MAJOR MULTI-USER RESEARCH FACILITIES $1,194,250,000

The FY 2006 Request for Facilities totals $1,195.25 million, a $114.97 million increase, or 10.6 percent, over the FY 2005 Current Plan of $1,080.08 million. Operations and maintenance of multi-user facilities and research resources are funded through the Research and Related Activities (R&RA) Account; major construction projects are funded through the Major Research Equipment and Facilities Construction (MREFC) Account.

NSF investments provide state-of-the-art tools for research and education, such as multi-user research facilities, distributed instrumentation networks and arrays, accelerators, telescopes, research vessels, aircraft, and earthquake simulators. In addition, investments in Internet-based and distributed user facilities are increasing as a result of rapid advances in computer, information, and communication technologies. NSF's investments are coordinated with those of other organizations, agencies and countries to ensure complementarity and integration.

NSF Funding for Major Multi-User Research Facilities

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Facilities	594.95	644.03	714.89	70.86	11.0%
Polar Facilities and Logistics	277.07	257.46	300.63	43.17	16.8%
Federally Funded R&D Centers[1]	191.59	178.59	179.53	0.94	0.5%
Total, Major Multi-user Research Facilities	$1,063.61	$1,080.08	$1,195.05	$114.97	10.6%

[1]Excludes the Science and Technology Policy Institute, which is an FFRDC but not a research platform.

To describe the life-cycle of a facility, the Foundation has adopted a set of distinct stages in its Facilities Management and Oversight Guide, found at http://www.nsf.gov/bfa/start.htm[1]. These stages are: 1) Concept/Development – the phase during which the idea of a facility is articulated and project planning and design begins and is completed; 2) Implementation – including construction, upgrade, and/or acquisition, system integration, commissioning, testing, acceptance, transition to operations, and management of these efforts; 3) Operations and Maintenance – including the day-to-day work required to support and conduct research and education activities, to ensure that the facility is operating efficiently and cost-effectively, and to provide small- and intermediate-scale technical enhancements when needed to maintain state-of-the-art research capabilities; and 4) Renewal or Termination – the stage in which decisions regarding continued support of a facility are made. The information learned during the Operations and Maintenance stage and through various reviews of the results of research and education activities and facility management is used to determine whether the facility will be renewed, upgraded, re-competed or terminated. The Facilities Management and Oversight Guide requires the use of Project Advisory Teams (PATs) to advise program officers on business, financial, legal, and other related aspects of projects and project management. The PAT is composed of the Deputy for Large Facility Projects (DLFP) who provides advice and assistance during the implementation phase of the facility life cycle and staff from the Directorates, the Office of the General Counsel, the Office of Legislative and Public

[1]At the December 2004 National Science Board (NSB) meeting, NSF announced that new guidelines for the development, review and approval of major research facilities will be available by about June 2005. The Facilities Management and Oversight Guide is currently being revised as part of this process.

Affairs, and the Office of Budget, Finance and Award Management. The DLFP also provides advice and assistance to Directorates, Divisions and Program staff throughout the life cycle of a facility project.

Major Multi-User Research Facilities Funding

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Facilities	**$594.95**	**$644.03**	**$714.89**	**$70.86**	**11.0%**
Academic Research Fleet	82.50	83.20	83.20	0.00	0.0%
Advanced Modular Incoherent Scatter Radar	12.40	12.50	11.00	-1.50	-12.0%
Cornell Electron Storage Ring	18.00	16.62	14.71	-1.91	-11.5%
Gemini Observatory	13.27	14.81	18.50	3.69	24.9%
HIAPER[1]	12.54	0.00	0.00	0.00	n/a
Incorporated Research Institutes for Seismology	13.00	12.16	13.31	1.15	9.5%
Integrated Ocean Drilling Program	35.10	32.10	30.00	-2.10	-6.5%
Large Hadron Collider	7.00	10.50	13.50	3.00	28.6%
Laser Interferometer Gravitational Wave Observatory	33.00	32.00	32.00	0.00	0.0%
MREFC Facilities[2]	148.90	190.39	267.63	77.24	40.6%
National High Magnetic Field Laboratory	24.50	25.50	25.50	0.00	0.0%
National Nanofabrication Infrastructure Network	13.80	13.90	13.90	0.00	0.0%
National Superconducting Cyclotron Laboratory	15.65	17.50	17.50	0.00	0.0%
Network for Earthquake Engineering Simulation[2]	8.05	19.54	20.52	0.98	5.0%
Shared Cyberinfrastructure Tools	110.66	120.76	114.00	-6.76	-5.6%
Terascale Computing Systems[2]	10.05	0.00	0.00	0.00	n/a
Other Facilities[3]	36.54	42.55	39.62	-2.93	-6.9%
Polar Facilities and Logistics	**$277.07**	**$257.46**	**$300.63**	**$43.17**	**16.8%**
Antarctic Facilities and Operations	151.11	152.55	196.32	43.77	28.7%
Polar Logistics	104.93	104.91	104.31	-0.60	-0.6%
South Pole Station[2]	21.03	0.00	0.00	0.00	n/a
Federally Funded R&D Centers[5]	**$191.59**	**$178.59**	**$179.53**	**$0.94**	**0.5%**
National Astronomy and Ionospheric Center	12.34	12.42	12.50	0.08	0.6%
National Center for Atmospheric Research	82.92	81.22	82.27	1.05	1.3%
National Optical Astronomy Observatory	41.35	37.92	37.36	-0.56	-1.5%
National Radio Astronomy Observatory	54.98	47.03	47.40	0.37	0.8%
Total	**$1,063.61**	**$1,080.08**	**$1,195.05**	**$114.97**	**10.6%**

[1]Implementation funding for HIAPER was provided through the MREFC Account. Operations and Maintenance activities are funded within the R&RA Account through the National Center for Atmospheric Research (NCAR), an FFRDC.

[2]Funding levels for MREFC projects in this table include initial support for operations and maintenance funded through R&RA as well as implementation costs funded through MREFC.

[3]Other Facilities includes support for the Network for Computational Nanotechnology, continued phase out of program and contract activities for the Ocean Drilling Program, and other physics, materials research, ocean sciences, atmospheric sciences, earth sciences and computational sciences facilities.

[5]Does not include the Science and Technology Policy Institute, which is an FFRDC, but not a research platform.

In February 2004, the National Academies released a report on "Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation". This report recommends an open process for selecting new projects to be funded, establishing well-defined criteria and including maximum community input. The results of this final prioritization should be "discussed, explained and

documented". NSF concurs with these recommendations and is currently refining the MREFC process to ensure that decisions are clearly documented and explained, and selection criteria clearly articulated.

Performance information related to NSF-funded facilities is available in the Performance Information chapter of this document and in the FY 2004 NSF Performance and Accountability Report (NSF-05-01). A list of Major Research and Equipment Facilities Construction (MREFC) projects can be found in this chapter. For a full discussion of these projects, please refer to the MREFC chapter.

FACILITIES

Academic Research Fleet

Project Description: The Academic Research Fleet consists of 27 vessels in the University-National Oceanographic Laboratory System (UNOLS). These vessels range in size, endurance, and capabilities, providing NSF and other federally-funded scientists with a diverse fleet capable of operating in coastal and open ocean waters to conduct ocean science research. Included is funding for ship operations, shipboard scientific support equipment, oceanographic instrumentation and technical services, ship acquisition and upgrade, and submersible support.

Principal Scientific Goals: The Academic Research Fleet serves as the main platform for the collection of data and testing of hypotheses in oceanography. Through use of these facilities, scientists contribute to advances made in areas such as climate, fisheries, and marine research.

Principal Education Goals: Vessels in the Academic Research Fleet permit shipboard training of future oceanographers. Through cruise participation, graduate and undergraduate students interact with scientists and marine technicians, enabling them to gain first-hand exposure to ocean science field research. Through recent technological innovations, research conducted at sea can be transmitted remotely back to the classroom, broadening the educational impact of the vessels to a wider audience, including K-12 students.

Partnerships and Connections to Industry: The Academic Research Fleet is supported through an interagency partnership, principally with the National Oceanic and Atmospheric Administration (NOAA) and the Office of Naval Research (ONR) via a Memorandum of Understanding (MOU). NSF provides approximately 65 percent of the operating funds for the Fleet, while the remaining operating costs are divided proportionally among the other vessel users. NSF also coordinates with ship-operating and non-operating academic institutions through its connection with UNOLS.

Management and Oversight: NSF provides oversight to the Academic Research Fleet through cooperative agreements with each ship-operating institution and the UNOLS Office, and through standard grants. In addition, NSF oversees the fleet through external review of proposals, site visits, ship inspections, and participation at UNOLS Council and Subcommittee meetings by Program Managers. Several Program Managers within the Division of Ocean Sciences (GEO) are involved in the activities and overall oversight of the academic research fleet.

Management of an individual institution's ship-operating facilities varies with the scale of the operation, but the core responsibility typically resides with the Director of the Institution, the Marine Superintendent (for all aspects of the facility), and the Ship's Captain (for at-sea operations). For larger multi-ship-operating institutions, a chief of marine technicians, schedulers and finance administrators may also be involved in facility management.

Current Project Status: NSF has supported this project for many years. Based on projected science requirements identified in recent reports and workshops, a fleet of vessels to support ocean science research will be needed far into the future. In coordination with the ocean science community, the Federal Oceanographic Facilities Committee (FOFC) is currently revising the report on long-range plans for renewal of the academic fleet. The FY 2006 Request for the Academic Research Fleet totals $83.20 million, level with the FY 2005 Current Plan, which will continue to support the operation, conversion and upgrade of the U.S. Academic Research Fleet. Also included are funds to continue development and construction of a new deep submergence capability to replace the pioneering submersible ALVIN; conversion of a seismic research vessel to replace the aging R/V Maurice Ewing; and, design and development of three Regional Class research vessels. These investments will open significant expanses of the deepest ocean to exploration, enhance coastal research activities and bring greatly enhanced capability to map structures under the sea floor to U.S. researchers.

Funding Profile: All funding for the Academic Research Fleet to date has been provided through the R&RA Account.

Academic Research Fleet Funding Profile

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	2.30	56.60	$58.90
FY 2002	2.30	59.60	$61.90
FY 2003	3.00	62.20	$65.20
FY 2004	10.00	72.50	$82.50
FY 2005 Current Plan	11.00	72.20	$83.20
FY 2006 Request	16.30	66.90	$83.20
FY 2007 Estimate	19.50	71.00	$90.50
FY 2008 Estimate	19.80	73.90	$93.70
FY 2009 Estimate	20.80	75.50	$96.30
FY 2010 Estimate	21.47	77.39	$98.85

NOTE: Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Implementation: From time to time, vessels require conversions or upgrades that go beyond the normal maintenance supported by operating costs. Funding decisions for conversions and upgrades are based on strong evidence of scientific need. In recent years, the funding has provided for the conversion or upgrade of ships already in service whose age, configuration, or operating costs have impaired their usefulness. Planning for future years includes the replacement of ships that have reached the end of their useful life and replacing the capability for studies in the deep ocean as the aging ALVIN submersible reaches the end of its useful life. In December 2001, the FOFC of the National Oceanographic Partnership Program (NOPP) prepared a report titled Charting the Future for the National Academic Research Fleet, which defines a federal interagency renewal strategy for the national academic research fleet. The report is currently being revised by the FOFC, however significant changes for renewal of the academic fleet are not anticipated. Major upgrade expenditures indicated in implementation estimates in FY 2006 and out-years are for development of a new deep

submergence vehicle, replacement of Regional Class ships and acquisition and reconfiguration of a seismic research vessel, consistent with community, NRC and FOFC reports.

- Operations and Maintenance: This includes funds for operating and maintaining the fleet, shipboard scientific support equipment, oceanographic instrumentation and technical services, and submersible support.

Renewal or Termination: Participation of each ship in the research fleet through a cooperative agreement is governed by the existence of an efficient schedule of scientific research cruises for that ship, assessments of the continued fitness of the ship to conduct research at sea, and the ability of the operating institution to maintain cost effective operations.

Associated Research and Education Activities: NSF-funded researchers utilizing the fleet are supported through NSF's research programs and are subjected to NSF's standard merit review process. The fleet supports approximately 2,500 users per year, which is based on the total number of individual researchers, postdoctoral candidates, graduate and undergraduate students, teachers, K-12 students and observers who have participated in cruises.

Science Support: Because of its collaborative nature and the interagency cooperation, which enables the operation of the academic fleet, NSF only pays for ship time used by NSF researchers.

Advanced Modular Incoherent Scatter Radar

Project Description: The Advanced Modular Incoherent Scatter Radar (AMISR) is a phased array incoherent scatter radar with unique features that allow efficient and cost-effective dismantling, shipping, and re-assembly. The radar comprises three identical antenna faces, each with approximately three times the sensitivity of the incoherent scatter radar currently operating in Sondre Stromfjord, Greenland. Each of the three fixed antenna faces is approximately 35 meters square with 4096 radiating elements located on 128 separate panels. In addition to being relocatable, AMISR will provide the means for unique scientific observations via two significant features that have not been technically feasible in the past and will greatly enhance the way observations and experimental campaigns are conducted. First, the phased-array concept will allow pulse-to-pulse beam steering, thus enabling three-dimensional "imaging" of electron density features in high signal-to-noise environments. Second, an incoherent scatter radar with a solid-state transmitter and no moving parts will permit both extended operating periods and true remote internet operation with virtual "control rooms" at universities world-wide.

A single panel of 32 dipole antennas for the Advanced Modular Incoherent Scatter Radar (AMISR). AMISR consists of three antenna faces, each containing 128 of these panels. *Credit: SRI International*

Principal Scientific Goals: Long-term measurements of atmospheric parameters will us help understand the processes influencing global change, and observations during solar storms will help us understand and predict space weather, the primary goal of the multi-agency National Space Weather Program. There will also be strong synergy between AMISR scientific activities and the Center for Integrated Space Weather

Modeling (CISM), one of NSF's Science and Technology Centers. The AMISR systems at Poker Flat, Alaska, and Resolute Bay, Canada, will enable researchers to investigate fundamental issues of solar-terrestrial science including how the Earth is magnetically and electrically coupled to the Sun; what the structure and dynamics of the magnetosphere, ionosphere, and upper atmosphere are; and how the global energy flowing into the upper atmosphere at the pole flows to the equator. The scientific goals will change in the future as AMISR is deployed at other locations.

