plasma heating, fueling, and surface protection technologies. While much of the effort is focused on current devices, a significant and increasing amount of the research is oriented toward the technology needs of future burning plasma experiments, especially ITER. Technology R&D efforts provide both evolutionary development advances in present day capabilities that will make it possible to enter new plasma experiment regimes, such as burning plasmas, and nearer-term technology advancements enabling international technology collaborations that allow the United States to access plasma experimental conditions not available domestically. A part of this element is oriented toward investigation of scientific issues for innovative technology concepts that could make revolutionary changes in the way that plasma experiments are conducted, such as liquid surface approaches to control of plasma particle density and temperature, microwave generators with tunable frequencies and steerable launchers for fine control over plasma heating and current drive, and magnet technologies that could improve plasma confinement. This element includes research on tritium technologies that will be needed to produce, control, and process tritium for self-sufficiency in fuel supply. This element also supports research on safety-related issues that enables both current and future experiments to be conducted in an environmentally sound and safe manner. Another activity is conceptual design of the most scientifically challenging systems for fusion research facilities that may be needed in the future. Also included are analysis and studies of critical scientific and technological issues, the results of which will provide guidance for optimizing future experimental approaches and for understanding the implications of fusion research on applications to fusion.

The Materials Research element focuses on the key science issues of materials for practical and environmentally attractive uses in fusion research and future facilities. This element continues to strengthen its modeling and theory activities, which makes it more effective at using and leveraging the substantial work on nanosystems and computational materials science being funded by the Office of Basic Energy Sciences and other government-sponsored programs, as well as more capable of contributing to broader materials research in niche areas of materials science. Through a variety of cost-shared international collaborations, this element conducts irradiation testing of candidate fusion materials in the simulated fusion environments of fission reactors to provide data for validating and guiding the development of models for the effects of neutron bombardment on the microstructural evolution, damage accumulation, and property changes of fusion materials. This collaborative work supports both nearer-term fusion devices, such as burning plasma experiments, as well as other future fusion experimental facilities. In addition, such activities support the long-term goal of developing experimentally validated predictive and analytical tools that can lead the way to nanoscale design of advanced fusion materials with superior performance and lifetime.

Management of the diverse and distributed collection of technology R&D activities continues to be accomplished through a Virtual Laboratory for Technology, with community-based coordination and communication of plans, progress, and results.

Technology Accomplishments

A number of technological advances were made in FY 2003. Examples include:

- Los Alamos National Laboratory (LANL) completed all characterization and stabilization activities of the Tritium Systems Test Assembly (TSTA) Facility and as per the Memorandum of Agreement signed by the Office of Science, Office of Environmental Management (EM), and the Office of Defense Programs in the National Nuclear Security Administration, overall management and financial responsibilities were transferred to EM on August 1. EM will now be responsible for conducting the surveillance and maintenance and eventually, the decontamination and decommissioning.

  The TSTA Facility was built to develop and demonstrate the deuterium-tritium fuel cycle technology for next step fusion devices as well as conduct tritium testing of different fusion components and systems. TSTA successfully and safely demonstrated the capability of processing over 1 kilogram of tritium per day which is approximately one tenth the rate of the ITER Tritium Plant. The data base from its operation was critical to the design of the ITER Tritium Plant.

- The Oak Ridge National Laboratory has completed the installation and testing of the Joint European Torus (JET) high power prototype antenna. This new antenna should enhance the heating of the plasma during experiments. The JET antenna was designed, fabricated and tested on schedule. As planned, the results of this collaborative program were used by JET scientists to design their production antenna.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Engineering Research	**30,558**	**19,763**	**20,421**
▪ **Plasma Technology**	**13,517**	**13,635**	**17,840**

Engineering research efforts will continue on critical needs of domestic plasma experiments and on the scientific foundations of innovative technology concepts for use and testing in ITER. Nearer-term experiment support efforts will be oriented toward plasma facing components and plasma heating and fueling technologies. Additional funds and redirected effort will be provided for technology R&D supporting U.S. responsibilities for ITER procurement packages. Fabrication started in FY 2004 of a 110 gigahertz, 1.5 megawatt industrial prototype gyrotron microwave generator that will be the most powerful of its kind for electron cyclotron heating of plasmas. Completion of the prototype and the beginning of testing will be accomplished in FY 2005. Testing will also begin in FY 2005 of a high speed, compact vertical pellet injector system relevant to the fueling requirements of burning plasma experiments. Based on the experimental research and initial designs during FY 2004 for a first-generation system that allows flowing lithium to interact directly with the plasma, potentially revolutionizing the approach to plasma particle density and edge temperature control in plasma experiments, the design of a lithium module for future deployment in NSTX will be initiated in FY 2005. During FY 2005, studies will continue in the Plasma Interactive Surface Component Experimental Station (PISCES) at the University of California at San Diego, and the Tritium Plasma Experiment at INEEL, of tungsten-carbon-beryllium mixed materials layer formation and redeposition with attached hydrogen isotopes, and results will be applied to evaluate tritium accumulation in ITER plasma facing components. Following initiation in FY 2004 of full-scale tritium operations in the Safety and Tritium Applied Research (STAR) facility at INEEL, preliminary results will be obtained in FY 2005 from material science experiments in STAR performed under a cost-sharing collaboration with Japan to resolve key issues of tritium behavior in materials proposed for use in fusion systems. Additional funds will be provided for ITER nuclear and safety design and analysis, as well as for research on safety, power extraction and tritium technologies for blanket concepts that will be tested in. Funds will be provided to continue superconducting magnet research, safety research, and innovative technology research in the area of plasma-surface interaction sciences that will enable fusion experimental facilities to achieve their major scientific research goals and full performance potential.

▪ **Fusion Technology**	**11,023**	**3,038**	**0**

Following close out of Fusion Technology efforts in FY 2004 in order to focus on research relevant to ITER, no activities are planned for FY 2005**.**

▪ **Advanced Design**	**6,018**	**3,090**	**2,581**

Funding for this effort will focus on studies of compact stellarators. Systems studies to assess both the research needs underlying achievement of the safety, economics, and environmental characteristics of such advanced magnetic confinement concepts will be conducted in an iterative fashion with the experimental community.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Materials Research	**7,741**	**7,600**	**7,379**

Materials Research remains a key element in establishing the scientific foundations for safe and environmentally attractive uses of fusion. Through a wide variety of modeling and experimental activities aimed at the science of materials behavior in fusion environments, research on candidate materials for the structural elements of fusion chambers will continue. Priorities for this work are based on the innovative approaches to evaluating materials and improved models of materials behavior that were adopted from recommendations of earlier FESAC reviews. Building on successes during FY 2004 in the first phase of a cost-shared collaborative program with Japan for irradiation testing of fusion materials in a U.S. fission reactor (High Flux Isotope Reactor), which provides key data to evaluate the effects of neutron bombardment on the microstructural evolution, damage accumulation, and property changes of fusion materials that could be used in next step devices, preliminary investigations will be completed in FY 2005 of nanocomposited ferritic steels with alloy compositions and fabrication techniques designed through nanoscience methods to operate at high temperatures without significant deformation by creep mechanisms. Investigations during FY 2005 will focus on thermodynamics, interface structure, irradiation stability, and helium trapping efficiency of the nanometer sized yttrium-titanium based oxide dispersoids in nano-composited ferritic alloys. In addition, an assessment will be made during FY 2005 of the effects of helium additions on the low temperature radiation embrittlement of ferritic steels.

	FY 2003	FY 2004	FY 2005
Total, Technology	**38,299**	**27,363**	**27,800**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Engineering Research	
Plasma Technology	
▪ Additional funds will be provided for ITER nuclear and safety design and analysis for research on power handling and tritium technology concepts that will be tested in ITER for extracting heat from burning plasmas and for producing sufficient amounts of tritium to achieve self-sufficiency and for technology R&D supporting U.S. responsibilities for ITER procurement packages.	+4,205
Fusion Technology	
▪ Fusion Technology, which generally consists of longer range technology activities, will be closed out in FY 2004 and no activities are planned in FY 2005. This action will provide additional resources for technology development that enables existing and near term facilities like ITER to achieve their full performance capability.	-3,038

	FY 2005 vs. FY 2004 ($000)
Advanced Design	
▪ Advanced Design funding is decreased due to the closeout of the next-step option.	-509
Total, Engineering Research	**+658**
Materials Research	
▪ Funding for research on vanadium alloys is reduced due to closeout of tasks that did not yield promising results.	-221
Total Funding Change, Technology	**+437**

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
General Plant Projects	1,300	1,415	1,643	+228	+16.1%
Capital Equipment	12,448	20,206	19,998	-208	-1.0%
Total, Capital Operating Expenses	13,748	21,621	21,641	+20	+0.1%

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 2003	FY 2004	FY 2005	Accept-ance Date
Alcator C-Mod LH Modification	5,180	4,471	709	0	0	FY 2003
NCSX	87,000-89,000[a]	0	7,897	15,921	15,921	FY 2008-FY 2009
Total, Major Items of Equipment		4,471	8,606	15,921	15,921	

[a] The preliminary TEC increased from $69,000,000 to $73,500,000 with completion in FY 2007, based on the completed conceptual design activities that demonstrated more contingency funds were needed for fabricating the highest risk components. However, because of a delayed start (April 2003) of the project attributable to delayed FY 2003 Congressional appropriations, more detailed information on the design and cost of NCSX components/systems, recommendations from three different review committees and revised funding profile, the NCSX TEC is now expected to be in the range of $87,000,000-$89,000,000 with completion expected to be in the late FY 2008/early FY 2009 time frame. After preliminary design is completed at the end of CY 2003, the cost and schedule baseline for the NCSX project will be established in early CY 2004. The NCSX MIE project will be completed when first plasma is attained during cryogenic operation.

Safeguards and Security

Funding Profile by Subprogram

(dollars in thousands)

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Safeguards and Security					
Protective Forces	27,951	27,003	0	27,003	32,353
Security Systems	9,319	4,664	+809[a]	5,473	7,836
Information Security	5,266	970	+1,671[a]	2,641	2,794
Cyber Security	13,593	11,551	+2,066[ab]	13,617	15,823
Personnel Security	4,397	2,369	+2,615[a]	4,984	5,439
Material Control and Accountability	2,076	2,060	+478[a]	2,538	2,521
Program Management	4,275	3,270	+2,802[a]	6,072	6,549
Subtotal, Safeguards and Security	66,877	51,887	+10,441	62,328	73,315
Less Security Charge for Reimbursable Work	-5,605	-4,383	-1,215[a]	-5,598	-5,605
Total, Safeguards and Security	61,272[c]	47,504	+9,226	56,730	67,710

Public Law Authorizations:
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance and Results Act of 1993"

Mission

The mission of the Office of Science (SC) Safeguards and Security program is to ensure appropriate levels of protection against: unauthorized access, theft, diversion, loss of custody or destruction of Department of Energy (DOE) assets and hostile acts that may cause adverse impacts on fundamental science, national security or the health and safety of DOE and contractor employees, the public or the environment.

[a] Includes $9,506,000 for the transfer in FY 2005 of the Pacific Northwest Site Office safeguards and security activities from the Office of Environmental Management, as follows: Security Systems ($809,000); Information Security ($1,671,000); Cyber Security ($2,346,000); Personnel Security ($2,615,000); Material Control and Accountability ($478,000); Program Management ($2,802,000); and Less Security Charge for Reimbursable Work ($-1,215,000).

[b] Excludes $280,274 for a rescission in accordance with the Consolidated Appropriations Act, 2004, as reported in conference report H.Rpt. 108-401, dated November 25, 2003.

[c] Excludes $286,748 rescinded in accordance with the Consolidated Appropriations Resolution, FY 2003. Includes $4,342,749 for the Emergency Wartime Supplemental Appropriations for FY 2003, $3,607,000 for the transfer of safeguards and security activities from Science Program Direction in FY 2004 and $9,494,000 for the transfer of the Pacific Northwest Site Office safeguards and security activities from the Office of Environmental Management in FY 2005.

Benefits

The benefit of the Safeguards and Security program is that it provides sufficient protection of DOE assets and resources, thereby allowing the programmatic missions of the Department to be conducted in an environment that is secure based on the unique needs of each site. This Integrated Safeguards and Security Management (ISSM) strategy encompasses a graded approach that enables each facility to design its security protection program to meet the facility-specific threat scenario.

The following is a brief description of the types of activities performed:

Protective Forces

The Protective Forces activity provides for security guards or security police officers and equipment, training and maintenance needed to effectively carry out the protection tasks during normal and increased or emergency security conditions (SECON). This request is adequate for up to 60 days of heightened security at the SECON 2 level.

Security Systems

The Security Systems activity provides for equipment to protect vital security interests and government property per the local threat. Equipment and hardware include fences, barriers, lighting, sensors, entry control devices, etc.

Information Security

The Information Security activity ensures that materials and documents that may contain classified or "Official Use Only" (OUO) information are accurately and consistently identified; properly reviewed for content; appropriately marked and protected from unauthorized disclosure; and ultimately destroyed in an appropriate manner.

Cyber Security

The Cyber Security activity ensures that OUO information that is electronically processed or transmitted is properly identified and protected, and that all electronic systems have an appropriate level of infrastructure reliability and integrity. This involves perimeter protection, intrusion detection, firewall protection and user authentication. Cyber security also includes enhancements in network traffic logging and monitoring, risk assessments, and improvements in incident response. It provides for the development of virtual private networks and added security for remote login and wireless connections.

Personnel Security

The Personnel Security activity includes security clearance programs, employee security education, and visitor control. Employee education and awareness is accomplished through initial, refresher and termination briefings, computer based training, special workshops, publications, signs, and posters.

Material Control and Accountability

The Material Control and Accountability activity provides for the control and accountability of special nuclear materials, including training of personnel for assessing the amounts of material involved in packaged items, process systems and wastes. Additionally, this activity provides the programmatic mechanism to ensure that theft, diversion or operational loss of special nuclear material does not occur. Also included is protection for on-site and off-site transport of special nuclear materials.

Program Management

The Program Management activity includes policy oversight and development and updating of security plans, assessments and approvals to determine if assets are at risk. Also encompassed are contractor management and administration, training, planning and integration of security activities into facility operations.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Ames Laboratory	**395**	**409**	**505**

The Ames Laboratory Safeguards and Security program coordinates planning, policy, implementation and oversight in the areas of security systems, protective forces, personnel security, material control and accountability, and cyber security. A protective force is maintained to provide protection of personnel, equipment, and property from acts of theft, vandalism, and sabotage through facility walk-through, monitoring of electronic alarm systems, and emergency communications. The increased funding for FY 2005 is primarily for cyber security. Reimbursable work is included in the numbers above; the amount for FY 2005 is $26,000.

Argonne National Laboratory	**7,680**	**7,651**	**9,784**

The Argonne National Laboratory Safeguards and Security program provides protection of nuclear materials, classified matter, government property, and other vital assets from unauthorized access, theft, diversion, sabotage, espionage, and other hostile acts that may cause risks to national security, the health and safety of DOE and contractor employees, the public, or the environment. Other program activities include security systems, material control and accountability, information security, and personnel security. In addition, a protective force is maintained. These activities ensure that the facility, personnel, and assets remain safe from potential threats. An increase in funding for FY 2005 will enable continued expansion of access control systems and improve the reliability of surveillance systems, cyber security, and foreign visit processing. Enhancements to the physical security systems will help reduce some of the reliance on protective force coverage. Increase also supports requirements of the revised Design Basis Threat (DBT). Reimbursable work is included in the numbers above; the amount for FY 2005 is $388,000.

Brookhaven National Laboratory	**10,929**	**10,756**	**11,342**

The Brookhaven National Laboratory (BNL) Safeguards and Security program activities are focused on protective forces, cyber security, physical security, and material control and accountability. BNL operates a transportation division to move accountable nuclear materials around the site. Material control and accountability efforts focus on accurately accounting for and protecting the site's special nuclear materials. The increase in funding for FY 2005 is associated primarily with the cyber security risk management and self-assessment programs, and projected maintenance of elevated SECON levels. Reimbursable work is included in the numbers above; the amount for FY 2005 is $806,000.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Fermi National Accelerator Laboratory	**2,805**	**2,837**	**3,067**

The Fermi National Accelerator Laboratory Safeguards and Security program efforts are directed at maintaining protective force staffing and operations to protect personnel and the facility, and toward continuing the security systems, and material control and accountability programs to accurately account for and protect the facility's special nuclear materials.

Lawrence Berkeley National Laboratory	**4,649**	**4,689**	**5,165**

The Lawrence Berkeley National Laboratory Safeguards and Security program provides physical protection of personnel and laboratory facilities. This is accomplished with protective forces, security systems, personnel security, and material control and accountability of special nuclear material. The increased funding for FY 2005 is primarily for projected maintenance of elevated SECON levels and enhanced cyber security. Reimbursable work is included in the numbers above; the amount for FY 2005 is $830,000.

Oak Ridge Institute for Science and Education	**1,250**	**1,254**	**1,410**

The Oak Ridge Institute for Science and Education (ORISE) Safeguards and Security program provides physical protection/protective force services by employing unarmed security officers. The facilities are designated as property protection areas for the purpose of protecting government owned assets. In addition to the government owned facilities and personal property, ORISE possesses small quantities of nuclear materials that must be protected. The increased funding for FY 2005 is primarily for enhanced cyber security and program management needs. Reimbursable work is included in the numbers above; the amount for FY 2005 is $319,000.

Oak Ridge National Laboratory	**9,433**	**6,894**	**8,713**

The Oak Ridge National Laboratory (ORNL) Safeguards and Security program includes security systems, information security, cyber security, personnel security, material control and accountability, and program management. Program planning functions at the Laboratory provide for short- and long-range strategic planning, and site safeguards and security plans associated with both the protection of security interests and preparations for contingency operations. Additionally, ORNL is responsible for providing overall laboratory policy direction and oversight in the security arena; for conducting recurring programmatic self-assessments; and for identifying, tracking, and obtaining closure on findings or deficiencies noted during inspections, surveys, or assessments of safeguards and security programs. The funding increase is primarily for cyber security to support monitoring and response for intrusions, malicious code and vulnerabilities; and for program management to provide training/professional development and to improve vulnerability assessments and radiological/ toxicological sabotage assessments. Reimbursable work is included in the numbers above; the amount for FY 2005 is $1,945,000.

Oak Ridge Operations Office	**11,593**	**11,688**	**15,872**

The Oak Ridge Operations Office Safeguards and Security program provides for contractor protective forces for the Oak Ridge National Laboratory. This includes protection of a Category I special nuclear material facility, Building 3019 ($11,060,000), the Spallation Neutron Source ($550,000) facility, and the Federal Office Building complex ($3,808,000). Other small activities include security systems, information security, and personnel security ($454,000). The FY 2005

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

increase is for protective force requirements associated with projected maintenance of elevated SECON levels and requirements of the revised DBT.

Office of Scientific and Technical Information...............	**265**	**60**	**590**

The Office of Scientific and Technical Information's (OSTI) mission is to collect, preserve, disseminate, and leverage the scientific and technical information resources of DOE to expand the knowledge base of science and technology and facilitate scientific discovery and application. Its safeguards and security funding priorities are to meet requirements of the revised DBT, for protective forces, security systems designed to protect information, and enhanced cyber security in FY 2005. The majority of the increase in FY 2005 is needed to implement the revised DBT. It will provide a main entrance security policy officer (1.5 Full Time Equivalent) at OSTI ($150,000) and the installation of badge readers, cameras, updated video surveillance, and vehicle barriers at OSTI ($180,000). In addition, it will provide additional funds needed to implement required cyber security enhancements ($200,000) to protect against intrusions and ensure reliability, integrity and confidentiality of the networks.

Pacific Northwest National Laboratory ……………...	**10,716**	**10,721**	**11,070**

The Pacific Northwest National Laboratory (PNNL) Safeguards and Security program consists of program management, physical security systems, information security, cyber security, personnel security, and material control and accountability. These program elements work together in conjunction with a counterintelligence program and an export control program to ensure appropriate protection and control of laboratory assets while ensuring that PNNL remains appropriately accessible to visitors for technical collaboration. As part of the organizational restructuring of PNNL from an Environmental Management (EM) Site to an SC Site, a Pacific Northwest Site Office (PNSO) is being established. Funding for protective force operations remains the responsibility of EM. Projected increase for FY 2005 is primarily focused on personnel security. Reimbursable work is included in the numbers above; the amount for FY 2005 is $1,222,000.

Princeton Plasma Physics Laboratory............................	**3,489**	**1,855**	**1,945**

The Princeton Plasma Physics Laboratory Safeguards and Security program provides for protection of government property and other vital assets from unauthorized access, theft, diversion, sabotage, or other hostile acts. These activities result in reduced risk to national security and the health and safety of DOE and contractor employees, the public, and the environment. The FY 2005 increase is for protective force requirements associated with projected maintenance of elevated SECON levels. Reimbursable work is included in the numbers above; the amount for FY 2005 is $54,000.