Principal Education Goals: The design for the AMISR is at the forefront of current radar, electronics, and signal processing technology. It uses advanced solid-state amplifiers that can be computer-controlled for maximum flexibility and ease of use. It will provide outstanding opportunities for students and young scientists and engineers to be involved with the development of the project and the operation of the instrument. The AMISR will be the first incoherent scatter radar designed for remote usage, allowing students and scientists to plan and configure experiments, and watch in real-time as the data is returned from remote sites. The web-based tools to be developed will make AMISR an excellent means to train the next generation of incoherent scatter radar specialists. The possibilities for new discoveries, combined with the ease of operation, will inspire hundreds of scientists from all over the globe to use the facility.

Partnerships and Connections to Industry: Manufacturing of the 12,000 antenna element units (AEUs) is being done by Sanmina SCI, a global electronics manufacturing firm with headquarters in San Jose, CA. The solid-state power amplifier for each of the units is being manufactured by Comtech PST, a company based in Melville, New York, that specializes in the production of amplifiers for commercial and military uses. The construction of the AMISR support structure and the foundation work at the sites in Alaska and Canada is being performed by VECO Corp., an Alaska-based company that specializes in management, engineering design and construction for the oil and power industries.

Management and Oversight: Overall project management and oversight is the responsibility of the program manager for Upper Atmospheric Facilities within the Division of Atmospheric Sciences. A Project Advisory Team has been appointed, which includes the Deputy for Large Facility Projects and members from the Directorate for Geosciences, the Office of Polar Programs, the Office of Budget Finance and Award Management, and the Office of the General Council. As required in the cooperative agreement for the AMISR construction, SRI has assembled a Technical Advisory Committee to provide technical oversight in the design and development of the AMISR system. SRI has also written a Project Execution Plan that describes the AMISR work breakdown structure, management structure, project milestones, and final test and acceptance plan.

Current Project Status: The cooperative agreement for AMISR construction was approved on August 1, 2003, during the design for manufacturing phase of the project, funded as a separate award for AMISR prototype development. The design of the antennal element units was finalized in 2004. The final design includes features that reduce cost and facility mass production of the units. Full-scale production is expected to begin in early 2005. A prototype system using 8 AMISR panels was deployed at the Jicamarca Radio Observatory in Peru, and initial tests are yielding satisfactory results. An additional 16 panels will be shipped to Gakona, Alaska, for further on-site testing. The Technical Advisory Committee met in December 2004 to review project status.

The AMISR is being developed in three stages. The first stage, which includes design and vendor selection, has been completed. The second stage is the assembly of the first AMISR antenna face at the Poker Flat Research Range in Alaska, a site that is both scientifically interesting and logistically advantageous. In the last stage, the second and third antenna faces will be assembled at the Resolute Bay Observatory in the Canadian Arctic. Future deployments will be determined on the basis of recommendations of a committee from the broader space science research community.

Future milestones for the project are outlined below:

FY 2005 Milestones:
- Initiate full-scale panel and AEU manufacturing
- Poker Flat Activities
  - Complete 128 panels w AEUs
  - Poker Flat (1 face) constructed
  - Poker Flat system test complete and operational
- Resolute Bay Activities:
  - Face 1 and 2 foundation materials, support scaffolding and distribution shelters shipped to Resolute Bay via sealift
  - Face 1 and 2 foundations constructed
  - Face 1 – 128 panels with AEUs shipped via sealift

FY 2006 Milestones:
- Resolute Bay Activities:
  - Complete 128 panels with AEUs
  - Face 1 erected
  - Face 1 system complete and operational
  - Complete 128 panels with AEUs
  - Face 2 – 128 panels w AEUs shipped via sealift

FY 2007 Milestones:
- Resolute Bay Activities:
  - Face 2 constructed
  - AMISR system test complete
- Full operations begin

Funding Profile: The implementation phase of AMISR began late in FY 2003 with an initial allocation of $14.0 million. Additional funding of $12.40 million was provided in FY 2004, as indicated in the table below. Funds allocated in previous fiscal years for prototype development are also shown in the table.

AMISR Funding Profile

(Dollars in Millions)

	Concept/ Development	Implementation	Operations & Maintenance	Total, NSF
FY 2001 & Earlier	3.60			$3.60
FY 2002	3.40			$3.40
FY 2003		14.00		$14.00
FY 2004		12.00	0.40	$12.40
FY 2005 Current Plan		10.00	2.50	$12.50
FY 2006 Request		8.00	3.00	$11.00
FY 2007 Estimate			3.00	$3.00
FY 2008 Estimate			3.00	$3.00
FY 2009 Estimate			3.08	$3.08
FY 2010 Estimate			3.15	$3.15

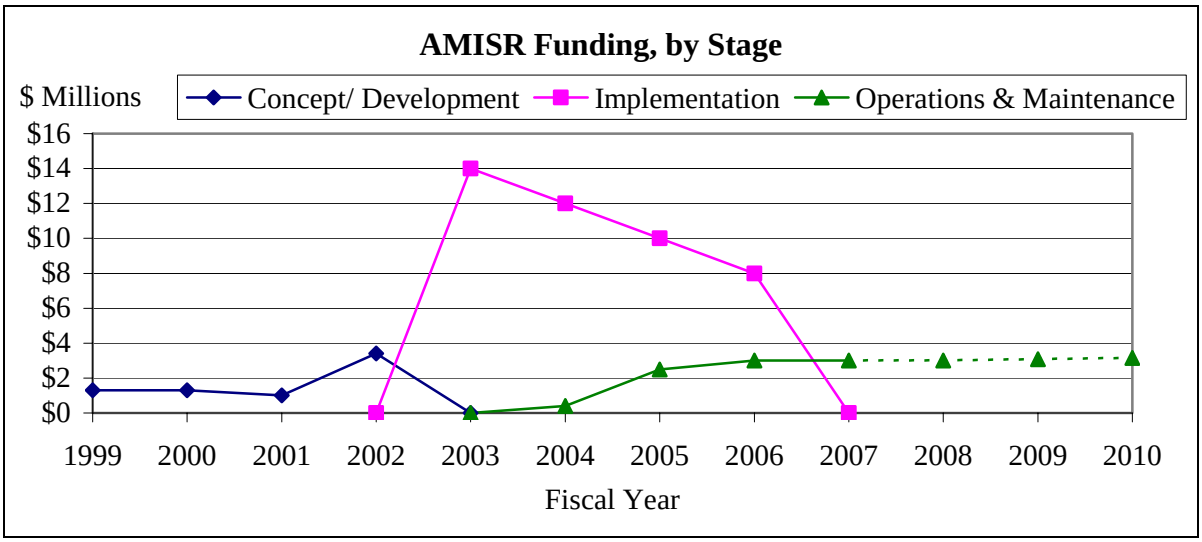
NOTE: A steady state of about $3 million in operations support is expected to occur in or about FY 2008. The expected operational lifespan of this project is 40 years, beginning in FY 2007. Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Concept/Development: Initial R&RA funding for AMISR began in FY 1999 with an award to SRI International to develop the design of the antenna element units. Subsequent funding was provided for building 32 engineering prototype units that were assembled into a panel for testing at the SRI field site near Stanford University and the U.S. Air Force antenna test facility in Ipswich, Massachusetts. The Concept/Development phase concluded with the competitive source selection of Sanmina SCI and two years of design for manufacturing activities involving close interaction between Sanmina and SRI engineers.

- Implementation: The first 4000 antenna element units will be manufactured during the first three months of 2005. Site preparation at Poker Flat is complete. The antenna elements will be assembled onto panels by SRI as they are received from the manufacturer. The assembled panels will be shipped to Alaska early in spring 2005 for integration and testing. This schedule will repeat for the two remaining faces to be deployed at Resolute Bay—the first in 2006 and the second in 2007.

- Operations and Maintenance: SRI is currently preparing a proposal for the initial operation and maintenance of the AMISR systems at Poker Flat and Resolute Bay. Operation and maintenance of the face at Poker Flat will be accomplished in collaboration with personnel at the Geophysical Institute, University of Alaska. Other participating institutions include Stanford University, MIT, and the University of Saskatchewan. Additional instrumentation for the two facilities will be funded through the R&RA grants programs within ATM.



Future Science Support: In addition to the operations support indicated above, AMISR research and education programs will be funded through the Aeronomy, Magnetospheric Physics, and Upper Atmospheric Facilities core programs within the Upper Atmospheric Research Section. The combined annual level of support for this research is estimated to be about $5 million.

Cornell Electron Storage Ring

Project Description: The Cornell Electron Storage Ring (CESR) is a facility that supports research in elementary particle physics as well as research in accelerator physics and superconducting radio frequency (RF) applications. CESR is an electron-positron collider that has provided important knowledge of the properties of the b-quark. Cornell University has modified CESR and the associated particle detector (CLEO) for operation over the energy range 1.5 GeV to 5.6 GeV per beam in order to address high-priority physics questions that relate to the c-quark and possible gluon states that cannot be addressed elsewhere. The transformed collider and detector are named CESR-c and CLEO-c respectively.

The CESR facility is also used by the materials research community at the Cornell High Energy Synchrotron Source (CHESS). CHESS is a high-intensity high-energy X-ray source supported by the NSF. It uses the synchrotron light given off by the charged particles, both electrons and positrons, as they circulate at nearly the speed of light around CESR. As a user facility, CHESS provides state-of-the-art synchrotron radiation facilities for research in physics, chemistry, biology, materials research and environmental sciences.

Principal Scientific Goals: CESR-c and CLEO-c explore a large set of critical weak and strong interaction phenomena, knowledge of which is either lacking or fragmentary. These in turn drive theoretical advances that both extend and enable the full program of physics targeted by many new-generation detectors, such as those at SLAC, Fermilab, and the Large Hadron Collider (LHC), and lay the foundation for strong interaction theory to meet the requirements of future physics beyond the Standard Model.

Principal Education Goals: To support and enhance Ph.D. level graduate education, postdoctoral research experience, research experiences for undergraduates, and research experiences for K-12 science teachers. Engendering excitement in science among young children will be a focus for strengthening K-12

engagements. An important component of that effort will be the participation of CLEO and CESR graduate students in school science classrooms.

Partnerships and Connections to Industry: CESR staff is transferring CESR Superconducting RF (SRF) technology to industry. Two new industrially fabricated SRF cavity systems have been acquired in order to shorten CESR bunch length with higher voltage. Through a license arrangement with Cornell, the ACCEL Corporation has manufactured two superconducting RF sources to power synchrotron light sources. They have been tested and installed in CESR to replace two older, lower gradient modules. Also some of the CHESS users are from industry, including pharmaceutical corporations (Rib-x Pharmaceuticals) and the research arms of Eastman Kodak, Xerox and General Motors. Some medical institutions also make use of CHESS (Dana Farber Cancer Institute, Boston Biomedical Research Institute, and Memorial Sloan-Kettering Institute).

Management and Oversight: CESR-c is managed by the Director of the Laboratory for Elementary Particle Physics (LEPP) at Cornell with help from an Assistant Director and an Associate Director for Accelerator Physics. The CLEO-c experiment is the sole CESR-c experiment in particle physics, and this collaboration consists of users from about 20 U.S. institutions. The CESR-c management interacts with the CLEO-c collaboration through the collaboration spokesperson and executive board as needed, and there are monthly meetings of the collaboration that include CESR-c management.

NSF oversight (PHY/MPS) is provided through annual site visits by NSF staff. Technical review of the award involved panel evaluation of the CESR-c proposal, and a site visit by NSF staff and external reviewers. The oversight process includes annual financial reports and program reports to the NSF and an annual review by a Program Advisory Committee of outside physicists reporting to the Laboratory Director and NSF. A comprehensive review will be held by NSF staff midway through the third year, of a five-year award initiated in FY 2003, with possible assistance from an external panel of experts.

CHESS is supported through the Division of Materials Research of the Directorate for Mathematical and Physical Sciences, the Directorate for Biological Sciences, and by the National Institutes of Health. Those organizations provide management oversight for CHESS through regular site visits. CHESS funding from NSF is $3.90 million in FY 2006.

Current Project Status: CESR reaches its final stages through the five-year Cooperative Agreement initiated in April 2003. Cornell University has modified the CESR colliding beam accelerator and the CLEO particle detector as mentioned above. In addition to the particle physics program, a vigorous program of accelerator science and technology development for accelerator concepts for the future will continue. CESR-c will also provide intense X-ray beams for the program in X-ray science at CHESS. The particle physics program and X-ray science program will now begin to use different accelerator energies, requiring the two programs to operate in different time periods. The FY 2006 Request for CESR totals $14.71 million, a decrease of $1.91 million from FY 2005. It is expected that the CESR-c and CLEO-c projects will cease at the end of the five-year period.

Funding Profile: The FY 2003 – FY 2008 estimated funding for CESR-c and CLEO-c will ensure completion of the elementary particle physics program and provide sufficient time for the particle physics group and the CHESS facility to plan their future activities. All funding for CESR to date has been provided through the R&RA Account.

CESR Funding Profile[1]

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001		19.49	$19.49
FY 2002		19.49	$19.49
FY 2003		19.49	$19.49
FY 2004		18.00	$18.00
FY 2005 Current Plan		16.62	$16.62
FY 2006 Request		14.71	$14.71
FY 2007 Estimate		15.00	$15.00
FY 2008 Estimate		10.00	$10.00

Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

[1]Includes funding for CESR only. No funding for CHESS is included in this table.

Information pertaining to the data in the table is included below.

- Management and Operations: The facility expects to operate about 5,700 hours per year for CLEO research and for accelerator physics and development. Maintenance is provided through a weekly 8-hour shift and through two or three, 3-week shut-downs for maintenance of the accelerator, superconducting RF, helium refrigerator, vacuum system, beam lines for CHESS, power systems, and other ancillary systems. Approximately 30 percent of the CESR funding is directed toward in-house research (both experimental elementary particle physics and accelerator physics) with the remainder used to operate and maintain the facility. The funding profile above includes minor detector and accelerator changes that are essential to completion of the scientific program before FY 2009.