Stanford Linear Accelerator Center................................	**2,211**	**2,207**	**2,341**

The Stanford Linear Accelerator Center Safeguards and Security program focuses on reducing the risk to DOE national facilities and assets. The program consists primarily of protective forces and cyber security program elements. The FY 2005 increase is for protective force requirements associated with projected maintenance of elevated SECON levels. Reimbursable work is included in the numbers above; the amount for FY 2005 is $15,000.

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
Thomas Jefferson National Accelerator Facility	**1,132**	**972**	**1,174**

The Thomas Jefferson National Accelerator Facility has a guard force that provides 24-hour services for the accelerator site and after-hours property protection security for the entire site. Other security programs include cyber security, program management, and security systems. The FY 2005 increase is for cyber security and protective force requirements associated with projected maintenance of elevated SECON levels.

	FY 2003	FY 2004	FY 2005
All Other	**330**	**335**	**337**

This funding provides for program management needs for SC and for the Presidential E-Gov initiative of SAFECOM.

	FY 2003	FY 2004	FY 2005
Subtotal, Safeguards and Security	**66,877**	**62,328**	**73,315**
Less Security Charge for Reimbursable Work	**-5,605**	**-5,598**	**-5,605**
Total, Safeguards and Security	**61,272**	**56,730**	**67,710**

Detailed Funding Schedule

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Ames Laboratory					
Protective Forces	143	143	157	+14	+9.8%
Security Systems	33	24	34	+10	+41.7%
Cyber Security	141	148	227	+79	+53.4%
Personnel Security	39	42	35	-7	-16.7%
Material Control and Accountability	7	7	8	+1	+14.3%
Program Management	32	45	44	-1	-2.2%
Total, Ames Laboratory	395	409	505	+96	+23.5%
Argonne National Laboratory					
Protective Forces	3,197	3,209	2,700	-509	-15.9%
Security Systems	422	455	2,155	+1,700	+373.6%
Information Security	299	211	294	+83	+39.3%
Cyber Security	1,775	1,744	2,012	+268	+15.4%
Personnel Security	960	904	1,067	+163	+18.0%
Material Control and Accountability	688	796	940	+144	+18.1%
Program Management	339	332	616	+284	+85.5%
Total, Argonne National Laboratory	7,680	7,651	9,784	+2,133	+27.9%
Brookhaven National Laboratory					
Protective Forces	6,706	6,146	6,739	+593	+9.6%
Security Systems	881	577	658	+81	+14.0%

(dollars in thousands)	FY 2003	FY 2004	FY 2005	$ Change	% Change
Information Security	121	131	116	-15	-11.5%
Cyber Security	2,247	2,270	2,664	+394	+17.4%
Personnel Security	53	49	29	-20	-40.8%
Material Control and Accountability	320	742	522	-220	-29.6%
Program Management	601	841	614	-227	-27.0%
Total, Brookhaven National Laboratory	10,929	10,756	11,342	+586	+5.4%
Fermi National Accelerator Laboratory					
Protective Forces	1,538	1,700	1,656	-44	-2.6%
Security Systems	456	246	320	+74	+30.1%
Cyber Security	640	780	910	+130	+16.7%
Material Control and Accountability	69	49	70	+21	+42.9%
Program Management	102	62	111	+49	+79.0%
Total, Fermi National Accelerator Laboratory	2,805	2,837	3,067	+230	+8.1%
Lawrence Berkeley National Laboratory					
Protective Forces	1,430	1,392	1,578	+186	+13.4%
Security Systems	860	942	790	-152	-16.1%
Cyber Security	1,915	1,955	2,339	+384	+19.6%
Personnel Security	11	11	9	-2	-18.2%
Material Control and Accountability	19	38	14	-24	-63.2%
Program Management	414	351	435	+84	+23.9%
Total, Lawrence Berkeley National Laboratory	4,649	4,689	5,165	+476	+10.2%
Oak Ridge Institute for Science and Education					
Protective Forces	279	288	297	+9	+3.1%
Security Systems	94	100	71	-29	-29.0%
Information Security	123	139	108	-31	-22.3%
Cyber Security	374	420	541	+121	+28.8%
Personnel Security	107	108	112	+4	+3.7%
Program Management	273	199	281	+82	+41.2%
Total, Oak Ridge Institute for Science and Education	1,250	1,254	1,410	+156	+12.4%
Oak Ridge National Laboratory					
Security Systems	3,676	1,865	2,466	+601	+32.2%
Information Security	378	392	411	+19	+4.8%
Cyber Security	2,580	1,978	2,657	+679	+34.3%
Personnel Security	1,087	972	1,095	+123	+12.7%
Material Control and Accountability	486	428	458	+30	+7.0%
Program Management	1,226	1,259	1,626	+367	+29.2%
Total, Oak Ridge National Laboratory	9,433	6,894	8,713	+1,819	+26.4%

(dollars in thousands)	FY 2003	FY 2004	FY 2005	$ Change	% Change
Oak Ridge Operations Office					
Protective Forces	11,097	11,174	15,418	+4,244	+38.0%
Security Systems	63	134	68	-66	-49.3%
Information Security	129	97	99	+2	+2.1%
Personnel Security	304	283	287	+4	+1.4%
Total, Oak Ridge Operations Office	11,593	11,688	15,872	+4,184	+35.8%
Office of Scientific and Technical Information					
Protective Forces	0	25	175	+150	+600.0%
Security Systems	90	35	215	+180	+514.3%
Cyber Security	175	0	200	+200	N/A
Total, Office of Scientific and Technical Information	265	60	590	+530	+883.3%
Pacific Northwest National Laboratory					
Security Systems	879	809	886	+77	+9.5%
Information Security	4,216	1,671	1,766	+95	+5.7%
Cyber Security	2,290	2,346	2,404	+58	+2.5%
Personnel Security	1,836	2,615	2,805	+190	+7.3%
Material Control and Accountability	487	478	509	+31	+6.5%
Program Management	1,008	2,802	2,700	-102	-3.6%
Total, Pacific Northwest National Laboratory	10,716	10,721	11,070	+349	+3.3%
Princeton Plasma Physics Laboratory					
Protective Forces	1,209	905	1,260	+355	+39.2%
Security Systems	1,633	113	33	-80	-70.8%
Cyber Security	490	775	612	-163	-21.0%
Program Management	157	62	40	-22	-35.5%
Total, Princeton Plasma Physics Laboratory	3,489	1,855	1,945	+90	+4.9%
Stanford Linear Accelerator Center					
Protective Forces	1,781	1,606	1,829	+223	+13.9%
Security Systems	26	0	0	0	0.0%
Cyber Security	404	601	512	-89	-14.8%
Total, Stanford Linear Accelerator Center	2,211	2,207	2,341	+134	+6.1%
Thomas Jefferson National Accelerator Facility					
Protective Forces	571	415	544	+129	+31.1%
Security Systems	206	173	140	-33	-19.1%
Cyber Security	270	308	453	+145	+47.1%

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Program Management	85	76	37	-39	-51.3%
Total, Thomas Jefferson National Accelerator Facility	1,132	972	1,174	+202	+20.8%
All Other					
Cyber Security	292	292	292	0	0.0%
Program Management	38	43	45	+2	+4.7%
Total, All Other	330	335	337	+2	+0.6%
Subtotal, Safeguards and Security	66,877	62,328	73,315	+10,987	+17.6%
Less Security Charge for Reimbursable Work	-5,605	-5,598	-5,605	-7	-0.1%
Total, Safeguards and Security	61,272	56,730	67,710	+10,980	+19.3%

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Ames Laboratory	
The increased funding is primarily in cyber security. Increases are also provided in the areas of protective forces and security systems with minor adjustments in the other elements.	+96
Argonne National Laboratory	
Increases mainly are associated with security systems requirements, cyber security, personnel security needs, and for program management. These increases will: enable continued expansion of access control systems, network monitoring and security for wireless connections; improve the reliability of surveillance systems to help meet the revised DBT requirements; support revisions to vulnerability assessments in support of revised DBT; and support full implementation of a compliant foreign visits and assignments program.	+2,133
Brookhaven National Laboratory	
The increase is associated primarily with the cyber security risk management and self-assessment programs, and projected maintenance of elevated SECON levels. Adjustments to other elements are made to reflect the latest priorities.	+586
Fermi National Accelerator Laboratory	
Limited funding increases are being applied to the security systems and cyber security activities.	+230

	FY 2005 vs. FY 2004 ($000)
Lawrence Berkeley National Laboratory	
The increased funding is primarily for cyber security. Also, projected maintenance of elevated SECON levels result in increased protective force funding.	+476
Oak Ridge Institute for Science and Education	
The increased funding is primarily for cyber security. The enhancements are needed to address identified vulnerabilities to sensitive information.	+156
Oak Ridge National Laboratory	
The funding increase is primarily for security systems to replace limited critical system components or equipment as necessary and to meet the revised DBT requirements; cyber security to support monitoring and response for intrusions, malicious code and vulnerabilities; and for program management to provide training/professional development and to improve vulnerability assessments and radiological/toxicological sabotage assessments..	+1,819
Oak Ridge Operations Office	
The funding increase is primarily for protective force requirements associated with Building 3019 and the Spallation Neutron Source facility. Consideration is also given to projected maintenance of elevated SECON levels and to meet requirements of the DBT.	+4,184
Office of Scientific and Technical Information	
The funding increase is reflected in cyber security for required enhancements primarily for classified archived data and in security systems and protective forces for requirements of the revised DBT.	+530
Pacific Northwest National Laboratory	
Increases are associated primarily with cyber security, information security and personnel security. The increases will enable continued self-assessment activities, full implementation of ISSM, protection of national security and nonproliferation classified information and provide adequate support for the Foreign Visits and Assignments program.	+349
Princeton Plasma Physics Laboratory	
The increase is for protective force requirements associated with projected maintenance of elevated SECON levels, partially offset by reductions to the other elements.	+90

	FY 2005 vs. FY 2004 ($000)
Stanford Linear Accelerator Center	
The increase is for protective force requirements associated with projected maintenance of elevated SECON levels, partially offset by a reduction in cyber security.	+134
Thomas Jefferson National Accelerator Facility	
The increase is for the cyber security program and protective force requirements associated with projected maintenance of elevated SECON levels. Adjustments to the other elements are made to reflect the latest priorities	+202
All Other	
Minor adjustment for program management needs	+2
Subtotal Funding Change, Safeguards and Security	+10,987
Less Security Charge for Reimbursable Work	-7
Total Funding Change, Safeguards and Security	**+10,980**

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

	(dollars in thousands)				
	FY 2003	FY 2004	FY 2005	$ Change	% Change
General Plant Projects	1,600	0	0	0	0.0%
Capital Equipment	1,297	102	104	+2	+2.0%
Total, Capital Operating Expenses	2,897	102	104	+2	+2.0%

Science Program Direction

Funding Profile by Subprogram

(dollars in thousands)

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Science Program Direction					
Program Direction	61,508	58,217	+8,354[a]	66,571	65,927
Field Operations	75,917	80,102	+5,908[b]	86,010	89,341
Office of Scientific and Technical Information	0	7,714	-7,714[c]	0	0
Energy Research Analysis	0	1,020	-1,020[d]	0	0
Subtotal, Science Program Direction	137,425	147,053	+5,528	152,581	155,268
Less Use of Prior Year Balances	0	-358	0	-358	0
Total, Science Program Direction	137,425[e]	146,695	+5,528	152,223	155,268

[a] Excludes $327,050 for a rescission in accordance with the Consolidated Appropriations Act, 2004, as reported in conference report H.Rpt. 108-401, dated November 25, 2003. Includes $1,013,000 for the alignment of program planning and analysis activities and $7,668,000 for the alignment of Office of Scientific and Technical Information (OSTI) activities to headquarters.