Associated Research and Education Activities: Cornell continues to be active in outreach:

- Approximately 200 high school physics teachers received tours, lesson plans, and/or presentation materials, along with educational videos on particle physics via outreach events from April 2003 to March 2004;

- Approximately 120 elementary and middle school students and 300 high school students were involved in activities hosted by LEPP. Over 300 people toured the Wilson Laboratory facility during this time frame;

- The Laboratory hosted 19 REU and two RET participants in collaboration with Wayne State University and George Mason University during the summer of 2004; and

- The laboratory trains graduate students in accelerator physics and has supported the development of superconducting radio frequency accelerating cavities.

Science Support: Approximately $3 million is provided annually by NSF in support of separate awards to external users of the CESR/CLEO facility. DOE provides a similar amount in support of awards to

individual investigators and groups. In addition, $600,000 is provided in a separate award to Cornell in support of theoretical elementary particle physics research.

About 200 physicists from 22 universities have built and are operating the CLEO detector to study the products of the electron-positron collisions. CESR is a national user facility and the current CLEO-c collaboration includes more than 130 researchers from 25 U.S. and foreign institutions.

The CHESS facility serves a wide spectrum of experimental groups from Universities, National Laboratories and Industry and is used by the materials research community, with typically 600-700 users per year.

Gemini Observatory

Project Description: The Gemini Observatory consists of two 8-meter telescopes, one in the northern hemisphere, in Hawaii, and one in the southern hemisphere, in Chile. The Hawaiian telescope is optimized for infrared observations and is located on Mauna Kea at an altitude of 4,200 meters. The telescope in Chile is located on Cerro Pachon, an outstanding photometric site, at an altitude of 2,700 meters. This siting of the two telescopes assures complete coverage of the sky to complement the observations from space-based observatories, and provides access to the center of our own Galaxy as well as the Magellanic Clouds, our nearest galactic neighbors. Both telescopes are designed to produce superb image quality and both use sophisticated adaptive optics technology to compensate for the blurring effects of the Earth's atmosphere. The Observatory is an international collaboration with the United Kingdom, Canada, Australia, Chile, Argentina and Brazil.

Principal Scientific Goals: Astronomers need to resolve important questions about the age and rate of expansion of the universe, its overall topology, the epoch of galaxy formation, the evolution of galaxies once they are formed, and the formation of stars and planetary systems. The new generation of optical/infrared telescopes with significantly larger aperture (8-meter diameter) than previous instruments provides better sensitivity and spectral and spatial resolution. Technological advances in a number of key areas of telescope construction and design allow these instruments to take advantage of the best performance the atmosphere will allow.

Gemini North dome/enclosure with setting sun (to left) lighting up the bottom half of the telescope through thermal vents (fully open). The observing slit is partially open, revealing the truss and top end of the telescope. *Credit: Neelon Crawford - Polar Fine Arts; courtesy of Gemini Observatory and NSF*

Principal Education Goals: The Gemini telescopes play a central role in the education and training of U.S. astronomy and engineering students. An estimated 20 percent of the projected 400 users per year are students from the partner countries. Gemini is also providing a focus for public outreach and high school student training in all the partner countries, including the development of "sister city" arrangements between Hilo, Hawaii and La Serena, Chile involving students and teachers at high school and elementary school levels. In FY 2004, the Gemini Director was awarded Chile's Gabriela Mistral medal for the Observatory's great contributions to cultural exchange and knowledge of the Universe by the Ministry of Education. This was the first time the medal has been awarded to a non-Chilean.

Partnerships and Connections to Industry: Gemini is an international partnership with the United Kingdom, Canada, Australia, Chile, Argentina, and Brazil. Construction of the telescopes and their instrumentation has involved a large number of industrial concerns in a number of partner and non-partner countries. These have involved firms in large and/or complex optical systems, aerospace industries, electronics and engineering firms, etc. Continued involvement of such industries is part of the instrumentation and facilities renewal activities included in the operating budget of the Gemini Observatory.

Management and Oversight: The project is governed by the Gemini Board, established by the International Gemini Agreement signed by the participating agencies. NSF serves as the Executive Agency for the seven-nation partnership, carrying out the project on their behalf. Programmatic management has been the responsibility of the Staff Associate for Gemini in the Division of Astronomical Sciences (MPS), assisted during construction by an internal Project Advisory Team (PAT) with representation from the Office of the General Counsel, the Office of Legislative and Public Affairs, the Office of Budget, Finance and Award Management, and the Office of International Science and Engineering. During construction, a committee of outside experts regularly reviewed progress and reported to the partnership. With the start of scientific operations, the Gemini Board has established an independent Visiting Committee that will advise on the operation of the Observatory. Gemini is managed by Associated Universities for Research in Astronomy (AURA), Inc., on behalf of the partnership through a cooperative agreement with NSF. AURA conducts its own management reviews through standing oversight committees. The current cooperative agreement expires in FY 2005. Under the terms of the international agreement, the partnership will determine whether to compete the management of the Observatory at that time.

Current Project Status: Construction of both telescopes is complete and science operations are routine at both sites. Commissioning of facility instruments continues at both telescopes. The Chilean partner in Gemini, CONICYT, had a perennial problem paying operations contributions, though they completed the construction payments in full. The astronomical community in Chile feels a far greater need to develop astronomy within the country than a need for more observing time. Gemini South is on Chilean soil and the conditions of exemption from taxes and duties under which Gemini operates in Chile are very advantageous.

CONICYT proposed that the Gemini partners effectively return the equivalent of Chile's construction payment to CONICYT to establish a fund whose proceeds would be used to develop astronomy for Chile. In a "cooperative agreement" CONICYT remains a partner and returns to the partnership the 5 percent observing time on both telescopes that they had been entitled to as a result of paying 5 percent of the capital and operating costs. This proposal has been accepted by the Gemini Board and has been discussed with the National Science Board's Committee on Programs and Plans. Within the partnership there is agreement that the U.S. will assume 52.5 percent of the Chilean share, Australia 30 percent, Canada 15 percent, and Brazil the remaining 2.5 percent. The International Gemini Agreement has been amended to formalize the change.

Funding Profile: The FY 2006 Request totals $18.50 million, an increase of $3.69 million over the FY 2005 Current Plan estimate of $14.81 million. Included in this increase is enhanced operational and visitor support, the start of funding of a new generation of advanced instrumentation, and $1.0 million for partial return of the U.S. share of Chilean capital.

Gemini Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation[1]		Operations & Maintenance[1]		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 1994 & Earlier	12.00		47.00				59.00		$59.00
FY 1995				41.00				41.00	$41.00
FY 1996					3.82		3.82		$3.82
FY 1997					5.32		5.32		$5.32
FY 1998				4.00	5.72		5.72	4.00	$9.72
FY 1999					8.05		8.05		$8.05
FY 2000					8.38		8.38		$8.38
FY 2001					8.66		8.66		$8.66
FY 2002					12.50		12.50		$12.50
FY 2003					13.48		13.48		$13.48
FY 2004					13.27		13.27		$13.27
FY 2005 Current Plan[2]					14.81		14.81		$14.81
FY 2006 Request[2,3]					18.50		18.50		$18.50
FY 2007 Estimate[3]					23.00		23.00		$23.00
FY 2008 Estimate[4]					25.00		25.00		$25.00
Subtotal, R&RA	$12.00		$47.00		$160.51		$219.51		$219.51
Subtotal, MREFC				$45.00				$45.00	$45.00
Total, Each Stage		**$12.00**		**$92.00**		**$160.51**			**$264.51**

[1]Reporting of costs in these categories is as considered and reported by NSF in its response to OIG report 01-2001.

[2] FY 2005 and FY 2006 funding includes the cost of the Chilean capital return, consistent with the U.S. assumption of a portion of the Chilean share.

[3]The current cooperative agreement ends in FY 2005. The figures for FY 2006 and onward reflect the anticipated growth of the operating budget and funds for second generation instrumentation being used by the Observatory and the Gemini Board for planning purposes. The anticipated lifetime of the Observatory is 25 years.

[4]A steady state of about $25 million annually is anticipated for the U.S. share of operations beginning in FY 2008.

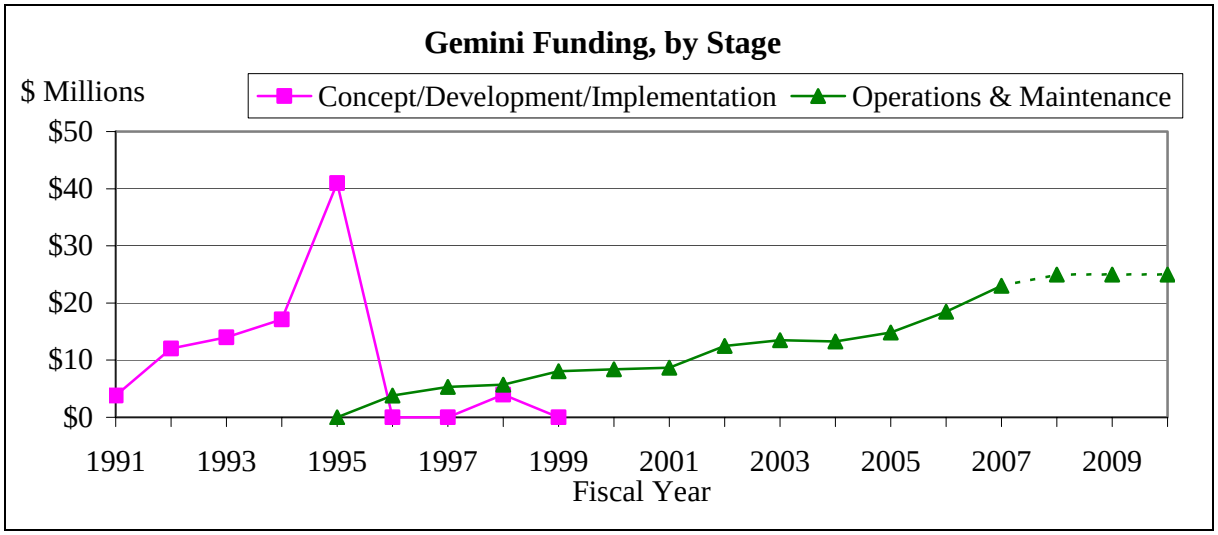
Information pertaining to the data in the table is included below.

- Concept/Development: Funds represent estimated U.S. investments in the development of mirror technologies for a new generation of telescopes, as recommended by the National Academy Report "Astronomy and Astrophysics for the 1980s." Three different mirror technologies were explored. These investments in technology development contributed to the plans for Gemini, as well as to other new telescopes that advance research in astronomy.

- Implementation: Gemini construction was initiated in FY 1991, before establishment of the MREFC Account in FY 1995. The $92 million obligated for Gemini construction is the U.S. share of the total cost ($184 million) for the two telescopes, with the balance provided by international partners.

- Management and Operations: Funding ramped up as the telescopes approached initial operations. Beginning in FY 2002, operations include the U.S. assumption of a portion of the Chilean share of operations costs, as agreed by the international partners. The funds provide additional observing time to the U.S. astronomy community while Chile maintains a share of observing time as host country.

Under this adjustment, NSF supports just over 50 percent of management, operations and maintenance. In FY 2005-2006, costs reflect Chilean capital return, consistent with U.S. assumption of a portion of Chilean share.



Renewal or Termination: The cooperative agreement for the support of Gemini operations is in its 5th year and expires in FY 2005. Under the terms of the international agreement, the partnership will determine whether to compete the management of the Observatory at that time.

Associated Research and Educational Activities: The public information and outreach office at Gemini carries out local outreach to schools, teachers, and the general public. The office also coordinates and serves as a liaison for the outreach efforts of partner countries and provides media services and web-based resources.

Science Support: Along with direct operations and maintenance support for Gemini, NSF will support research performed at the facility, through ongoing research and education programs. The annual support for such activities is estimated to be about $5 million.

Stephan's Quintet as imaged using the Multi-Object Spectrograph on Gemini North. The interacting members of the cluster are almost 300 million light years away. The galaxy NGC 7320 (top–center) is thought by most astronomers to be in the foreground (about 8-times closer) and is distinguished in this image by multiple red blobs indicating hydrogen clouds where stars are forming. *Credit: Gemini Observatory/Travis Rector, University of Alaska Anchorage*

Incorporated Research Institutes for Seismology

Project Description: IRIS is a consortium of 102 U.S. universities and not-for-profit institutions with research and teaching programs in seismology. IRIS operates a distributed national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research in the earth sciences, in earthquake research, and in nuclear test ban monitoring. IRIS is also leading the construction of one aspect of the EarthScope MREFC project. IRIS is organized in four major program elements: (1) The Global Seismographic Network (GSN), which currently consists of a global deployment of 137 permanently installed digital seismic stations; (2) The

Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL), which manages a pool of portable seismometers that are made available to the seismology research community for scheduled regional and local scale studies; (3) The IRIS Data Management System (DMS), which provides the national and international seismic research community with timely access to data from the GSN and PASSCAL; and (4) The IRIS Education and Outreach (E&O) Program, which enables audiences beyond seismologists to access and use seismological data and research for educational purposes, including teacher workshops, student internships, museum exhibits, educational materials, and programs for under-resourced schools.

Principal Scientific Goals: The Earth's interior remains a major scientific frontier holding the key to understanding the origin of the planet. Recent developments in seismic sensor design, and the acquisition, transmission and storage of data have resulted in dramatic improvements in the resolving power of seismic imaging of the interior. Earthquake research, including rapid and accurate location and characterization of the earthquake source, its magnitude and a better understanding of the physical process involved, has also benefited greatly from recent technical advances. The IRIS facility serves the research needs of the national and international seismology community by making available state-of-the-art designs in seismic sensors and data acquisition systems. In addition to its role in providing the observational data essential for basic research in geophysics and earthquake dynamics, IRIS plays a significant role in seismic monitoring of the Comprehensive Test Ban Treaty and in bringing seismology to students and the public through the activities of its Education and Outreach program.

Principal Education Goals: The IRIS Education and Outreach (E&O) Program enables audiences beyond seismologists to access and use seismological data and research for educational purposes. E&O activities include teacher workshops, student field internships, museum exhibits, educational materials, the development of classroom seismic stations, and programs for under-resourced schools. E&O projects serve not only to advance public understanding of geoscience, but also to foster improved understanding of the scientific process and scientific data.