[b] Excludes $484,076 for a rescission in accordance with the Consolidated Appropriations Act, 2004 and $944,000 for a transfer in FY 2005 to Nuclear Energy (NE) of 7 FTEs at Oak Ridge Operations Office (ORO) associated with Uranium management activities. Includes $6,236,000 (adjusted for rescission) for the transfer in FY 2005 of 46 FTEs from the Office of Environmental Management (EM) to the Office of Science (SC) for the establishment of the Pacific Northwest Site Office (PNSO) and $1,100,000 for the transfer in FY 2005 of 10 FTEs from the National Nuclear Security Administration (NNSA) to SC for site office activities previously under Oakland Operations Office (OAK).

[c] Excludes $46,000 for a rescission in accordance with the Consolidated Appropriations Act, 2004 and $7,668,000 for the alignment of OSTI activities to headquarters.

[d] Excludes $7,000 for a rescission in accordance with the Consolidated Appropriations Act, 2004 and $1,013,000 for the alignment of program planning and analysis activities to headquarters.

[e] Excludes $881,185 rescinded in accordance with the Consolidated Appropriations Resolution, FY 2003, $820,000 for distribution of a general reduction, $3,607,000 for the transfer in FY 2004 of safeguards and security activities to Science Safeguards and Security and $911,000 for a transfer in FY 2005 to NE of 7 FTEs at ORO associated with Uranium management activities. Includes $5,942,000 for the transfer in FY 2005 of 46 FTEs from EM to SC for the establishment of PNSO and $1,050,000 for the transfer in FY 2005 of 10 FTEs from NNSA to SC for site office activities previously under OAK.

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Staffing (FTEs)					
Headquarters (FTEs)	356	284	+72	356	356
Field Operations (FTEs)	658	609	+49	658	658
Office of Scientific and Technical Information (FTEs)	0	72	-72	0	0
Total, FTEs	1,014	965	+49	1,014	1,014

Public Law Authorization:
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance and Results Act of 1993"

Mission

The mission of Science Program Direction (SCPD) is to provide a Federal workforce, skilled and highly motivated, to manage and support basic energy and science-related research disciplines, diversely supported through research programs, projects, and facilities under the Office of Science's (SC) leadership.

SCPD consists of two subprograms: Program Direction and Field Operations. The Program Direction subprogram is the single funding source for the SC Federal staff in Headquarters responsible for directing, administering, and supporting the broad spectrum of SC scientific disciplines. This subprogram also includes program planning and analysis activities which provide the capabilities needed to evaluate and communicate the scientific excellence, relevance, and performance of SC basic research programs. Additionally, Program Direction includes funding for the Office of Scientific and Technical Information (OSTI), which collects, preserves, and disseminates the scientific and technical information of the Department of Energy (DOE) for use by the DOE, the scientific community, academia, U.S. industry, and the public to expand the knowledge base of science and technology. The Field Operations subprogram is the centralized funding source for the Federal workforce within the field complex responsible for providing best-in-class business, administrative, and specialized technical support across the entire SC enterprise and to other DOE programs.

Overview

Significant Program Shifts

- Both OSTI and program planning and analysis activities are reflected in the Program Direction subprogram because of their organizational reference and relevance to other SC Headquarters offices.
- SC is proposing a restructuring and reengineering project, OneSC, and anticipates that this effort will result in functional consolidations, process reengineering and elimination of skills imbalances throughout the SC complex. Full implementation of this realignment is expected to begin in FY 2004. Functions targeted for workforce reductions will also be identified. This project reflects the

changes envisioned by the President's Management Agenda (PMA) and directly supports the PMA objective to manage government programs more economically and effectively.

- Beginning in FY 2003, the Berkeley Site Office (BSO) and Stanford Site Office (SSO) began identifying the impact of the closure of the Oakland Operations Office (OAK) as a result of the organizational restructuring of the National Nuclear Safety Administration (NNSA). The closure of OAK significantly impacts all support areas required by the BSO and SSO. In response, NNSA and SC have agreed to, and DOE and the Office of Management and Budget (OMB) have approved, the transfer of ten FTEs and associated funding from OAK to BSO/SSO in FY 2005. SC has determined that the Chicago (CH) Operations Office will be the primary service center for the BSO and SSO organizations.
- In response to the functional transfer within the Richland Operations Office from the Office of Environmental Management (EM), in support of the Pacific Northwest National Laboratory, SC has established a Pacific Northwest Site Office (PNSO). EM and SC have agreed to, and DOE and OMB have approved, the transfer of 46 FTEs and associated funding for the new PNSO. SC has determined that the Oak Ridge (OR) Operations Office will be the primary service center for the PNSO.
- SC has also agreed to, and DOE has approved, the functional transfer of seven FTEs and associated funding supporting uranium management activities from the OR Operations Office to Nuclear Energy, Science and Technology (NE).

Program Direction

Funding Schedule by Category

(dollars in thousands, whole FTEs)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Headquarters					
Salaries and Benefits	39,711	41,841	44,009	+2,168	+5.2%
Travel	1,201	1,644	1,645	+1	+0.1%
Support Services	12,072	13,710	11,627	-2,083	-15.2%
Other Related Expenses	8,524	9,376	8,646	-730	-7.8%
Total, Headquarters	61,508	66,571	65,927	-644	-1.0%
Full Time Equivalents	356	356	356	0	0.0%

Mission

The Program Direction subprogram funds all of the SC Federal staff in Headquarters responsible for directing, administering, and supporting the broad spectrum of scientific disciplines. These disciplines include High Energy Physics, Nuclear Physics, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, and Advanced Scientific Computing Research programs. Additionally, this subprogram supports management, human resources, policy, technical, and administrative support staff responsible for budget and finance; general administration; grants and contracts; information technology; policy review and coordination; infrastructure management; construction management; safeguards and security; and environment, safety and health. Funding for OSTI is also provided within this subprogram activity. OSTI is responsible for sharing the agency's R&D knowledge and fulfills this responsibility through leading-edge e-government information systems. Although the majority of DOE's R&D output is open to the scientific community, a sizable share is classified or sensitive. Here, OSTI's responsibilities are to ensure protection and limited, appropriate access in order to promote homeland defense. By supporting its Federal workforce (to include travel, contractual services, Working Capital Fund (WCF), and other related expenses), SC is able to successfully administer major Federal science programs, projects and facilities across the nation in a safe, secure, and efficient manner.

Detailed Justification

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
Salaries and Benefits	**39,711**	**41,841**	**44,009**

This funds 356 FTEs in Headquarters pending completion of the OneSC Project. The FY 2005 salary request includes the proposed January 2005 1.5 percent increase in personnel compensation.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Travel	**1,201**	**1,644**	**1,645**

Travel includes all costs of transportation of persons, subsistence of travelers, and incidental travel expenses in accordance with Federal travel regulations. The FY 2005 request incorporates a non-pay Gross Domestic Product (GDP) inflation factor of 1.3 percent.

Support Services	**12,072**	**13,710**	**11,627**

Provides funding for general administrative services and technical expertise provided as part of day-to-day operations, including mailroom operations; travel management; environment, safety and health (ES&H) support; security and cyber security support; and administration of the Small Business Innovation Research (SBIR) program.

Funding also supports program planning and analysis activities in the following areas: (1) current curriculum of *Original and Collaborative Research Projects*, which includes benchmarking, planning studies, research management theory, the development and validation of performance metrics, options theory, and datamining/statistical analysis tools, (2) support of *Case Studies* to demonstrate and document the societal impact (outcomes) of SC research in key fields/subfields critical to DOE missions and National needs, and (3) E. O. Lawrence Award ceremony and other high profile projects.

Capital Equipment funding is included for computer hardware (i.e., purchase of servers, routers and backup storage space) to support electronic information exchange efforts through E-Government Information Systems.

The $2,083,000 decrease in FY 2005 is the net result of the following: program planning and analysis activities (+$18,000); incorporates a non-pay GDP inflation rate of 1.3 percent for support service contract requirements (+$37,000); the development of integrated business applications and enhancement of leading-edge technologies in support of research and improved business processes ($+267,000); and the implementation of the e-Government Corporate R&D Portfolio Management, Tracking and Reporting Environment (ePME) to automate receipt and review of laboratory proposals ($-2,405,000).

Other Related Expenses	**8,524**	**9,376**	**8,646**

Provides funds for a variety of tools, goods, and services that support the Federal workforce, including acquisitions made through the WCF, computer and office equipment, publications, training, etc.

The $730,000 decrease in FY 2005 is the net result of several items: support for IM projects including ePME and maintenance of e-government information systems (+$78,000); projected increase in the WCF (+$223,000); and realignment of resources previously reserved for the OneSC Project to other critical needs within the SC Program Direction budget (-$1,031,000).