Partnerships: IRIS is heavily involved in partnership activities, many international in nature. Installation and operation of the Global Seismographic Network (GSN) has put IRIS in contact with scientists as well as government and non-government organizations all over the world. Many international IRIS GSN stations are designated as the official stations for nuclear test ban monitoring in their host countries. International teams of scientists organize most PASSCAL projects overseas. The IRIS facilities also are multi-use resources for other government agencies that have responsibilities for development of a nuclear test-ban monitoring capability and for monitoring of global seismicity. For these purposes, agencies in partnership with NSF have provided substantial support to IRIS for accelerated development of the GSN (Department of Defense), shared operation and maintenance of the GSN (U.S. Geological Survey), and accelerated development of the PASSCAL instrument pool (Department of Energy).

Connections to Industry: The use of IRIS PASSCAL instruments for investigations of the shallow crust provides opportunities for collaboration with the petroleum exploration industry. Many students involved in these experiments receive training in techniques that prepare them for careers in the exploration industry. In a broader sense, IRIS continues to closely collaborate with industry in development of seismic instrumentation and software.

Management and Oversight: IRIS is incorporated as a nonprofit consortium representing practically all U.S. university and nonprofit organizations with research and teaching programs in seismology. Each member institution appoints a representative. However, all IRIS program and budget decisions are made by a nine-member Board of Directors. These decisions are made after consultation with the IRIS advisory committees (the four standing committees for each of the four IRIS programs and additional ad hoc working groups appointed for special tasks). The Board of Directors appoints a president of IRIS to a

two-year term. The president is responsible for IRIS operations, all of which are managed through the IRIS Corporate Office.

The Division of Earth Sciences, through its Instrumentation & Facilities Program (IF), provides IRIS with general oversight to help assure effective performance and administration. The Program also facilitates coordination of IRIS programs and projects with other NSF-supported facilities and projects and with other Federal agencies and evaluates and reviews the scientific and administrative performance of IRIS.

Current Project Status: The IRIS consortium was founded in 1984 by 26 universities in response to recommendations in a report issued in 1983 by the Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academies. This report urged that "NSF act as overall coordinator and lead agency for funding a global digital seismic array and that the operation be planned and overseen by a university consortium." During the last twenty years, with support from the Foundation and federal partners, the IRIS consortium has grown to 102 full-member (voting) U.S. universities that operate core research facilities consisting of a Global Seismographic Network (GSN), the Program of Array Seismic Studies of the Continental Lithosphere (PASSCAL), and a Data Management System (DMS). During the last cooperative agreement period, IRIS initiated a new Education and Outreach (E&O) program. The FY 2006 Request for IRIS totals $13.31 million, an increase of $1.15 million over the FY 2005 Current Plan.

Funding Profile: All funding for IRIS to date has been provided through the R&RA Account.

IRIS Funding Profile

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	1.90	11.38	$13.28
FY 2002	1.50	11.40	$12.90
FY 2003	3.70	9.50	$13.20
FY 2004	3.10	9.90	$13.00
FY 2005 Current Plan	2.85	9.31	$12.16
FY 2006 Request	3.00	10.31	$13.31
FY 2007 Estimate	3.10	10.50	$13.60
FY 2008 Estimate	3.20	11.00	$14.20
FY 2009 Estimate	3.30	11.50	$14.80
FY 2010 Estimate	3.41	11.79	$15.19

NOTE: Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Implementation: Implementation includes funds for major equipment purchases (data recorders and seismometers) for the PASSCAL Instrument Center in Socorro, NM and the Global Seismographic Network (GSN).

- Operations and Maintenance: This category includes funds to support the IRIS corporate office in Washington, DC, including the Education & Outreach Program (E&O); the PASSCAL Instrument

Center in Socorro, NM; the Data Management System (DMS) in Seattle, WA; and the Global Seismographic Network (GSN). IRIS conducts no "in-house research."

Renewal or Termination: Two reviews have been stipulated in the new NSF cooperative agreement with IRIS: (1) an in-depth study by IRIS of the operation, personnel, and instrument costs, and support of the Global Seismographic Network (GSN), in collaboration with the USGS, representatives of the Federation of Digital Seismic Networks (FDSN), and GSN network operators by July 1, 2003; and (2) an NSF review of IRIS management in coordination with IRIS and its appropriate governance committees, to be completed by July 1, 2004. Both reviews have now been completed. The latter review provided more information for the basis of the decision to either allow the submission of a renewal proposal or to recompete the operation of this facility.

Associated Research and Education Activities: IRIS sponsors an active education and outreach program, which touches a vast number of individuals annually. There are over 2000 individuals on the IRIS mailing list, and over 100 K-12 schools and science centers are using seismographs provided by IRIS. In FY03 350 freshman engineering students designed seismographs under the guidance of IRIS members. The website visitors data in the table below indicate a yearly sum of unique visitors each month, and the K-12 students number assumes each teacher interacts with 80 students per year and continues to teach new students each year. IRIS holds a number of hour-long and 1-day workshops each year for K-12 teachers and college faculty; in FY 2004, 6 such workshops were held. The museum display visitors number is the total number of visitors to the museums that have an IRIS/USGS display.

IRIS Participation

Year	K12 Students taught by IRIS trained teachers	Undergrad summer interns	Graduate students sponsored to attend annual IRIS workshop	K-12 Teachers trained in IRIS workshops	College faculty trained in 1-day workshops	Museum display visitors	Posters distributed	Website visitors
FY 1998	3,400	2	28	43		500,000	2,000	
FY 1999	5,300	6	22	23	35	2,000,000	5,000	
FY 2000	6,900	2	30	20	20	9,000,000	4,000	
FY 2001	12,000	3	33	65	25	9,000,000	3,000	250,000
FY 2002	18,000	6	24	76	16	9,000,000	2,000	300,000
FY 2003	27,000	9	25	117	25	9,000,000	4,000	450,000
FY 2004	35,000	4	20	103	18	16,000,000	8,500	650,000

Science Support: The EAR/Geophysics and Continental Dynamics Programs and the OCE/Marine Geology and Geophysics Program provide most of the funds for NSF-sponsored research, totaling approximately $15 million per year. Funds permit deployment of PASSCAL instruments and use of GSN data stored at the DMS to solve major earth science problems.

Integrated Ocean Drilling Program

Project Description: The Ocean Drilling Program (ODP) terminated in September 2003 with its final drilling programs in the North Atlantic. During the 18-year duration of the ODP, NSF provided 60% of the program's resources and all of the required facilities, with the remaining funding provided by international partners. Phase-out of program and contract activities is planned through FY 2007.

The Integrated Ocean Drilling Program (IODP), begun in FY 2004, is the successor program to the Ocean Drilling Program (ODP), and represents an expanded international partnership of scientists, research institutions, and funding agencies organized to explore the evolution and structure of Earth as recorded in the ocean basins. Ocean drilling is an essential capability in modern geoscience research and education and is used to examine processes ranging from changes in the Earth's climate to the rifting and drifting of continents. Over 600 ocean and earth scientists have completed an internationally coordinated planning effort to examine the scientific objectives for IODP, culminating in the Initial Science Plan Earth, Oceans, and Life. These objectives require a heavy vessel for drilling deep sedimentary and crustal holes, a lighter vessel to provide widely distributed arrays of high-resolution cores to address climate, environmental, and observatory objectives, and occasional use of drilling platforms for the Arctic and nearshore projects, which cannot be undertaken from the two primary IODP vessels.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan has secured funding of at least $500 million and has completed construction of the heavy drillship *Chikyu* (Earth, in Japanese) to address deep drilling objectives in the new program. *Chikyu* was launched in January 2002, will undergo testing through 2006, and will be available for IODP operations in 2007. NSF's planned contribution to this program includes the acquisition, conversion and outfitting of a vessel suitable to achieve the goals of the light vessel requirement using MREFC funds in 2005-2007. An initial period of light drillship operations, from June 2004 to January 2006, uses the ODP drillship *JOIDES Resolution*. The European Consortium for Ocean Research Drilling (ECORD), composed of 15 countries (including Canada), is participating in IODP and providing short-term use of chartered drilling platforms for Arctic and near-shore objectives. The People's Republic of China is an additional IODP participant, and several other potential Asian members may join in the future.

IODP drilling operations provide sediment and rock samples (cores), shipboard and shore-based facilities for the study of these samples, downhole geophysical and geochemical measurements (logging), and opportunities for special experiments to determine in situ conditions beneath the seafloor. The IODP drilling platforms collect geologic samples from the floor of the deep ocean basins primarily through rotary coring and hydraulic piston coring. The logs and samples of the cores are made available to qualified scientists throughout the world for research projects.

Principal Scientific Goals: The IODP scientific program is identified in the Initial Science Plan for the IODP, Earth, Oceans and Life, and includes emphasis on the following research themes:

- The Deep Biosphere and the Sub-seafloor Ocean: Drilling will concentrate on defining the architecture and dynamics of the vast subseafloor plumbing system, where flowing water alters rock, modifies the long-term chemistry of the oceans, lubricates seismically active faults, concentrates economic mineral deposits, and controls the distribution of the deep biosphere.

- The Processes and Effects of Environmental Change: Using a global array of sites, ocean sediment cores will be used to construct a detailed record of the causes, rates and severity of changes in the earth's climate system and their relation to major pulses in biologic evolution.

- Solid Earth Cycles and Geodynamics: Drilling will concentrate on sampling and monitoring regions of the seafloor that currently have the highest rates of energy and mass transfer, and comparing these results to older geologic settings. A crucial initial program of deep drilling will study the seismogenic zone responsible for large destructive earthquakes along active plate boundaries.

Principal Education Goals: Undergraduate and graduate students participate in drilling expeditions, working with some of the world's leading scientists and becoming part of the intellectual fabric essential for future advances in the earth sciences. To reach students that do not participate directly in IODP,

investments are made in curriculum enrichment including interactive CD-ROMs, visiting lecture programs, museum displays, and remote classroom broadcasts from the drillship.

Partnerships: MEXT and NSF are equal partners in the IODP and contribute equally to program operation costs. A consortium of 14 European countries and Canada (ECORD) and the People's Republic of China have officially joined IODP. In addition to its financial contribution, the European consortium supplies additional drilling facilities for IODP for short-term operations in shallow water and the Arctic. Several other Asian countries may join in the future.

Connections to Industry: As it did in ODP, NSF is contracting the services of the light drillship from a leading offshore drilling contractor. A commercial contractor provides downhole-logging services. In addition, scientists from industrial research laboratories participate in IODP cruises, are members of the program's scientific and technical advisory committees, and supply data for planning and interpretation of drilling results.

Management and Oversight: NSF and MEXT have signed a Memorandum of Cooperation, which identifies procedures for joint management of a contract to an IODP Central Management Office (CMO). The CMO coordinates and supports scientific planning, drilling platform activity, data and sample distribution, and publication and outreach activities through its management of commingled international science funds, collected and provided by NSF. A non-profit corporation founded by U.S. and Japanese institutions (IODP Management International, Inc.) has been contracted by NSF for the CMO activity. Drillship providers are responsible for platform operational management and costs. NSF provides the light drillship through contract with the U.S. System Integration Contractor (SIC), the JOI Alliance, a consortium of the Joint Oceanographic Institutions, Inc. (JOI), Texas A&M University, and Lamont-Doherty Earth Observatory. MEXT will manage its drillship through the Japan Marine Science and Technology Center (JAMSTEC), while the British Geological Survey manages European drilling contributions.

Scientific advice and guidance for IODP is provided through the scientific advisory structure (SAS). The SAS is responsible for providing scientific advice and guidance for IODP, and consists of the Science Planning and Policy Oversight Committee (SPOCC, the IODP executive authority) and an advisory structure headed by the Science Planning Committee (SPC). The CMO, under the direction of the SPC Chair, is responsible for the coordination of the SAS committees and panels, and for integrating the advice from the panel structure in a manner suitable for providing drilling and operational guidance to the CMO. Membership in the SAS is proportional to IODP financial contribution.

The Division of Ocean Sciences manages the IODP for NSF under the NSF Ocean Drilling Program. NSF's Ocean Drilling Program is placed within the Marine Geosciences Section, with several program officers dedicated to its oversight. One of the program officers serves as the contracting officer's technical representative on the CMO and SIC contracts.

Current Program Status and Future Program Planning: IODP started in FY 2004. A first phase of light drillship drilling activity started in mid-FY 2004 and will continue into early FY 2006. The NSF-supplied light drillship, converted using MREFC funds for IODP needs, will begin drilling in mid FY 2007. The heavy drillship *Chikyu* is expected to begin scientific drilling operations at the beginning of FY 2007. A European-funded drilling expedition to the northern Arctic used several icebreakers, one modified for drilling, in late FY 2004 and early FY 2005.

NSF and MEXT will contribute equally to IODP operations costs, with up to one-third of total costs contributed by the European consortium. NSF is requesting $30.0 million in FY 2006 for operation of the IODP program through the R&RA Account.

Funding Profile: All funding for the operation of the ODP has been provided through the R&RA Account. Implementation funding in FY 2005-2007 is MREFC Account funding that supports the acquisition and outfitting of a drillship for use in the program. For more information on this project, please see the Scientific Ocean Drilling Vessel section of the MREFC Chapter of this document.

Ocean Drilling Funding Profile

(Dollars in Millions)

	Implementation[1]	ODP Operations & Maintenance	IODP Operations & Maintenance	Total, NSF
FY 1997		27.09		$27.09
FY 1998	3.00	26.95		$29.95
FY 1999	3.00	28.13		$31.13
FY 2000		29.50	0.10	$29.60
FY 2001		30.60	0.20	$30.80
FY 2002		31.50	0.30	$31.80
FY 2003		32.00	3.90	$35.90
FY 2004			35.10	$35.10
FY 2005 Current Plan	14.88	5.90	32.10	$52.88
FY 2006 Request	57.92	2.00	30.00	$89.92
FY 2007 Estimate	42.20	1.50	40.00	$83.70
FY 2008 Estimate			60.00	$60.00
FY 2009 Estimate			61.50	$61.50
FY 2010 Estimate			63.04	$63.04

NOTE: Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

[1]Implementation funding in FY 2005-2007 represents the acquisition component of IODP, the Scientific Ocean Drilling Vessel (SODV). The SODV will be funded through the MREFC Account. Please see the MREFC chapter for additional information pertaining to this project.

Information pertaining to the data in the table is included below.

- Implementation: NSF's planned contribution to this program includes the acquisition, conversion and outfitting of a Scientific Ocean Drilling Vessel (SODV) suitable to achieve the goals of the light vessel requirement using MREFC funds in 2005-2007. An initial period of light drillship operations, from June 2004 to January 2006, uses the ODP drillship *JOIDES Resolution*. Further information regarding acquisition of the NSF-supplied light drillship can be found under Scientific Ocean Drilling Vessel in the MREFC chapter.

- Operations and Maintenance: The general contractor for the overall management and operation of the ODP is Joint Oceanographic Institutions, Inc. (JOI), a consortium of major United States oceanographic institutions. Drilling operations and science support services (laboratory equipment, technical support, database maintenance, sample storage and distribution) are managed by Texas A&M University. Lamont-Doherty Earth Observatory of Columbia University manages logging. Support for participation and drilling-related research performed by U.S. scientists is provided by NSF.

Renewal or Termination: IODP international agreements and contracts cover activities through FY 2013. Activities regarding IODP renewal are expected to commence in FY 2011.

Associated Research and Education Activities: A breakdown by year and by category is reflected in the table below. Much of the support for Education and Outreach activities in ODP is through a cooperative agreement with JOI Inc., which has resulted in various educational products and services described here in brief. Three educational CD-ROMs with teaching activities, interviews with scientists, and operational footage have been developed and widely distributed. An educational poster titled, "Blast from the Past," describing the meteorite impact that led to the demise of the dinosaurs was printed, and 64,000 copies have been distributed. A brochure of abstracts (text and figures), highlighting 17 of the Ocean Drilling Program's greatest scientific accomplishments, was published and distributed. JOI also publishes a newsletter three times a year with a distribution of about 2,000. In addition, a display of ODP materials was produced and contributed to the Smithsonian Museum, in Washington DC, where it has been on permanent display since 1997. This display is viewed daily by thousands of museum visitors (numbers are not reflected in the table below).

The services of the program are also listed here in brief. A Distinguished Lecturer Series, through which each year approximately 6 lecturers give a total of about 30 lectures at universities, colleges, and other institutions throughout the country. An Undergraduate Student Trainee Program enables undergraduates to sail on a research vessel as members of the scientific team. Mentors and scientific projects are an integral part of this program. An internship program at JOI Inc. was initiated several years ago as an attempt to introduce recent graduates to the career opportunities of science program management. A longstanding fellowship program provides graduate student fellowship awards to conduct ODP research. Each year, JOI sponsors educational and promotional booths at national and international meetings where products and services are highlighted. The drillship *JOIDES Resolution* has visited U.S. ports approximately 10 times since 1994. At each visit, ship tours are given, and promotional and educational activities have been held at five of these port calls. JOI/ODP sponsors scientific research and planning workshops that commonly involve graduate students. And lastly, many graduate students have sailed on the *JOIDES Resolution*.

ODP Participation

Year	K-12	Undergrad	Graduate	Teachers
FY 1996	620	1,500	1,400	700
FY 1997	2,620	6,210	4,900	1,800
FY 1998	1,300	4,110	3,800	1,300
FY 1999	2,600	5,740	5,900	2,200
FY 2000	17,600	13,680	7,400	4,200
FY 2001	5,600	9,750	9,400	9,700
FY 2002	6,000	8,000	9,500	7,000
FY 2003	6,500	8,500	9,500	7,500
FY 2004	6,500	8,500	9,500	7,500
FY 2005 Estimate	6,500	8,500	9,500	7,500

Science Support: Over 1,600 scientists from forty nations have participated on ODP and IODP cruises since 1985. About 750 of these have been U.S. scientists from over 150 universities, government agencies, and industrial research laboratories, with over 300 of them participating in more than one ODP cruise. Samples and data have been distributed to an additional 800 or more U.S. scientists. These

1,500+ direct U.S. users of ODP materials constitute approximately 10 to 15 percent of the U.S. geoscience community as identified by the American Geological Institute.

NSF provides most of the support for the participation of U.S. scientists in the IODP. The majority of the funding comes from the Division of Ocean Sciences, with additional funding from the Office of Polar Programs related to Antarctic drilling research. Total funding for U.S. participation and analysis of samples and data is expected to reach approximately $30 million annually.

Large Hadron Collider

Project Description: The Large Hadron Collider (LHC) will be the premier facility in the world for research in elementary particle physics. The facility will consist of a superconducting particle accelerator providing two, counter-rotating beams of protons, each beam having an energy up to 7 TeV ($1TeV=10^{12}$ electron volts). The U.S. is involved in the construction of two particle detectors, A Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS). They are being constructed to characterize the different reaction products produced in the very high-energy proton-proton collisions that will occur in intersection regions where the two beams are brought together.

The LHC is an international project under construction at the CERN laboratory in Geneva, Switzerland. NSF awarded MREFC grants to Northeastern and Columbia Universities under cooperative agreements with subcontracts to over 50 U.S. universities. In FY 2003, the funding of LHC construction by NSF was completed. A total of 34 international funding agencies participate in the ATLAS detector project, and 31 in the CMS detector project. NSF and DOE are providing U.S. support. CERN is responsible for meeting the goals of the international LHC project. The ATLAS and CMS detectors are expected to take data approximately 200 days per year. The remaining time is to be used for maintenance and testing.

The U.S. LHC Research Program, funded through the R&RA account, is now ramping up with awards to Northeastern University and UCLA (for CMS) and Columbia University (for ATLAS). This program consists of Maintenance and Operations, Software and Computing activities and some R&D for future detector upgrades.

The U.S. LHC collaboration has been a leader in the development of Grid-based computing. The Grid will enable the enhanced participation of U.S. universities, and thus the training of students, in both state of the art science and computational techniques, in a project that is centered overseas. The Grid is expected to have broad application throughout the scientific and engineering communities.

Principal Scientific Goals: The LHC will enable a search for the Higgs particle, the existence and properties of which will provide a deeper understanding of the origin of mass of known elementary particles. The LHC will also enable a search for particles predicted by a powerful theoretical framework known as supersymmetry, which will provide clues as to how the four known forces evolved from different aspects of the same 'unified' force in the early universe, and can investigate the possibility that there are extra-dimensions in the structure of the universe.

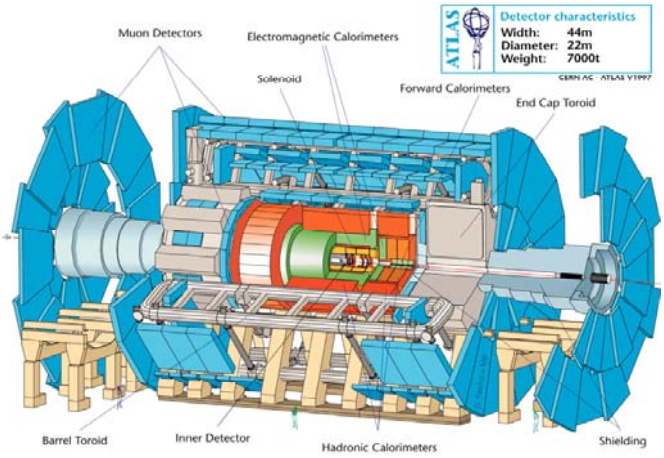
Principal Education Goals: Through the participation of young investigators, graduate students, undergraduates, and minority institutions in this international project, LHC serves the goal of helping to produce a diverse, globally-oriented workforce of scientists and engineers. Further, innovative education and outreach activities, such as the QuarkNet project, allow high school teachers and students to participate in this project (see the URL: http://quarknet.fnal.gov/). Many highly-trained students in high-energy physics move into industrial jobs.

Connections to Industry: Major procurements of components of both warm and superconducting magnets, as well as high-speed electronics, are performed through U.S. industries. Major developments in Grid computing are also valuable outcomes.

Management and Oversight: A program director in the Physics Division of the Directorate for Mathematical and Physical Sciences (MPS) is responsible for day-to-day project oversight. The NSF program director also participates in an internal Project Advisory Team, including staff from the Office of Budget, Finance and Award Management, including the Deputy for Large Facility Projects, the Office of the General Counsel, the Office of Legislative and Public Affairs, and the Office of the Assistant Director for MPS.

U.S. LHC program management is performed through a Joint Oversight Group (JOG), created by the NSF and DOE. The JOG has the responsibility to see that the U.S. LHC Program is effectively managed and executed to meet commitments made under the LHC International Agreement and its Protocols.

Current Project Status: CERN Project Management is making every effort to maintain the LHC extended schedule, which aims for first collisions in 2007, without significant delays. While both experiments may benefit from the extended LHC schedule by having additional time to optimize their installation plans, the U.S. collaborators continue on the original baseline schedule, to avoid any increases in labor and costs. The entire U.S. LHC construction activity is being maintained within the funding cap set forth in the original U.S. funding guidance for the project.



This is a diagram of the particle detector ATLAS (A Toroidal LHC Apparatus). ATLAS and the Compact Moun Solenoid (CMS) represent the U.S. contribution to the construction of the Large Hadron Collider at the CERN laboratory in Geneva, Switzerland. *Credit: LHC project.*

The NSF-supported components of the ATLAS and CMS detectors are scheduled for completion in FY 2005; the final year of appropriated construction funding was in FY 2003. The U.S. ATLAS construction project, as of November, 2004, was 93 percent complete, as measured by Earned Value. The U.S. CMS project is 88 percent complete. Milestones for both projects are being completed in the anticipated years. U.S. cost performance has been excellent, with material contracts typically below estimates, and labor costs tracking close to plan. The U.S. strategy aims for the completion of 95% of the U.S. deliverables by the end of FY 2005, with the remaining items linked to the installation schedule.

Major remaining milestones for the NSF components of LHC are outlined below:

FY 2005 Milestones:

US ATLAS
- Complete delivery of Liquid Argon Forward Calorimeter (Section A);
- Complete delivery of Silicon Strip Pixels Disk system at CERN;
- Complete production and installation of Transition Radiation Tracker (Barrels); and
- Complete production of Muon Cathode Strip Chamber Readout.

US CMS

Complete delivery of Electromagnetic (EM) Calorimeter Optical Links;
50 percent of Silicon Tracker Rods completed; and
Complete Muon Trigger Card Production Test

FY 2006 Milestones:

Continue ATLAS and CMS detector installation and testing in underground halls.

FY 2007 Milestone:

First data taking using both ATLAS and CMS detectors.

Funding Profile: Funding for the overall LHC project, including the ATLAS and CMS detectors and the accelerator, is provided through an international partnership involving NSF, the Department of Energy (DOE), and the CERN member states, with CERN member states providing the major portion. Other countries that are not member states are also participating.

The total U.S. contribution to the construction project will be $531 million, with $450 million from the DOE and $81 million from NSF. NSF and DOE will jointly provide a total contribution of $331 million for the detector construction, while DOE will provide the entire U.S. contribution ($200 million) for the accelerator construction. There are two other major detectors being constructed, ALICE and LHC-B, in which the U.S. does not play a role.

LHC Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 1999 & Earlier	5.70		0.15	22.00	0.16		6.01	22.00	$28.01
FY 2000				15.90	0.53		0.53	15.90	$16.43
FY 2001				16.36	2.30		2.30	16.36	$18.66
FY 2002				16.90	1.60		1.60	16.90	$18.50
FY 2003				9.69	5.00		5.00	9.69	$14.69
FY 2004[1]					7.00		7.00		$7.00
FY 2005 Current Plan					10.50		10.50		$10.50
FY 2006 Request					13.50		13.50		$13.50
FY 2007 Estimate					18.00		18.00		$18.00
FY 2008 Estimate					18.00		18.00		$18.00
FY 2009 Estimate					18.00		18.00		$18.00
FY 2010 Estimate					18.00		18.00		$18.00
Subtotal, R&RA	$5.70		$0.15		$112.59		$118.44		
Subtotal, MREFC				$80.85				$80.85	
Total, Each Stage		**$5.70**		**$81.00**		**$112.59**			**$199.29**

NOTE: The estimated operational lifespan of this project is approximately 20 years. Operations and Maintenance Estimates for FY 2007 and beyond are subject to the availability of funds and appropriate program balance and may not reflect actual budget requirements.

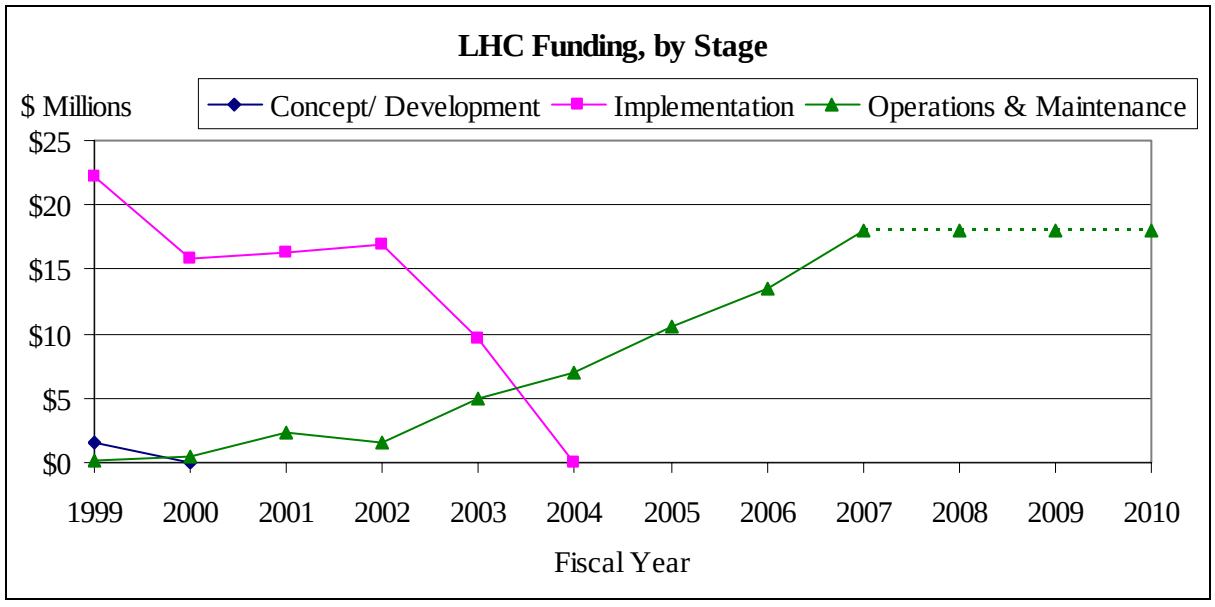
[1]As of FY 2004, start dates for projected NSF funding correspond to accelerated schedules to begin on: 8/1/04, 5/1/05, 2/1/06 and 11/1/06. Thereafter, funding will begin on November 1 of each year.