Total, Program Direction	**61,508**	**66,571**	**65,927**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Salaries and Benefits	
■ Supports 356 FTEs and factors 1.5 percent pay adjustment in personnel compensation. This includes FTEs and funding for OSTI.	+2,168
Travel	
■ Supports Federal employees and incorporates non-pay inflation rate of 1.3 percent.	+1
Support Services	
■ Increase in program planning and analysis activities that support SC programs through the development of management tools, analysis of policy direction set by the Administration and Congress, development and integration of SC strategic plans and research portfolios, evaluation of programs and performance, and facilitation of SC collaborations with other Federal agencies and major stakeholders.	+18
■ Increase incorporates non-pay inflation rate of 1.3 percent for support service contract activity requirements in the areas of ES&H, safeguards and security; mail room and travel management; and SBIR	+37
■ Supports development of integrated business applications; development and implementation of ePME; development and enhancement of leading-edge technology in support of research and improved business processes; and alignment of OSTI activities to headquarters. Decrease partially offset by use of uncosted balances.	-2,138
Total, Support Services	-2,083
Other Related Expenses	
■ Supports SC Headquarters IT infrastructure requirements and maintenance of e-government information systems including technical management of ePME; and alignment of OSTI activities to headquarters.	+78
■ Funds activities and projected increase in the WCF	+223
■ Decrease related to the ramp-down of the OneSC Project	-1,031
Total, Other Related Expenses	-730
Total Funding Change, Program Direction	-644

Support Services by Category

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Technical Support					
Test and Evaluation	988	1,060	1,168	+108	+10.2%
Management Support					
Automated Data Processing	8,421	9,930	7,695	-2,235	-22.5%
Reports and Analyses Management and General Administrative Services	2,663	2,720	2,764	+44	+1.6%
Total, Management Support	11,084	12,650	10,459	-2,191	-17.3%
Total, Support Services	12,072	13,710	11,627	-2,083	-15.2%

Other Related Expenses by Category

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Other Related Expenses					
Communications, Utilities, Misc.	350	350	350	0	0.0%
Working Capital Fund	4,100	4,338	4,561	+223	+5.1%
Other Services	4,074	4,688	3,735	-953	-20.3%
Total, Other Related Expenses	8,524	9,376	8,646	-730	-7.8%

Field Operations

Funding Schedule by Category

(dollars in thousands, whole FTEs)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Chicago Operations Office					
Salaries and Benefits	30,221	30,695	32,401	+1,706	+5.6%
Travel	431	542	550	+8	+1.5%
Support Services	510	2,307	2,592	+285	+12.4%
Other Related Expenses	639	3,910	3,664	-246	-6.3%
Total, Chicago Operations Office	31,801	37,454	39,207	+1,753	+4.7%
Full Time Equivalents	302	302	302	0	0.0%
Oak Ridge Operations Office					
Salaries and Benefits	33,217	34,193	35,634	+1,441	+4.2%
Travel	590	521	533	+12	+2.3%
Support Services	3,259	7,203	7,320	+117	+1.6%
Other Related Expenses	7,050	6,639	6,647	8	+0.1%
Total, Oak Ridge Operations Office	44,116	48,556	50,134	+1,578	+3.2%
Full Time Equivalents	356	356	356	0	0.0%
Total Field Operations					
Salaries and Benefits	63,438	64,888	68,035	+3,147	+4.8%
Travel	1,021	1,063	1,083	+20	+1.9%
Support Services	3,769	9,510	9,912	+402	+4.2%
Other Related Expenses	7,689	10,549	10,311	-238	-2.3%
Total, Field Operations	75,917	86,010	89,341	+3,331	+3.9%
Full Time Equivalents	658	658	658	0	0.0%

Mission

The Field Operations subprogram is the centralized funding source for the SC Field Federal workforce responsible for the management and administrative functions at the Chicago (CH) and Oak Ridge (OR) Operations Offices supporting SC laboratories and facilities. These include Ames, Argonne, Brookhaven. Fermi, Lawrence Berkeley National Laboratories, Oak Ridge National Laboratory, Princeton Plasma Physics Laboratory, Thomas Jefferson National Accelerator Facility, Stanford Linear Accelerator Center, and Spallation Neutron Source.

This subprogram supports the Federal workforce that is responsible for SC and other DOE programmatic missions performed in support of science and technology, energy research, and environmental management. Workforce operations include financial stewardship, personnel management, contract and procurement acquisition, labor relations, security, legal counsel, public and congressional liaison, intellectual property and patent management, environmental compliance, safety and health management, infrastructure operations maintenance, and information systems development and support.

In addition, this subprogram provides funding for the fixed requirements associated with rent, utilities, and telecommunications. Other requirements such as IT maintenance, administrative support, mail services, document classification, personnel security clearances, emergency management, printing and reproduction, travel, certification training, vehicle acquisition and maintenance, equipment, classified/unclassified data handling, records management, health care services, and facility and ground maintenance are also included. Services provided through the Department's WCF include online training in the Corporate Human Resource Information System (CHRIS) and payroll processing. These infrastructure requirements are relatively fixed. This subprogram also supports the Inspector General operations located at each site by providing office space and materials. Other operational requirements funded include occasional contractor support to perform ecological surveys, cost validations, and environmental assessments; ensure compliance with Defense Nuclear Facilities Safety Board safety initiatives; abide by site preservation laws and regulations; and perform procurement contract closeout activities.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Salaries and Benefits..	**63,438**	**64,888**	**68,035**

Supports 658 FTEs within the SC Field complex and includes the proposed January 2005 1.5 percent increase in personnel compensation.

Travel	**1,021**	**1,063**	**1,083**

Enables field staff to participate on task teams, work various issues, conduct compliance reviews, and perform contractor oversight to ensure implementation of DOE orders and regulatory requirements at the facilities under their purview. Also provides for attendance at conferences and training classes, and permanent change of station relocation, etc. The FY 2005 request incorporates the non-pay GDP inflation factor of 1.3 percent.

Support Services...	**3,769**	**9,510**	**9,912**

The Field uses a variety of administrative and technical assistance services that are critical to their success in meeting local customer needs. The services provided support IT routine computer maintenance, specific improvements, operating systems upgrades, cyber security, network monitoring, firewalls, and disaster recovery tools. Other areas include staffing 24-hour emergency and communications centers, processing/distributing mail, travel management centers, contract close-out activities, copy centers, directives coordination, filing and retrieving records, etc. Requirements in FY 2003 appear artificially low because some of the requirements funded in FY 2003 came from prior year uncosted balances to avoid involuntary reductions in force (IRIFs) in FY 2003. The $402,000 increase incorporates the non-pay GDP inflation factor of 1.3 percent for support service contract requirements (+$152,000) and requirements redistributed from Other Related Expenses to the correct category (i.e. Support Services) based on FY 2002 actuals (+$250,000).

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
Other Related Expenses	**7,689**	**10,549**	**10,311**

Funds day-to-day requirements associated with operating a viable office, including fixed costs associated with occupying office space, utilities, telecommunications and other costs of doing business, e.g., postage, printing and reproduction, copier leases, site-wide health care units, records storage assessments, office equipment/furniture, building maintenance, etc. Employee training and development and the supplies and furnishings used by the Federal staff are also included. Requirements in FY 2003 appear artificially low because some of the requirements were funded in FY 2003 from prior year uncosted balances to avoid IRIFs in FY 2003. The $238,000 decrease incorporates the non-pay GDP inflation factor of 1.3 percent for support service contract requirements (+$158,000), redistributed requirements to support services (-$196,000) and a projected decrease in WCF support (-$200,000).

	FY 2003	FY 2004	FY 2005
Total, Field Operations	**75,917**	**86,010**	**89,341**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Salaries and Benefits	
■ Supports 658 FTEs within the SC Field complex and factors 1.5 percent pay adjustment in personnel compensation. Includes transfers from EM and NNSA in support of PNSO, BSO and SSO	+3,147
Travel	
■ Supports Federal employees and incorporates the non-pay GDP inflation factor	+20
Support Services	
■ Increase incorporates the non-pay GDP inflation factor of 1.3 percent for support service activities (contract closeout, mail/travel management, etc.)	+152
■ Increase represents redistribution of requirements from Other Related Expenses	+250
Total, Support Services	+402
Other Related Expenses	
■ Increase incorporates the non-pay GDP inflation factor of 1.3 percent in support of day-to-day activities such as building services and maintenance, janitorial, other supplies and materials, and systems support; i.e., the Financial Service Center processes	+158

	FY 2005 vs. FY 2004 ($000)
■ Decrease redistributes requirements to support services category	-196
■ Decrease projected within WCF in the Field Complex based on historical trend	-200
Total, Other Related Expenses	-238
Total Funding Change, Field Operations	**+3,331**

Support Services by Category

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Management Support					
Automated Data Processing	2,649	4,188	4,452	+264	+6.3%
Reports and Analyses Management and General Administrative Services	1,120	5,322	5,460	+138	+2.6%
Total, Support Services	3,769	9,510	9,912	+402	+4.2%

Other Related Expenses by Category

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Other Related Expenses					
Printing and Reproduction	36	250	254	+4	+1.6%
Communications, Utilities, Misc.	3,842	4,545	4,675	+130	+2.9%
Working Capital Fund	453	500	300	-200	-40.0%
Other Services	3,358	5,254	5,082	-172	-3.3%
Total, Other Related Expenses	7,689	10,549	10,311	-238	-2.3%

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Capital Equipment	150	150	150	0	0.0%

Workforce Development for Teachers and Scientists

Funding Profile by Subprogram

(dollars in thousands)

	FY 2003 Comparable Appropriation	FY 2004 Original Appropriation	FY 2004 Adjustments	FY 2004 Comparable Appropriation	FY 2005 Request
Workforce Development for Teachers and Scientists					
Undergraduate Internships..........	3,614	3,768	-38[a]	3,730	3,650
Graduate/Faculty Fellowships..................................	903	1,900	0	1,900	3,110
Pre-College Activities	875	802	0	802	900
Subtotal, Workforce Development for Teachers and Scientists.............	5,392	6,470	-38	6,432	7,660
Less Use of Prior Year Balances.	0	-74	0	-74	0
Total, Workforce Development for Teachers and Scientists..................	5,392[b]	6,396	-38	6,358	7,660

Public Law Authorizations:
Public Law 95-91, "Department of Energy Organization Act"
Public Law 103-62, "Government Performance and Results Act of 1993"
The Omnibus Energy Legislation: Sec. 995. Educational Programs in Science and Mathematics amends the Public Law 101-510, "DOE Science Education Enhancement Act"

Mission

The mission of the Workforce Development for Teachers and Scientists program is to provide a continuum of opportunities to the Nation's students and teachers of science, technology, engineering and mathematics (STEM).

Benefits

Through this unified program, WDTS can attract, train, and retain the talent needed to supply our National Laboratories with the workforce it will need to execute the compelling science that the Office of Science will implement in the coming years.

The Workforce Development for Teachers and Scientists program supports three science, technology and workforce development subprograms: 1) Undergraduate Internships, for a broad base of undergraduate students planning to enter STEM careers, including teaching; 2) Graduate/Faculty Fellowships for STEM students, teachers, and faculty; and 3) Pre-College Activities for middle and high school students,

[a] Excludes $37,736 for a rescission in accordance with the Consolidated Appropriations Act, 2004, as reported in conference report H.Rpt. 108-401, dated November 25, 2003.

[b] Excludes $35,277 for a rescission in accordance with Consolidated Appropriations Resolution, FY 2003.

the principle effort being the National Science Bowl. Each subprogram targets a different group of students and teachers to attract as broad a range of participants to the programs and to expand the pipeline of students who will enter the STEM workforce. In this fashion, the subprograms use our National Laboratories to meet the Department's own, as well as a national need for a well-trained scientific and technical workforce. The program also has a focus on professional development for teachers and faculty who often serve their students as the primary models and inspiration for entering the scientific and technical workforce.

Significant Program Shifts

- In FY 2005, the Laboratory Science Teacher Professional Development activity will run at five or more DOE National Laboratories with about 90 participating STEM teachers, in response to the national need for science teachers who have strong content knowledge in the classes they teach. The DOE National Laboratories provide mentor-intensive, research focused, professional development where the teacher is immersed in the culture and world of science and technology. The multidisciplinary, team-centered, scientific culture of the National Laboratories is an ideal setting for teachers to fully comprehend the science and technology principles they are asked to teach. More importantly, the extensive mentoring power of our laboratory scientists and their commitment to knowledge transfer are ideal means to establish a link between teachers, their classroom and the scientific community. Armed with this knowledge and experience, each teacher could enter the classroom as a genuine effective representative of the exciting world of science and technology. Teacher classroom performance and student commitment to STEM career paths will help measure the long-term impact of this program.
- A new Faculty Sabbatical activity, proposed in FY 2005, is aimed at providing sabbatical opportunities to 12 faculty members from minority serving institutions (MSIs) to facilitate the entry of their faculty into the research funding mainstream. This proposed activity is an extension of the successful Faculty and Student Teams (FaST) program where teams consisting of a faculty member and two or three undergraduate students, from colleges and universities with limited prior research capabilities, work with mentor scientists at a National Laboratory to complete a research project that is formally documented in a paper or presentation.

Supporting Information

As documented by a July 2001 DOE's Inspector General, the Department faces a critical and immediate shortage of scientific and technical staff sufficient to meet its mission requirements. Further, unless current trends are reversed the Department could, within less than five years, face a 40 percent shortage in these job function areas. The Office of Workforce Development is addressing this shortfall by managing its current programs, and initiating target programs, that align with the mission of SC and the Laboratories.

Our programs provide a grade school through post-grad school set of opportunities that are unified under the common belief that Department of Energy (DOE) National Laboratories can provide unique training and professional development research experiences that enhance the technical skills and content knowledge in science and mathematics of teachers and students, strengthen their investigative expertise, inspire commitments to science and engineering careers, and build a link between the resources of the National Laboratories and the science-education community. These opportunities are complimentary to the efforts of other federal agencies, such as the National Science Foundation, and provide support that might otherwise be unavailable to these agencies' programs and students they serve.

Undergraduate Internships

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Undergraduate Internships					
Science Undergraduate Laboratory Internship	2,503	2,615	2,650	+35	+1.3%
Community College Institute of Science and Technology	601	605	560	-45	-7.4%
Pre-Service Teachers	510	510	440	-70	-13.7%
Total, Undergraduate Internships	3,614	3,730	3,650	-80	-2.1%

Description

The mission of the Undergraduate Internships subprogram is to continue the Department's long-standing role of providing mentor-intensive research experiences at the National Laboratories for undergraduate students to enhance their content knowledge in science and mathematics, their investigative expertise, and inspire commitments to careers in science and engineering and K-12 STEM teaching. Through providing a wide variety of college undergraduates the opportunity to work directly with many of the world's best scientists and use the most advanced scientific facilities available, this program will expand the nation's supply of highly skilled scientists and engineers, especially in the physical sciences where the greatest demand lies because of a steady decline in U.S. citizens entering these fields.

Benefits

The Undergraduate Internships subprogram provides a wide diversity of opportunities for undergraduate students to see and experience what a career in a National Laboratory has to offer. It allows the National Laboratories to have a broader and more skilled pool from which to draw employees. It also provides the laboratory mentors with a more enriching environment in which to conduct their research.

Supporting Information

The Undergraduate Internships subprogram contains three activities:

The "Science Undergraduate Laboratory Internship" strengthens the students' academic training and introduces them to the unique intellectual and research facility resources present at the National Laboratories. Research internships are available during the spring, summer, and fall terms.

The "Community College Institute (CCI) of Science and Technology" provides a 10-week summer workforce development program through research experiences at several DOE National Laboratories for highly motivated community college students. The CCI is targeted at underserved community college students who have not had an opportunity to work in an advanced science-research environment. It incorporates both an individually mentored research component and a set of enrichment activities that include: lectures, classroom activities, career guidance/planning, and field trips.

"Pre-Service Teachers" (PST) is for undergraduate students who plan on pursuing a teaching career in science, technology, engineering or mathematics. Students work with scientists or engineers on projects related to the laboratories' research programs. They also have the mentorship of a master teacher who is currently working in K-12 education as a teacher and is familiar with the research environment of a specific National Laboratory.

Accomplishments

- Workforce Development has fully implemented an innovative, interactive Internet system for all Office of Science national workforce development programs, to receive and process hundreds of student and teacher/faculty applications for summer, fall, and spring semester research appointments at participating DOE laboratories. The on-line application system is linked with an SC laboratory central processing center, called Education Link, and allows the students and researchers at the laboratories to select and match in research areas of common interest.
- This system enhances communication with the participants regarding their internships, contains pre- and post-surveys that quantify student knowledge, performance and improvement, allows SC to measure program effectiveness, track students in their academic and career path, and be a hosting site for publishing student papers, abstracts and all activity guidelines. This system also provides valuable data on the quality of experiences and provides various metrics for outside evaluators to access the impact of the program.
- Through special recruitment efforts, the Science Undergraduate Laboratory Internship (SULI) has attracted a diverse group of students using the electronic application. Over 20 percent of those submitting applications were from under-represented groups. Approximately 40 percent of the applicants were females, and more than 25 percent were from low-income families. In the summers of 2000 through 2003, about 500 appointments were made each year through the on-line application process.
- In order to document and evaluate the quality of the research experience and the collaboration of the intern with their mentor researcher, the program publishes the *Journal of Undergraduate Research* containing full-length peer-reviewed research papers and abstracts of students' research in the activity. All scientific research abstracts are graded to measure the quality of the students' ability to prepare scientific manuscripts. A third edition was published in 2003, with 15 full-length papers and 488 abstracts. In 2003, more than 95% of all students in undergraduate research internships submitted abstracts and research papers. The students who published full-length papers presented their work at a poster session at the American Association for the Advancement of Science (AAAS) national meeting. Students have received awards at these events for their research and the communication of their accomplishments.
- The program has revised its *Undergraduate Internships Program Guidebook*. The guidebook is an invaluable tool for both students and laboratory research mentors as it describes the responsibilities, requirements, and outcomes that are to be accomplished to have a successful internship. Contained therein are formats and instructions for the written requirements, including scientific abstract, research paper, oral presentation, and poster; and instructions for an education module for the Pre-Service Teachers.
- The DOE Community College Institute of Science and Technology (CCI) is open to students from all community colleges. In the summer of 2003, 81 community college students attended a 10-week mentor-intensive scientific research experience at several DOE National Laboratories. Almost 60

percent of the participating students came from underrepresented groups in STEM disciplines; many were "non-traditional" students. Grades of abstracts for these students were statistically equal to those from the 4 year program.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Science Undergraduate Laboratory Internship............	**2,503**	**2,615**	**2,650**

The Science Undergraduate Laboratory Internship (SULI) supports a diverse group of students at our National Laboratories in individually mentored research experiences. Through these unique and highly focused experiences these students will comprise a repository of talent to help the DOE meet its science mission goals. The paradigms of the activity are: 1) students apply on a competitive basis and are matched with mentors working in the students' fields of interest; 2) students spend an intensive 10-16 weeks working under the individual mentorship of resident scientists; 3) students must each produce an abstract and formal research report; 4) students attend seminars that broaden their view of career options and help them understand how to become members of the scientific community; and 5) activity goals and outcomes are measured based on students' research papers, students' abstracts, surveys and outside evaluation. An undergraduate student journal is produced annually that publishes selected full research papers and all abstracts of students in the activity. Full research papers published in the journal are presented by the student authors at the annual national conference of the American Association for the Advancement of Science (AAAS) and the abstracts of their presentations are posted on the AAAS web site. The National Science Foundation (NSF) began a collaboration with this activity as of FY 2001 to offer students in its undergraduate student programs access to individually mentored research internships that they would otherwise not have. The activity will ensure a steady flow of students with growing interest in science careers into the Nation's pipeline of workers in both academia and industry. A system is being refined to track students in their academic career paths. In FY 2003, 25 students participated in the Spring semester program, 336 students participated in the summer, and 19 students in the fall semester program. An estimated 370 students in FY 2004 and 360 students in FY 2005 will participate in the Science Undergraduate Laboratory Internship.