Information pertaining to the data in the table is provided below.

- Concept/Development: The LHC has been under discussion since FY 1989. NSF funding in FY 1996-99 supported technical design studies.

- Implementation: NSF components of the ATLAS and CMS detectors, constructed with funds provided FY 1999-FY 2003, are anticipated to be completed, tested and ready to install in FY 2005. The overall LHC project is now anticipated for completion at CERN in FY 2007. (In FY 1999, $150,000 in R&RA funds was provided to meet the scheduled award total of $22.15 million. This R&RA action was noted in subsequent NSF MREFC budget justifications to Congress.) Final implementation funding was provided in FY 2003.

- Management & Operations: FY 1999-2008 funding primarily represents investments in university computing infrastructure and software development for remote access, to allow university scientists and students to participate in LHC research as well as other projects. Estimated funding for FY 2005 and beyond reflects the NSF share of operations as the ATLAS and CMS detectors approach and initiate operations. Components of these detectors, by far the largest ever constructed in particle physics, become inaccessible when additional components are installed, and all become inaccessible when data taking begins. To insure satisfactory performance, components must be operated, tested and repaired as soon as installed. Estimated funding during the same period also includes the development of LHC grid software and computing (S&C). Detector operations costs and S&C costs are approximately equal. It is anticipated that over the lifetime of the LHC project, upgrades and new components to address emerging research questions will be considered. Funds for such activities are not included here.



Future Science Support: Along with direct support for operations and maintenance for LHC, NSF will support science and engineering research performed at the facility, through ongoing research and education programs. The annual support for such activities is presently estimated to be about $5.0 million through individual PI awards once the facility reaches full operations. Both ATLAS and CMS have well-developed outreach activities (see Education Goals above).

Laser Interferometer Gravitational Wave Observatory

Project Description: Einstein's theory of general relativity predicts that cataclysmic processes involving super-dense objects in the universe will produce gravitational radiation that will travel to Earth. Detection of these gravitational waves is of great importance, both for fundamental physics and for astrophysics. LIGO, the most sensitive gravitational wave detector ever built, comprises two main facilities, one in Livingston Parish, LA and one in Hanford, WA. At each facility, a large vacuum chamber, with two 4-km arms joined at right angles, houses one or more optical interferometers. The interferometers are used to measure minute changes in the apparent distances between test masses at the ends of the arms caused by a passing gravitational wave. The predicted distortion in space caused by a gravitational wave from a likely type of source is of order one part in 10^{21}, meaning that the expected change in the apparent 4-km length is only of order 4×10^{-18} meters or about 1/1000th of the size of a proton. The 4-km length for LIGO, by far the largest for any optical interferometer, was chosen to make the expected signal as large as possible within the terrestrial constraints. Looking for coincident signals in all the interferometers simultaneously increases the likelihood for gravitational wave detection. The Phase I LIGO currently operating is close to its design specifications. The Advanced LIGO (AdvLIGO) upgrade, designed to reach best possible sensitivity for an earth-based instrument, is requested to begin construction in FY 2008. For more information on AdvLIGO, please see the MREFC Chapter.

Principal Scientific Goals: Of the four known fundamental forces of nature (electromagnetic, weak, strong, and gravitational), the gravitational force is the most enigmatic. It is by far the weakest, yet it holds the universe together, ignites the fusion reaction in stars, and curves space in black holes so severely that light is trapped. And, although the universe is believed to be filled with gravitational waves from a host of cataclysmic cosmic phenomena, we have never detected a gravitational wave and measured its waveform.

The principal scientific goals of LIGO are to detect gravitational waves on Earth for the first time and to develop this capability into a new window on the universe, a window through which we can observe phenomena such as the inspiral and coalescence of neutron stars in binary orbit, black hole collisions, unstable dynamics of newborn neutron stars, supernovae, stochastic background from the early universe, and a host of more exotic or unanticipated processes.

Arial view of LIGO facility in Hanford, WA. The facility, and its companion in Livingston, LA, each houses laser interferometers consisting of mirrors suspended at each of the corners of a gigantic L-shaped vacuum system measuring 4 km on a side. Precision laser beams in the interferometers sense small motions of the mirrors such as those expected to be caused by a gravitational wave. LIGO is about to begin its fourth in a series of long term observations in February 2005 to search for gravitational waves generated by cataclysmic astronomical events. *Credit: www.ligo.caltech.edu*

Principal Education Goals: LIGO is a significant source of highly trained Ph.D. graduates for the country's workforce. With the beginning of LIGO science runs in FY 2002, the number of graduate students is expected to grow. In addition, LIGO has a diverse set of educational activities at its different sites, activities that involve a large number of undergraduates (including those from minority-serving institutions), hands-on activities for K-12 classes, teachers at all levels, and informal education and outreach activities for the public. In FY 2004, LIGO received a large grant to build a Visitor's Center at the Livingston, LA

site that will be filled with Exploratorium exhibits and will be the focal point for augmenting teacher education at Southern University and other student-teacher activities state-wide through the Louisiana Systematic Initiative Program.

Connections to Industry: Substantial connections with industry have been required for the state-of-the-art construction and measurements involved in the LIGO projects. Some have led to new products. Areas of involvement include novel vacuum tube fabrication technology, seismic isolation techniques, ultrastable laser development (new product introduced), development of new ultra-fine optics polishing techniques, and optical inspection equipment (new product).

Management and Oversight: LIGO is sponsored by NSF and managed by Caltech under a cooperative agreement. The management plan specifies significant involvement by the user community, represented by the LIGO Scientific Collaboration (LSC), and collaboration with the other major gravitational wave detector activities in Japan, Europe, and Australia. External peer-review committees organized by the NSF help provide oversight through an annual review. NSF oversight is coordinated internally by the LIGO program director in the Division of Physics (MPS), who also participates in the Physics Division Project Advisory Team, comprising staff from the Office of General Counsel, the Office of Legislative and Public Affairs, the Office of Budget, Finance and Award Management, including the Deputy for Large Facility Projects, and the Office of International Science and Engineering.

Current Project Status: All three LIGO interferometers were fully operational by the spring of 2002. Since then, activity has been divided between improving the sensitivity of the interferometers and collecting scientific data. The first science run, S-1, accumulated nearly 100 hours of triple coincidence data in the period from August 23, 2002 to September 9, 2002, with a sensitivity of about a factor of 100 from the design goal. Results from S-1 have been announced at major scientific conferences and reported in three published articles. Work on instrumental refinements between the end of S-1 and the beginning of S-2 in February 2003 produced sensitivities about ten times better than those observed in S-1, i.e., only a factor of about 10 from the design goal. S-2 lasted 59 days (February 14, 2003 – April 14, 2003) with over 300 hours in triple coincidence accumulated. Results from S-2 were presented in 2004 at both the meeting of the American Physical Society in Denver (five talks) and at the International GR-17 Meeting in Dublin (four talks). In S-3 (October 31, 2003 – January 8, 2004), the sensitivity achieved with the best of the three interferometers was only about a factor of 3.5 from the design goal, strengthening expectations that the sensitivity for S-4 that should commence sometime in early 2005 will be at or very near the targeted level. The Hydraulic External Pre-Isolators (HEPI) systems, designed and intended for use with the advanced detectors, have been installed at the Livingston site where they have successfully eliminated interference from excessive seismic noise. The FY 2006 Request for LIGO totals $32.0 million, the same as the FY 2005 Current Plan. This funding level reflects work to develop improved detectors and full operations of LIGO to run their interferometers at sites at Hanford, WA and Livingston, LA in coincidence with each other and with gravitational wave detectors abroad.

Funding Profile: The history of the LIGO project dates back to early conceptual work in the mid-1970s, moving through pre-construction R&D in the late 1980s to the initiation of LIGO construction in FY 1992. LIGO pre-dates the establishment of the MREFC Account in FY 1995.

LIGO Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 2001 & Earlier	47.56		35.90	236.00	49.50		132.96	236.00	$368.96
FY 2002					28.00		28.00		$28.00
FY 2003					33.00		33.00		$33.00
FY 2004					33.00		33.00		$33.00
FY 2005 Current Plan					32.00		32.00		$32.00
FY 2006 Request					32.00		32.00		$32.00
FY 2007 Estimate					33.00		33.00		$33.00
FY 2008 Estimate					33.00		33.00		
FY 2009 Estimate					33.00		33.00		
FY 2010 Estimate					33.00		33.00		$33.00
Subtotal, R&RA	$47.56		$35.90		$339.50		$422.96		
Subtotal, MREFC				$236.00				$236.00	
Total, Each Stage		**$47.56**		**$271.90**		**$339.50**			**$658.96**

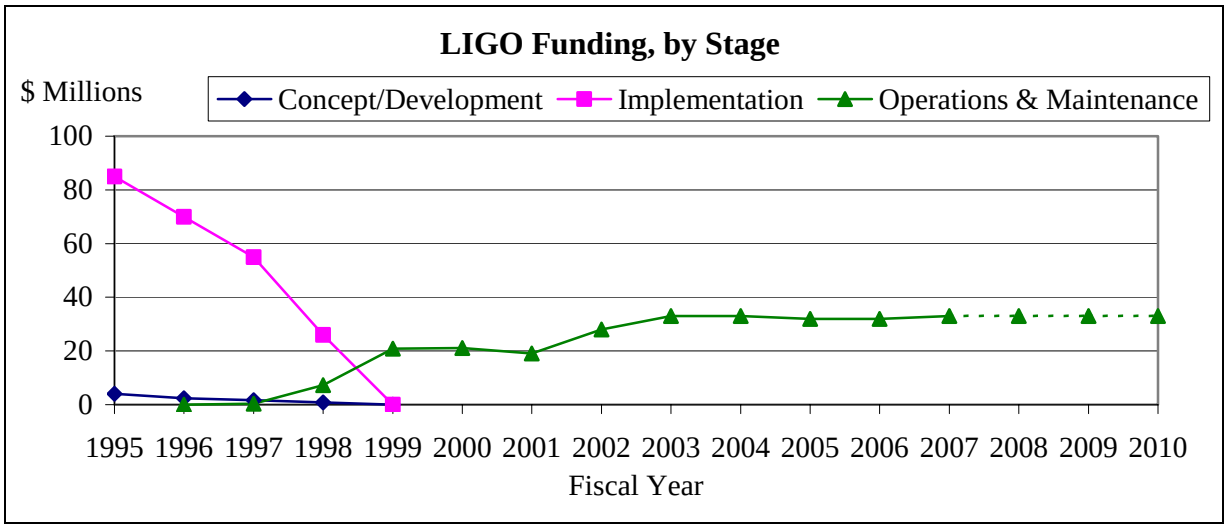
NOTE: The expected operational lifespan of this project is about 20 years. Operations and Maintenance Estimates for FY 2007 and beyond are subject to the availability of funds and appropriate program balance and may not reflect actual budget requirements.

Information pertaining to the data in the table is included below.

- Concept/Development: Funds supported three phases of planning, design and development for LIGO: early conceptual R&D - $11.6 million (FY 1975-87); pre-construction R&D - $16 million (FY 1988-91); and ongoing R&D throughout construction - $20 million (FY 1992-98).

- Implementation: LIGO construction occurred between FY 1992-98, totaling $271.90 million. Prior to the start of the MREFC Account, construction funding was provided through the R&RA Account.

- Management and Operations: LIGO management and operations (M&O) costs began phasing-in in FY 1997. Commissioning costs are included in LIGO operations through FY 2001. M&O funding includes operation for science and engineering runs and R&D for advanced detectors.



Renewal or Termination: The cooperative agreement for the support of LIGO operations expires in FY 2006. NSF expects to renew the agreement at that time pending a satisfactory performance review.

Associated Research and Education Activities: Active outreach programs have been developed at both the Livingston and Hanford sites. Teams at both sites have provided visual displays, hands-on science exhibits, and fun activities for visiting students and members of the public. In the last three years an average of over 2,000 students per year have taken advantage of this opportunity. More formal programs at the sites include participation in the Research Experience for Teachers (RET) Program, a set of "scientist-teacher-student" research projects in support of LIGO, and participation in the SURF/REU programs for college students. In collaboration with RET participants and networks of local educators, both sites have developed Web-based Resources for teachers that includes information on research opportunities for schools and a set of standards-based classroom activities, lessons, and projects related to LIGO science. In FY 2004, NSF initiated a project to build a Visitor's Center at the Livingston, LA site that will be filled with Exploratorium exhibits and that will be the focal point for augmenting teacher education at Southern University and other student-teacher activities state-wide through the Louisiana Systematic Initiative Program. Plans are in progress to hire an outreach coordinator at each site to augment the existing activities.

Science Support: Along with direct operations and maintenance support for LIGO, NSF supports science and engineering research directly related to LIGO activities through ongoing research and education programs. The annual support for such activities is estimated to be about $5 million.

In 1997 LIGO founded the LIGO Scientific Collaboration (LSC) to organize the major international groups doing research that was supportive of LIGO. The LSC now has 44 collaborating institutions with over 440 participating scientists. The role and membership responsibilities of each participating institution are determined by a MOU between the LIGO Laboratory and each institution. The LSC plays a major role in many aspects of the LIGO effort including: R&D for detector improvements, R&D for Advanced LIGO, data analysis and validation of scientific results, and setting priorities for instrumental improvements at the LIGO facilities.

MREFC Facilities

The MREFC Account supports the acquisition, construction and commissioning of major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering. Projects supported by this account are intended to extend the boundaries of technology and open new avenues for discovery for the science and engineering community. Initial planning and design, and follow on operations and maintenance costs of the facilities are provided through the Research and Related Activities (R&RA) and Education and Human Resources (EHR) Accounts.

NSF believes that the highest priority within the MREFC Account must be the current projects. To that end, highest priority in FY 2006 is to continue to request funding for the Atacama Large Millimeter Array ($49.24 million); EarthScope ($50.62 million); the IceCube Neutrino Observatory ($50.45 million); the Scientific Ocean Drilling Vessel ($57.92 million); and Rare Symmetry Violating Processes ($41.78 million). NSF is requesting no new starts in FY 2006. Two new starts are requested in FY 2007, and one new start is requested in FY 2008. In priority order, these are: Ocean Observatories in FY 2007; the Alaska Region Research Vessel in FY 2007; and Advanced LIGO in FY 2008[2].

For additional information of projects funded through the MREFC Account, please see the MREFC Chapter of this document.

National High Magnetic Field Laboratory

Project Description: The NHMFL develops and operates high magnetic field facilities that scientists use for research in physics, biology, bioengineering, chemistry, geochemistry, biochemistry, materials science, medicine, and engineering. It is the world's largest and highest-powered magnet laboratory, outfitted with a comprehensive assortment of high-performing magnet systems. Many of the unique facilities were designed, developed, and built by the magnet engineering and design team at the NHMFL in collaboration with industry. The facilities are available to all qualified scientists and engineers through a peer-reviewed proposal process.

Principal Scientific Goals: NHMFL scientific goals are to provide the highest magnetic fields, state-of-the-art instrumentation, and support services for scientific research conducted by users from a wide range of disciplines, including all areas of science and engineering.

Principal Education Goals: NHMFL promotes science education and assists in developing the next generation of scientists, engineers, and science education leaders. A variety of programs, opportunities, and mentorship experiences are available for teachers and students at all academic levels – K-12 through post-graduate. The laboratory, with its distinguished faculty and world-class facilities, provides a unique interdisciplinary learning environment and has had a national impact in curriculum development. In FY 2004, its regional K-12 outreach efforts engaged over 6,252 students from Florida and neighboring Georgia in hands-on science activities and tours of the laboratory.

[2] The National Science Board (NSB) established the priority of all unfunded but NSB-approved projects at the May 2004 NSB meeting, prior to the FY 2005 Omnibus Appropriation. SODV and RSVP received MREFC funds in the Omnibus and are now ongoing projects. NEON received R&RA funding and is also an ongoing project. AdvLIGO received NSB approval for inclusion in a future Budget Request in October 2004 (http://www.nsf.gov/nsb/meetings/2004/1004/major_action_1004_updt.pdf) and is as yet unranked.

Partnerships and Connections to Industry: The Magnet Science and Technology (MS&T) Division of the NHMFL has broad responsibility to develop high magnetic fields and materials for high field magnet wires in response to national needs, such as building advanced magnet systems for the NHMFL sites, working with industry to develop the technology to improve and address new opportunities in magnet-related technologies, and pushing the state-of-the-art beyond what is currently available in high field magnet systems through materials research and magnet technology development. To this purpose, MS&T has established leading capabilities in many aspects of magnet system engineering and assessment. In addition, MS&T cooperates with industry and other international magnet laboratories on a variety of technology projects, including the advancement of conducting materials for magnets, including high quality Cu-Nb micro-composite wires with outstanding characteristics (strength, conductivity, and resistive ratio) now available for the construction of high field coils. These projects cover the range of analysis, design, materials, component development and testing, coil fabrication, cryogenics, system integration and testing.

The newly commissioned 900 MHz wide bore nuclear magnetic resonance magnet: The results achieved so far surpass almost all expectations for this stage of the commissioning phase. *Credit: NHMFL*

The laboratory engages in numerous consortia as one of its mission objectives "to engage in the development of future magnet technology." NHMFL researchers and staff work with both academic and non-academic private partners in diverse areas of magnet technology. In 2003, the laboratory collaborated with 17 private sector companies, 13 national laboratories and federal centers, and 19 international institutions. In addition, the NHMFL has established numerous partnerships and programs to enhance science education and public awareness. The educational and outreach activity reaches nearly 9,000 students, teachers and members of the general public.

Management and Oversight: The NHMFL is operated for the NSF by a consortium of institutions comprised of Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL) under a cooperative agreement that sets forth the goals and objectives of the NHMFL. NSF established the NHMFL in 1990 and new facilities were dedicated and open to users in October 1994. FSU, as the signatory of the cooperative agreement, has the responsibility for establishing and maintaining appropriate administrative and financial oversight and for ensuring that the operations of the laboratory are of high quality and consistent with the broad objectives of the cooperative agreement.

The principal investigator serves as the director of the NHMFL. Four senior faculty members serve as co-principal investigators. The laboratory is organized into three functional activities: User Programs, Magnet Science and Technology Programs, and Research Programs. In addition, the NHMFL has an Office of Government and Public Relations that oversees corporate outreach activities, including interactions with private industry, federal agencies and institutions, and international organizations. The NHMFL also operates a Center for Integrating Research and Learning (CIRL) that manages educational outreach at all levels. Through the organizational network, the director receives guidance and recommendations from the NHMFL Executive Committee, staff, the participating institutions, and user communities. Two external committees meet regularly to provide the laboratory with critical advice on

important user, management, and operational issues. The Users' Committee, elected by the user community, reflects the broad range of users of all of the NHMFL facilities and provides guidance on the development and use of NHMFL facilities and services in support of users. The External Advisory Committee is comprised of representatives from academic, government, and industrial organizations, and from the user community and reports directly to the President of Florida State University. It provides advice and guidance on matters critical to the success of the management of the NHMFL.

From the inception of the NHMFL, NSF administration and oversight was the responsibility of the Executive Officer, Division of Materials Research (MPS), with guidance from an ad hoc working group with representatives from the Division of Chemistry (MPS), the Directorate for Engineering, and the Directorate for Biological Sciences. Site visit reviews are conducted annually. Representatives from other federal agencies including DOE and NIH are invited to participate as observers at the site visit reviews. In July 2002 a new position of Program Director, National Facilities, was established in the NSF Division of Materials Research (DMR). Primary responsibility for NSF administration and oversight of the NHMFL was then assigned to this position, together with similar responsibilities for DMR's other national facilities.

Current Project Status: The NHMFL was established in FY 1990. It is currently moving its primary emphasis from magnet technology and development to a new phase of service to users and research. A 5-year renewal proposal was reviewed in FY 2000. More than 300 groups currently use the NHMFL facilities annually, and the laboratory was described by the NSF external review committee as the leading institution of its kind in the world. The National Science Board (NSB) approved NSF support for the requested 5-year period (January 2001 through December 2005), making support for the final three years of the award contingent on satisfactory progress in the R&D program, management, and leadership of the Nuclear Magnetic Resonance program. A comprehensive NSF site visit review was conducted in May 2002; progress was assessed as satisfactory and the NSB was informed of the outcome of this review in October 2002. A subsequent annual review conducted in October 2003 recommended to continue tracking large, new magnet projects and to continue the process of commissioning the 900 MHz NMR magnet. The NHMFL continued its efforts to strengthen the NMR program. In FY 2004, NSF recommended and the NSB approved a two year extension with level funding moving the expiration date to FY 2007.

The FY 2006 Request for the NHMFL totals $25.50, the same level as the FY 2005 budget, as recommended by the NSB. This budget includes support for the National High Field Mass Spectrometry Facility (NHFMS) supported by the Division of Chemistry of MPS at the level of $1.50 million starting in FY 2005. The National High Field Mass Spectrometry (NHFMS) facility is located at the NHMFL in Tallahassee, Florida. Its purpose is to develop and exploit the unique capabilities of Fourier Transform Ion Cyclotron Resonance (FT-ICR) mass spectrometry. To that end, the NHFMS facility is routinely used to analyze samples that require the ultrahigh resolution and high mass accuracy of FT-ICR. Examples of the ultrahigh resolution provided by this technique include the precise identification of thousands of molecular components in complex biological, pharmaceutical, or petroleum samples.

Funding Profile: All NSF funding for the NHMFL to date has been provided through the R&RA Account.

NHMFL Funding Profile

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	6.20	13.80	$20.00
FY 2002	7.97	17.00	$24.97
FY 2003[1]	6.50	17.43	$23.93
FY 2004[1,2]	3.44	21.06	$24.50
FY 2005 Current Plan	3.83	21.67	$25.50
FY 2006 Request	4.00	21.50	$25.50
FY 2007 Estimate	4.00	21.65	$25.65
FY 2008 Estimate	4.00	22.00	$26.00
FY 2009 Estimate	4.00	22.00	$26.00
FY 2010 Estimate	4.00	22.00	$26.00

The data is presented as being either implementation (permanent equipment) or operations and maintenance (non-permanent equipment). Estimates for FY 2007 and beyond are developed for planning purposes and are based on current usage and cost profiles. They will be updated as new information becomes available.

[1]Excludes $183,272 in FY 2003 and $106,000 in FY 2004 for education activities such as the Research Experiences for Teachers Program.

[2]Data for FY 2004 through FY 2009 includes funding for the National High Field Mass Spectrometry Center (not included in FY 2003 at $990,000).

Information pertaining to the data in the table is included below.

- Implementation: The NHMFL supports a wide range of state-of-the-art magnets and instrumentation that are continuously upgraded for the user community. Capacitor driven magnets are the backbone of user programs at the Pulsed Field Facility at Los Alamos. Magnet Science and Technology has aggressively pursued several major magnet projects that are part of the NHMFL core mission: to develop world-class magnet systems for high field research. The Ultra-Wide Bore 900 MHz NMR magnet was successfully brought to field in the NMR building and preliminary solution and solid-state NMR spectra suggest that this will be a very powerful scientific tool for some of the most important items on the Nation's scientific agenda. The results have shown that the system has exceeded all expectations. It will be open to users in the Spring of 2005. There has been significant progress in the DC and pulse user magnet facilities towards field, bore, homogeneity and cooling time upgrades to the standard magnet systems. The Series-Connected Hybrid has been initiated and will provide combined high field and high homogeneity at lower power to the DC facility in a field-homogeneity parameter space never before available in the world, thereby providing copious unique scientific opportunities. Several collaborations were also completed in 2004 including a Sweeper magnet for the National Superconducting Cyclotron Laboratory, undulator magnets for the Advanced Photon Source at Argonne National Laboratories and quench protection of a crystal puller magnet for Duksung Corporation. In addition, the high temperature superconducting magnet and materials group, in collaboration with Oxford Superconducting Technologies, designed and built a high field 5 tesla insert coil and successfully tested it in the 20 tesla wide bore resistive magnet. World records for high field insert coils were established for current density in the high temperature superconducting (HTS) winding at high field, stored energy, peak mechanical stress, diameter in a layer-wound HTS coil, and the total number of turns.

The NHMFL's ICR Program successfully commissioned two FT-ICR mass spectrometers. A 14.5 T system is the highest field FT-ICR mass spectrometer in the world, and will be used to attack a broad range of biological, drug discovery, and petrochemical problems that require ultrahigh resolution and extremely accurate mass. A 7 T FT-ICR mass spectrometer is dedicated to analysis of volatile mixtures (e.g., low boiling fractions of crude oil) and FT-ICR instrumentation development

- Operations and Maintenance: These funds support the operation of the NHMFL, including magnet technology and development, support for user programs, in-house research, routine maintenance, instrumentation and technical services, and education and outreach programs. The increased level of maintenance and operations support that began in FY 2002 enabled the NHMFL to strengthen its programs for user support, equipment and facility maintenance, educational outreach and partnerships, and in-house research, and to meet increased costs for internal facilities and administration including electricity demand charges to operate high-field magnets. Research in the DC general-purpose facility is supported by eight scientists and an engineer whose specialties cover the kinds of measurements needed for most of the science done at the NHMFL and who work directly with users. In addition, the DC facility is supported by eight magnet plant and cryogenic system operators and mechanical, electronic, and computer engineers and technicians.

Renewal or Termination: The cooperative agreement for the support of NHMFL operations was to expire in FY 2005. In FY 2004, the NSB approved a two year extension at level funding, moving the expiration date to FY 2007. NSF plans are to consider support of the NHMFL either by renewal or to hold a recompetition. The decision will be based on the outcome of the recommendation of a blue ribbon panel and the National Academies study on High Magnetic Fields.

Associated Research and Education Activities: The NHMFL base award currently includes approximately $240,000 per year in support of Research Experiences for Undergraduates and a wide variety of pre-college educational outreach and partnership activities with additional funding from the State of Florida. Supplementary NSF funding of approximately $183,000 supports a Research Experiences for Teachers program for FY 2003 through FY 2005.

In FY 2004, educators at the Center for Integrating Research and Learning provided in-class educational experiences for 6,252 students from 34 schools in 9 counties and 3 states. In addition, tours of the NHMFL were provided to 970 members of the general public, with a total of over 8800 students, teachers, and the general public coming in contact with some facet of educational programs. The Center provided professional development opportunities for over 100 teachers through summer institutes, workshops, and conferences.

Participation in NHMFL Education Programs

Year	K-12	Undergrad[1]	Graduate[2]	Teachers[3]
FY 1994	1,200	8	N/A	3
FY 1995	1,515	10	N/A	9
FY 1996	3,990	16	N/A	30
FY 1997	4,075	18	19	255
FY 1998	4,080	18	15	547
FY 1999	7,100[a]	20	16	385
FY 2000	4,266	21	22	1,875[b]
FY 2001	3,959	17	20	1117
FY 2002	3,500	15	22	1319
FY 2003	6,841	21	19	226[c]
FY 2004	6,252	20	12	189

[1]Undergraduates participating in the Summer Minority Program and/or REU

[2]NHMFL-affiliated graduate students earning Ph.D.'s

[a]Statewide implementation of curriculum project in 1999.

[b]Teacher workshops extended to Connecticut and Illinois in 2000.

[c]State of Florida eliminated funding for "Science, Tobacco and You" Program.

In addition to the individuals depicted in the table above, the NHMFL also integrates undergraduate and graduate students and postdoctoral fellows into its ongoing research activities on a regular basis. For example, during 2003, the NHMFL at FSU supported an average of 86 graduate students, 29 postdocs, and 16 undergraduates through awards outside the NSF-NHMFL core funding, e.g., individual investigator grants, state funding, and external sources. The NHMFL is actively preparing and recruiting the next generation of high-field magnet scientists, engineers, and users.

Science Support: Users are supported by NSF, other Federal, state and local agencies, other national agencies, and the private sector. User projects and time are allocated by merit on a competitive basis. NSF does not track the level of user support from non-NSF sources. The laboratory serves more than 2,000 individuals annually.

National Nanofabrication Infrastructure Network

Project Description: The National Nanotechnology Infrastructure Network (NNIN) comprises 13 university sites that form an integrated national network of user facilities supporting research and education in nanoscale science, engineering, and technology. The NNIN provides users across the nation with access, both on-site and remotely, to leading-edge tools, instrumentation, and capabilities for fabrication, synthesis, characterization, design, simulation, and integration. The broad scope of NNIN coverage includes areas of physics, chemistry, materials, mechanical systems, geosciences, biology, life sciences, electronics, optics, molecular synthesis, and molecular scale devices, among others. The NNIN expands significantly beyond the capabilities of the predecessor five-university National Nanofabrication Users Network (NNUN), which concluded after ten years of NSF support at the end of 2003.