Community College Institute of Science and Technology	**601**	**605**	**560**

The Community College Institute (CCI) of Science and Technology was originally a collaborative effort between DOE and its National Laboratories with the American Association of Community Colleges and specified member institutions. Through a recent Memorandum of Understanding with the NSF, undergraduate students in NSF programs (e.g., Lewis Stokes Alliance for Minority Participation and Advanced Technology Education program) are also participating in this activity and in FY 2002 the CCI was made available to students from all community colleges. This allows students in NSF-funded programs access to advanced laboratories, which would otherwise be unavailable to them, to perform research that will advance their STEM careers. This activity is designed to address shortages, particularly at the technician and paraprofessional levels, and will help develop the workforce needed to continue building the Nation's capacity in critical areas for the next century. Since community colleges account for more than half of the entire nation's undergraduate enrollment, this is a clear avenue to find and develop talented scientists and engineers. The Institute provides a ten-week

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005

mentored research internship at a DOE National Laboratory for highly motivated community college students. The paradigms of the activity are: 1) students apply on a competitive basis and are matched with mentors working in the students' field of interest; 2) students spend an intensive 10 weeks working under the individual mentorship of resident scientists; 3) students must each produce an abstract and formal research report; 4) students attend professional enrichment activities, workshops and seminars that broaden their view of career options, help them understand how to become members of the scientific community, and enhance their communication and other professional skills; and 5) activity goals and outcomes are measured based on students' research papers, students' abstracts, surveys and outside evaluation. An undergraduate student journal was created to publish selected full research papers and all abstracts of students in this activity. The National Science Foundation entered into a collaboration with the Office of Science on this activity in FY 2001. This allows NSF's undergraduate programs to include a community college internship in the opportunities they provide to students. In FY 2003, 81 students directly participated in this internship. A similar number is expected in FY 2004 and in FY 2005 there will be approximately 73 students. The decrease in the number of students in the Undergraduate Research Internships subprogram is because additional funding was provided to: (a) Faculty and Students Teams, (b) Albert Einstein Distinguished Educator Fellowship and (c) US First Robotics [per FY 2004 Appropriations language].

Pre-Service Teachers...	**510**	**510**	**440**

The Pre-Service Teachers activity is for students who are preparing for a teaching career in a STEM discipline. This effort is aimed at addressing the national need to improve content knowledge of STEM teachers prior to entering the teaching workforce. The paradigms of the activity are: 1) students apply on a competitive basis and are matched with mentors working the student's field of interest; 2) students spend an intensive 10 weeks working under the mentorship of master teachers and laboratory scientists to help maximize the building of content, knowledge, and skills through the research experience; 3) students must produce an abstract and an educational module related to their research and may also produce a research paper or poster or oral presentation; 4) students attend professional enrichment activities, workshops and seminars that help students apply what they learn to their academic program and the classroom, and also to help them understand how to become members of the scientific community, and enhance their communication and other professional skills; and 5) activity goals and outcomes are measured based on students' abstracts, education modules, surveys and outside evaluation. In FY 2003, 65 students are participating in this program. Approximately 80 students in FY 2004 and 68 students in FY 2005 are expected to participate in the Pre-Service Teachers activity. The decrease in the number of students in the Undergraduate Research Internships subprogram is because additional funding was provided to: (a) Faculty and Students Teams, (b) Albert Einstein Distinguished Educator Fellowship and (c) US First Robotics [per FY 2004 Appropriations language].

Total, Undergraduate Internships..................................	**3,614**	**3,730**	**3,650**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Science Undergraduate Laboratory Internship	
▪ This increase allows Science Undergraduate Laboratory Internship (SULI) students to attend the American Association for the Advancement of Science national meeting. The number of students in SULI decreases by 10 from 370 in FY 2004	+35
Community College Institute of Science and Technology	
▪ The number of students in the Community College Institute of Science and Technology decreases by 7 from 80 in FY 2004	-45
Pre-Service Teachers	
▪ The number of students participating in the Pre-Service Teachers activity decreases by 12 from 80 in FY 2004	-70
Total Funding Change, Undergraduate Internships	**-80**

Graduate/Faculty Fellowships

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Graduate/Faculty Fellowships					
Laboratory Science Teacher Professional Development	60	1,000	1,500	+500	+50.0%
Faculty and Student Teams	180	210	320	+110	+52.4%
Albert Einstein Distinguished Educator Fellowship	588	600	700	+100	+16.7%
Energy Related Laboratory Equipment	75	90	90	+0	0.0%
Faculty Sabbatical Fellowship	0	0	500	+500	--
Total, Graduate/Faculty Fellowships	903	1,900	3,110	+1,210	+63.7%

Description

The mission of the Graduate/Faculty Fellowships subprogram is to build a link between the resources of the National Laboratories and the science-education community by providing mentor-intensive research experiences at the National Laboratories to teachers and faculty to enhance their content knowledge in science and mathematics, their investigative expertise and to enhance the research capabilities at academic institutions.

Benefits

These Graduate/Faculty Fellowship activities bring in fresh ideas and a greater diversity of faculty and colleges interacting with the National Laboratories.

Supporting Information

The Graduate/Faculty Fellowships subprogram contains five activities:

The Laboratory Science Teacher Professional Development program addresses the Administration's goal of a "qualified teacher in every classroom." The program provides K-14 classroom teachers long-term, mentor-intensive professional development through scientific research opportunities at the National Laboratories. The program will improve: teachers' content knowledge; student achievement in science, technology, engineering and mathematics (STEM); and numbers of students pursuing STEM careers. Students will show increased involvement in STEM courses, extracurricular activities and pursuit of higher level STEM courses and ultimately show rising average scores on standardized tests. Teachers completing the initial laboratory summer experience will be provided: monetary support to help them extend what they have learned to their classes; support to connect students via classroom activities to ongoing national laboratory research; support for continuing communication and collaboration with other participant teachers and laboratory scientists; subject enhancement trips to the laboratory; and support to present their experiences at professional conferences and in publications.

The Faculty and Student Teams (FaST) program provides research opportunities at a National Laboratory to faculty and undergraduate students from colleges and universities with limited prior research capabilities as well as institutions serving populations, women, and minorities underrepresented in the fields of science, technology, engineering, and mathematics. These opportunities are also extended to faculty from NSF funded institutions.

The Faculty Sabbatical Fellowship program is an extension of the successful Faculty and Student Teams program. It provides a research fellowship where a faculty member may collaborate with resident scientists at a national laboratory for up to one year on research projects specific to the visiting professors' areas of investigation and the courses they teach. It is the extended stay at the laboratory, along with the concentrated support, that will enhance them as professors and help them better prepare and apply for grants from federal science agencies and other granting institutions.

The "Albert Einstein Distinguished Educator Fellowship" activity supports outstanding K-12 science and mathematics teachers, who provide insight, extensive knowledge, and practical experience to the legislative and executive branches. This activity is in compliance with the Albert Einstein Distinguished Educator Act of 1994 (signed into law in November 1994). The law gives DOE responsibility for administering the activity of distinguished educator fellowships for elementary and secondary school mathematics and science teachers.

The "Energy Related Laboratory Equipment" (ERLE) activity was established by the Department of Energy (DOE) to grant available excess equipment to institutions of higher education for energy-related research.

Accomplishments

- An innovative, interactive Internet system has been developed and implemented for all Office of Science national workforce development programs to receive and process hundreds of student and teacher/faculty applications for summer, fall, and spring semester research appointments at participating DOE laboratories. The automated system is virtually paperless and provides an excellent example of how the Internet can be used to streamline the operation of the Department's research participation programs. The on-line application system is linked with an SC laboratory central processing center called Education Link.
- This system enhances communication with the participants regarding their internships, contains pre- and post-surveys that quantify student knowledge, performance and improvement, allows SC to measure program effectiveness and track students in their academic and career path, and to be a hosting site for publishing student papers, abstracts and all activity guidelines.
- The Albert Einstein Distinguished Educator Fellowship activity placed four outstanding K-12 science, math, and technology teachers in Congressional offices and two at DOE, as directed by legislation. The National Aeronautics and Space Administration, the National Science Foundation, and the National Institute of Standards and Technology contributed funds to place seven additional Einstein Fellows in those agencies.
- Five Office of Science laboratories – Argonne National Laboratory, Brookhaven National Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory and Pacific

Northwest National Laboratory directly provided support for 12 Faculty and Student Teams. In collaboration with the National Science Foundation, this number was leveraged to support a total of 23 teams in FY 2003. Faculty and students from colleges and universities with limited prior research capabilities and those institutions serving populations, women, and minorities underrepresented in the fields of science, engineering, and technology were part of a research team at a National Laboratory. Over a ten week summer visit to the laboratory, the faculty were introduced to new and advanced scientific techniques that will help them prepare their students for careers in science, engineering, computer sciences and technology and their own professional development.

Detailed Justification

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Laboratory Science Teacher Professional Development	**60**	**1,000**	**1,500**

The *National Commission on Mathematics and Science Teaching* and numerous other studies indicate that professional staff development is one of the most effective ways of improving the achievement of K-14 students. The National Laboratories can play a significant role in providing carefully designed *mentor-intensive training for science and math teachers* that will allow them to more effectively teach, *attract their students' interests to science, mathematics and technology careers,* and improve student achievement. The paradigms of the pilot "*Laboratory Science Teacher Professional Development*" activity are: 1) Teachers apply on a competitive basis and are matched with mentors working in their subject fields of instruction; 2) *approximately 60 teachers per year in FY 2004 and 90 in FY 2005 will spend an intensive 4 to 8 weeks at five or more National Laboratories* working under the mentorship of master teachers and laboratory mentor scientists to help build content knowledge research skills and a lasting connection with the scientific community through the research experience. *Master teachers,* who are expert K-14 teachers and adept in both scientific research experience at a National Laboratory and scientific writing, *will act as liaisons between the mentor scientists and the teacher researchers to help the teachers transfer the research experience to their classroom environments*; 3) follow-on support is considered critical. Master teachers and other teacher participants receive an $800/week stipend, travel and housing expenses. All teachers completing the initial immersion experience will be provided monetary support, which consists of approximately $3,000 to *purchase materials and scientific equipment,* to help them transfer their research experience to their classroom. Follow-on support also will include: returning to the laboratory in the first year for *additional training sessions* of approximately 1 week; and *long-term support* in following years through communication with other participants and laboratory scientists, more *return trips* to the National Laboratory, and support to *present their experience at teaching conferences and publications*; and 4) *outside evaluation* of program effectiveness including visits to participant teachers' schools and long term impact of the program on student achievement. Success of this research experience relies on two elements: 1) proper placement of each participant to match their professional developmental needs and, 2) the follow-on interaction between the teachers and the National Laboratories. In FY 2004, the program will be initiated at five or more National Laboratories.

	(dollars in thousands)		
	FY 2003	FY 2004	FY 2005
Faculty and Student Teams	**180**	**210**	**320**

Faculty and Student Teams (FaST) activities at the Department of Energy, Office of Science Laboratories are being conducted in collaboration with the National Science Foundation. Faculty from colleges and universities with limited prior research capabilities and those institutions serving women, minorities, and other populations underrepresented in the fields of science, engineering, and technology are encouraged to take advantage of the FaST opportunity to prepare students for careers in science, engineering, computer sciences and technology and for their own professional development. The first year (FY 2001) of this program there was one Faculty and Student Team. In collaboration with National Science Foundation, there were 6 teams in FY 2002 and 23 teams in FY 2003. This is a very productive and over-subscribed activity among the laboratory scientists and faculty members and has enjoyed wide support from the National Laboratories. It provides an opportunity for faculty to advance their scientific expertise through a close relationship with a National Laboratory. Three teams have received peer-reviewed publications that were published in the *Journal of Undergraduate Research*.

Albert Einstein Distinguished Educator Fellowship	**588**	**600**	**700**

The Albert Einstein Fellowship Awards for outstanding K-12 science, mathematics, and technology teachers continues to be a strong pillar of the program for bringing real classroom and education expertise to our education and outreach activities. Albert Einstein Fellows bring to Congress, DOE and other Federal agencies the extensive knowledge and experience of classroom teachers. They provide practical insights and “real world” perspectives to policy makers and program managers. The Einstein Fellowship has been a valuable professional growth opportunity for the teachers, as they return to their education field, with knowledge of federal resources and an understanding of national education issues.

Energy Related Laboratory Equipment	**75**	**90**	**90**

The “Energy Related Laboratory Equipment” (ERLE) grant activity was established by the Department of Energy (DOE) to provide available excess used equipment to institutions of higher education for energy-related research. Through the Energy Asset Disposal System, DOE sites identify laboratory equipment that is then listed on the ERLE website, which is maintained at the Office of Scientific and Technical Information and updated several times a week. Colleges and universities can search for equipment of interest to them and apply via the website. DOE property managers approve or disapprove the applications. The equipment is free; however, the receiving institution pays all shipping costs.

Faculty Sabbatical Fellowship	**0**	**0**	**500**

In FY 2005, the Faculty Sabbatical Fellowship activity will provide sabbatical research opportunities for 12 faculty members from minority serving institutions to enhance their research capabilities as well as the research capacity of their home institution. The Faculty Sabbatical provides support for up to a year of direct research with resident National Laboratory scientists on research projects specific to their areas of investigation and courses they teach. The Faculty Sabbatical activity is designed for each minority serving institution (MSI) faculty member to work with a national laboratory scientist on a well funded focused research project of the faculty member's choice. This will not only develop the faculty members' scientific expertise, but also develop their abilities and support their efforts to apply for and receive grants from the Office of Science and other granting institutions. Each faculty member would receive

	FY 2003	FY 2004	FY 2005

(dollars in thousands)

half of their sabbatical support from their home institutions. Since their salaries are comparatively low, this insufficient level of monetary support prevents them from an extended stay at a National Laboratory. This sabbatical would match each faculty member's home institution contribution, bringing the sabbatical salary level to the level of a National Laboratory scientist. This would enable faculty to spend an academic year working on research projects of their interest. It would enhance their research capabilities, adding to their own teaching and research strength, as well as the research capacity of their home institution. Each faculty member can bring their students to the National Laboratories, ultimately increasing workforce numbers and diversity. It is the extended stay at the National Laboratory, along with the concentrated support from the resident scientists, that will enhance them as professors and better prepare them to apply for and receive grants from federal science agencies and other granting institutions.

	FY 2003	FY 2004	FY 2005
Total, Graduate/Faculty Fellowships	**903**	**1,900**	**3,110**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Laboratory Science Teacher Professional Development	
▪ This allows an evaluation of results for the Laboratory Science Teacher Professional Development activity and supports 30 additional teachers in FY 2005.	+500
Faculty and Student Teams	
▪ This allows an increase of four additional Faculty and Student Teams, compared to 16 in FY 2004, to participate in a 10 week mentored research experience at a DOE National Laboratory.	+110
Albert Einstein Distinguished Educator Fellowship	
▪ Increase the number of Einstein Fellowships from 12 to 13 and increase their stipends by 10% per Fellow to remain in step with rapidly rising costs of living in the Washington D.C. area.	+100
Faculty Sabbatical Fellowship	
▪ Initiate the Faculty Sabbatical pilot for 12 faculty members from minority serving institutions (MSIs). For faculty from MSIs to effectively compete for and receive research grants, they must be well trained in their science and fully adept in not only understanding where the cutting edge science is, but also how to actually apply for and receive grants. Typically MSIs do not have the infrastructure or the experienced faculty to enter and succeed in this highly competitive arena. This full sabbatical experience would allow faculty from these under-represented	

	FY 2005 vs. FY 2004 ($000)
institutions to become fully engaged in their respective fields of research and access to the support structure of the National Laboratories, which will provide them with the expertise and experience to apply for and receive federally and non-federally funded research grants	+500
Total Funding Change, Graduate/Faculty Fellowships	**+1,210**

Pre-College Activities

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Pre-College Activities					
National Science Bowl	725	702	750	+48	+6.8%
Middle School Science Bowl	150	100	150	+50	+50.0%
Total, Pre-College Activities	875	802	900	+98	+12.2%

Description

Beyond providing students an opportunity to interact with the scientific community, an additional goal of the middle and high school Science Bowl is to provide opportunities for students interested in science and math to share and demonstrate their talents outside the classroom in an interactive manner that validates their accomplishments and encourages future science and math studies.

Benefits

These Pre-College Activities introduce middle and high school students to the National Laboratory system and the available opportunities they may wish to participate in when they go to college.

Supporting Information

The Pre-College Activities subprogram contains two activities which provide an avenue of enrichment, enlightenment, inspiration and reward through academic science achievement:

The "National Science Bowl®" activity is a prestigious educational event that continues to grow in reputation among students, educators, science coaches, and volunteers as a very important educational event and academic tournament. It is a "grass roots" tournament where over 1,800 high schools from all across the nation participate in about 68 regional events and where each regional sends a team to the national event. The regional and national events are primarily volunteer programs where several thousand people dedicate weeks of their time to run and judge educational events and be involved with bright, enthusiastic students who attend science and technology seminars and compete in a verbal forum to solve technical problems and answer questions in all branches of science and math. High school teams also design, build and race hydrogen fuel cell model cars. Since its inception, more than 90,000 high school students have participated in regional tournaments leading up to the national event. At the national event, students meet numerous DOE and non-DOE scientists and are given a rare chance to learn about the wide variety of careers that scientists in all fields pursue.

The Middle School Science Bowl attracts students at the most critical stage of their academic development. The emphasis at this grade level will be on discovery and hands-on activities such as designing, building and racing model solar cars. Students also answer questions in the life and physical sciences and mathematics.

Accomplishments

- Two additional regional competitions were held in FY 2003 in conjunction with DOE's National Science Bowl®. More than 12,000 high school students participated in the 67 regional science bowl events.
- A pilot Middle School Science Bowl was added in FY 2002, bringing eight teams to Washington, DC for the National event. In 2003, the activity was expanded to 16 regional sites, including some Jr. Solar Sprint sites. The National Event is hosted by the National Renewable Energy Laboratory in Golden, Colorado. The event has two main activities: 1) a science and mathematics academic question and answer forum; and 2) a hands-on activity sponsored by General Motors, where each team designs, builds and races a scale-model solar car and teachers are provided a day-long seminar in Hydrogen fuel cells and the Hydrogen economy.
- Saturday morning science seminars were expanded to include an entire day, at the National Science Bowl weekend, introducing students to many contemporary issues and findings in contemporary scientific research. These seminars have featured world class scientists and Nobel laureates.
- National Science Bowl awards were expanded to include a wide variety of academic awards to the top 18 teams and a Civility Award sponsored by IBM.
- In FY 2003, the Hydrogen Fuel Cell Model Car Challenge was added to National Science Bowl. Ten of the 67 teams took part in designing, building and racing their cars. Awards were presented to the top teams in this event.
- To accommodate the additional activities and events, an additional day was added in FY 2003.

Detailed Justification

(dollars in thousands)	FY 2003	FY 2004	FY 2005
National Science Bowl..	**725**	**702**	**750**

SC will manage and support the National Science Bowl® for high school students from across the country for DOE. Since its inception, more than 90,000 high school students have participated in this event. The National Science Bowl® is a prestigious academic event among teams of high school students who: answer questions on scientific topics in astronomy, biology, chemistry, mathematics, physics, earth and general science; participate in various hands-on science activities; and attend seminars on contemporary issues in science. In 1991, DOE developed the National Science Bowl® to encourage high school students from across the Nation to excel in mathematics and science and to pursue careers in those fields. The National Science Bowl® provides the students and teachers a forum to receive national recognition for their talent and hard work. An entire day of Saturday seminars in the latest scientific topics and the hydrogen fuel cell challenge has recently been added to the National Science Bowl® weekend. Selected teams build and race hydrogen fuel cell cars. Students participating in the National Science Bowl® will now be tracked to see the long-term impact on their academic and career choices.

The regional and nationals are all primarily volunteer programs where several thousand people dedicate a few weeks of there time to organize and judge educational events and be involved with bright, enthusiast middle and high school students.

(dollars in thousands)

	FY 2003	FY 2004	FY 2005

In FY 2005, an additional $48,000 will allow 68 teams (an additional 2 regional sites over the FY 2004 level) to participate. Without this funding, these additional students will not participate in these events, activities and seminars.

	FY 2003	FY 2004	FY 2005
Middle School Science Bowl	**150**	**100**	**150**

It is well recognized that the middle school years are the most productive time to exert an effort to attract students to science and math subjects. There are two events at the Middle School Science Bowl – an academic mathematics and science forum and an alternative energy model car race. The academic competition is a fast-paced question and answer contest where students answer questions about earth science, life science, physical science, mathematics, and general science. The model alternative energy car competition challenges students to design, build, and race alternative energy model cars in order to help them understand the future energy challenges that our nation is facing. Students who win in regional events will then enjoy a trip to a National Laboratory and participate in a final three day event that will be designed to capture their interest and reward them for their hard work.

In FY 2005, an additional $50,000 will allow 24 teams (an additional 4 regional sites over the FY 2004 level) to attend and participate in the National event. Without this additional funding, these middle school students will not have this opportunity to compete in the regional events.

	FY 2003	FY 2004	FY 2005
Total, Pre-College Activities	**875**	**802**	**900**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
National Science Bowl	
▪ This is to increase the number of National Science Bowl teams by 2 and to also provide a whole day of scientific seminars and workshops for the students. DOE provides all funding for the teams to attend the National finals.	+48
Middle School Science Bowl	
▪ This is to increase the number of participating Middle School Science Bowl teams to 24 from 20. DOE provides all funding for the teams to attend the National finals.	+50
Total Funding Change, Pre-College Activities	**+98**