Principal Scientific Goals: The NNIN's broad-based national user facilities enable the nation's researchers from academia, small and large industry, and government to pursue new discoveries and applications in diverse domains of nanoscale science and engineering, and help stimulate technological

innovation. The network also develops the infrastructure and intellectual and institutional capacity needed to examine and address societal and ethical implications of nanotechnology, including issues of environment, health, and safety.

Principal Educational and Outreach Goals: The NNIN undertakes on a national scale a broad spectrum of innovative activities in education, human resource development, knowledge transfer, and outreach, with special emphasis on non-traditional users and under-represented groups, including women and minorities.

Partnerships and Connections to Industry: The NNIN seeks to leverage its capabilities through connections and collaborations with national and industrial laboratories, and with foreign institutions. Through such partnerships and joint meetings and workshops, the network will share expertise and perspectives, provide specialized training opportunities, coordinate access to unique instrumentation, and transfer newly developed technologies.

Management and Oversight: The NNIN is managed as a cohesive and flexible network partnership through a Network Executive Committee derived from the individual Site Directors, and the Education/Outreach and Society/Ethics Coordinators. The Network Director provides intellectual leadership for the network; is responsible, in cooperation with the Network Executive Committee, for developing strategies, operational plans, and coordination of the activities of the network; and serves as the principal contact on behalf of the network with the NSF. An external Network Advisory Board meets at least annually and provides independent advice and guidance to the Network Director and Executive Committee concerning the network's programs, activities, vision, funding allocations, and new directions. The Advisory Board shares its major recommendations with the NSF. The Site Directors are responsible for local management functions of the individual user facilities, for interfacing with other facilities and with the management team for the overall network, and for connections with the outside communities.

NSF provides oversight to the NNIN under a cooperative agreement. The NNIN is reviewed through annual site reviews held at one of the network sites. In addition, a semi-annual review is held at the NSF attended by the Network Director and Executive Committee members. The program officer for the NNIN activity resides in the Division of Electrical and Communications Systems in the Directorate for Engineering (ENG). The program officer coordinates NNIN oversight with other Division and Directorate members of the NNIN working group. The working group consists of representatives from all NSF Directorates.

Current Project Status: The NNIN began operation under its award on March 1, 2004. The first comprehensive annual review of the NNIN was held following an initial 9 months of operation at the Georgia Tech node in December 2004. In part due to continuity provided by the five sites in the previous NNUN, and to the credit of the NNIN management team, the network already displays many of the attributes promised in the original vision from the proposal: a broad area of accessible micro- and nano-fabrication and characterization resources; a solid base of users with a significant representation from outside the host institutions including industrial and educational users; a strong research portfolio generated by the user community; positive initial performance at new sites with good plans in place to make them fully functioning nodes with solid user bases, including external users; and network-wide plans and efforts underway on educational outreach and societal and ethical implications of nanotechnology.

Funding Profile: The first year of funding in FY 2004 was $13.80 million. The FY 2006 Request is $13.90 million, level with the FY 2005 Current Plan. Primary funding for NNIN is provided by ENG; additional funding is provided by all the Directorates in the Research and Related Activities Account. The Directorate for Education and Human Resources provides support for NNIN in the amount of $200,000.

NNIN Funding Profile
(Dollars in Millions)

	Implementation	Operations & Maintenance[1]	Total, NSF
FY 2004		13.80	$13.80
FY 2005 Current Plan		13.90	$13.90
FY 2006 Request		13.90	$13.90
FY 2007 Estimate		16.10	$16.10
FY 2008 Estimate		18.50	$18.50
FY 2009 Estimate		20.30	$20.30
FY 2010 Estimate		20.81	$20.81

[1]Data in FY 2004-2006 does not include $200,000 provided through the Advanced Technological Education program in the Directorate for Education and Human Resources. Estimates for FY 2007 and beyond are developed strictly for planning purposes and are based on current usage and cost profiles. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Management and Operations: The major portion of NSF funds provides for operation and staffing of the user facilities and associated network activities. They also provide for acquisition and for in-house development of appropriate instrumentation, tools, and processes to serve the user needs. NSF may provide up to a 15 percent annual increase in budget beginning in FY 2007 should there be a need to cover anticipated growth in the user base, with related increased education, training and staffing costs; and enhanced instrumentation. NNIN has provided cumulative user data for its initial reporting year of 2004, which covers the 10-month period from the beginning of operation on March 1, 2004 to December 31, 2004. The cumulative number of users for all 13 NNIN sites is 3,479. This includes 2,914 academic users, 519 industrial users, and 46 government/international users.

Renewal or Termination: The award may be renewed once, without re-competition, for an additional five years, subject to satisfactory review of performance and availability of funds. The maximum duration of the award is for ten years.

Associated Research and Education Activities: The institutions comprising the NNIN have strong underlying internal research programs that provide critical research mass and knowledge base in developing new processes, methodologies, and instrumentation. Planned and ongoing NNIN educational contributions include a hyperlinked open textbook on nanotechnology for undergraduate and graduate students, a science magazine designed to stimulate and challenge 6-10 years olds to explore the physical sciences, a web-based multimedia suite encompassing training and courses for various disciplines in nanoscale science and engineering, and a network-wide research experience for undergraduates (REU) program. In its first year of the REU program, 72 students were accepted, of which 37 percent were female and 14 percent were minority. In FY 2005, the number of REU students will increase to 100.

Science Support: NSF and other agencies independently award research grants to principal investigators who may use the NNIN facilities to carry out some aspects of their research projects.

National Superconducting Cyclotron Laboratory

Project Description: This project supports the operation of the NSCL at Michigan State University (MSU) as a national user facility and also supports the MSU research program. The NSCL is the leading rare isotope research facility in the United States. NSCL scientists and researchers employ a wide range of tools for conducting advanced research in fundamental nuclear science, nuclear astrophysics, and accelerator physics. Important applications of the research conducted at the NSCL benefit society in numerous areas, including new tools for radiation treatments of cancer patients and the assessment of health risks to astronauts. The NSCL began operations of the coupled cyclotron radioactive beam facility in FY 2002, providing users with unique access to beams of unstable nuclei. The NSCL is among the world leaders in heavy ion nuclear physics and nuclear physics with radioactive beams.

The NSCL operates two superconducting cyclotrons. The K500 was the first cyclotron to use superconducting magnets, and the K1200 is the highest-energy continuous beam accelerator in the world. These and other related devices have enabled researchers to learn more about the origins of the elements in the cosmos. Through the newly completed Coupled Cyclotron Facility (CCF), heavy ions are accelerated by the K500 and then injected into the K1200, enabling the production of rare unstable isotopes at much higher intensities.

Principal Scientific Goals: Scientists at the NSCL work at the forefront of rare isotope research. They make and study atomic nuclei that cannot be found on earth and perform experimental research using beams of unstable isotopes to extend our knowledge of new types of nuclei, many of which are important to an understanding of stellar processes. Research activities include a broad program in nuclear astrophysics studies, the studies of nuclei far from stability using radioactive ion beams, and studies of the nuclear equation of state. In addition, research is carried out in accelerator physics.

Principal Education Goals: NSCL supports and enhances Ph.D. level graduate education and post-doctoral research experience. In addition, the site provides research experiences for undergraduate students, as well as training for K-12 teachers.

Partnerships and Connections to Industry: NSCL occasionally enters into license agreements with industry for cyclotron technology or nuclear electronics. A specific license agreement with Accel Corporation exists for compact cyclotrons based on superconducting technology.

Management and Oversight: The NSCL is managed by the Laboratory Director and two Associate Directors: one for Nuclear Science and one for Accelerator Research. During the NSCL upgrade, NSF convened several technical panels to review cost, schedule, technical progress, and management of the project. The NSCL research program is guided by a Program Advisory Committee consisting of external experts as well as an in-house expert, and includes the chairperson of the full NSCL User Group. The procedure for users includes writing and submitting proposals to the NSCL Director and oral presentations. There are two opportunities for proposal submission each year. Approximately 5,000 beam hours for experiments are provided each year. There is generally at least a one-year backlog for experiments. NSF oversight is provided through annual site visits by the cognizant program officer of the Physics Division (MPS) and other staff, accompanied by external experts.

Current Project Status: An experimental program using the recently completed coupled cyclotron facility is now underway. The FY 2006 Request for the NSCL totals $17.50 million, level with the plan of $17.50 million for FY 2005. This will support operations and research at this unique radioactive ion beam facility.

Funding Profile: All funding for NSCL to date has been provided through the R&RA Account.

NSCL Funding Profile
(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	1.00	11.40	$12.40
FY 2002	0.40	14.41	$14.81
FY 2003		15.65	$15.65
FY 2004		15.65	$15.65
FY 2005 Current Plan		17.50	$17.50
FY 2006 Request		17.50	$17.50
FY 2007 Estimate		17.94	$17.94
FY 2008 Estimate		17.94	$17.94
FY 2009 Estimate		17.94	$17.94
FY 2010 Estimate		17.94	$17.94

The current Cooperative Agreement expires in FY 2006. Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Implementation: The facility was recently upgraded to couple two superconducting cyclotrons and to upgrade the fragment separator to produce intense beams of unstable isotopes providing a facility unique in the world. This recent upgrade of the NSCL to the coupled cyclotron facility was accomplished using $12.0 million in incremental funding from the NSF and over $6.0 million from MSU. In addition, $4.0 million was provided to upgrade the cryogenic plant.

- Operations and Maintenance: Funding within this category supports the operation of the facility. Such activities include routine preventive maintenance of the two coupled NSCL cyclotrons, including vacuum systems, RF power systems, beam transport systems, the helium refrigerator used to supply coolant for the superconducting cyclotrons, and miscellaneous subsystems, are carried out each quarter. Approximately 25 percent of the funding is directed toward in-house research (both experimental nuclear science and accelerator research & development) with the remainder used to operate and maintain the facility. The facility serves several hundred active users.

Renewal or Termination: The current cooperative agreement expires at the end of FY 2006. NSF expects to consider a proposal to renew the agreement at that time pending a satisfactory performance review.

Associated Research and Education Activities: The figures shown in the table below are for high school teachers and students participating in the NSCL Physics of Atomic Nuclei (PAN) program. This is a two-week summer program sponsored by MSU with the objective to stimulate an interest in science, particularly in female and minority students.

Participants in the NSCL Physics of Atomic Nuclei (PAN) Program

Year	HS Teachers	HS Students
1995	8	33
1996	8	34
1997	15	30
1998	9	23
1999	13	25
2000	12	21
2001	13	21
2002	12	21
2003	4	15
2004	7	13

Science Support: Theoretical nuclear physics research at the NSCL is separately supported by annual grants totaling approximately $500,000. Additionally, in several recent years Major Research Instrumentation grants have been awarded which have permitted construction of detectors and other equipment important to the operation of the laboratory as a user facility.

George E. Brown Jr. Network for Earthquake Engineering Simulation

Project Description: NEES is a national, networked simulation resource of fifteen geographically distributed, shared use next-generation experimental research equipment sites with teleobservation and teleoperation capabilities. NEES provides national resources to advance earthquake engineering research and education through collaborative and integrated experimentation, computation, theory, databases, and model-based simulation to improve the seismic design and performance of U.S. civil infrastructure systems. Research equipment includes shake tables, geotechnical centrifuges, a tsunami wave basin, large-scale laboratory experimentation systems, and mobile and permanently installed field equipment. NEES equipment is located at academic institutions (or at off-campus field sites) throughout the United States, networked together through a high performance Internet2 cyberinfrastructure system. NEES completed construction on September 30, 2004 and opened for user research and education projects on October 1, 2004. Between FY 2005 and FY 2014, NEES will be operated by the non-profit corporation NEES Consortium, Inc. (NEESinc), located in Davis, California. Through a cooperative agreement with NSF, NEESinc operates the 15 equipment sites; the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships.

Principal Scientific Goals: NEES' broad-based national research equipment and cyberinfrastructure will enhance understanding and provide more comprehensive, complete, and accurate models of how civil infrastructure systems respond to earthquake loading (site response, soil-foundation-structure interaction, tsunami effects, and structural and nonstructural response). This will enable the design of new methods, modeling techniques, and technologies for earthquake hazard mitigation.

Principal Education Goals: NEES engages engineering, science, and other students in earthquake engineering discovery through on-site use of experimental facilities, telepresence technology, archival experimental and analytical data, and computational resources with the aim of integrating research and education. NEES has developed an education, outreach and training strategic plan to develop a broad spectrum of education and human resource development activities with special emphasis on non-traditional users and underrepresented groups.

Partnerships and Connections to Industry: Through the Congressionally mandated National Earthquake Hazards Reduction Program (NEHRP), the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), NSF, and the U.S. Geological Survey (USGS) participate to support research related to earthquake hazard mitigation. Connections to industry include private engineering consultants and engineering firms engaging in NEES research or using data and models developed through NEES. NEES is leveraging and complementing its capabilities through connections and collaborations with large testing facilities at foreign earthquake-related centers, laboratories, and institutions. Through such partnerships and joint meetings and workshops, NEES shares its expertise in testing and cyberinfrastructure, provides specialized training opportunities, and coordinates access to unique testing facilities and the central data repository.

The NEES Tsunami Wave Basin is pictured above. Located at Oregon State University, it is the world's largest shared-use research facility for the study of effects of tsunami inundation on coastal buildings and lifeline infrastructures. A solition (or solitary wave) is being demonstrated in this photo. *Credit: Kelly James, Oregon State*

Management and Oversight: Through a NSF cooperative agreement, NEES Consortium, Inc. (NEESinc) operates the 15 equipment sites and the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships. As a non-profit corporation, NEESinc operates under its own governance structure and is overseen by a Board of Directors elected from its membership in accordance with its by-laws. Day-to-day operations of NEESinc is overseen by its headquarters staff that is led by an Executive Director. Each equipment site has a facility director responsible for local day-to-day equipment management, operations, and interface with NEESinc, other NEES equipment sites, users, and the NEES cyberinfrastructure center for network coordination. The NEES cyberinfrastructure center maintains the telepresence, data, collaborative, simulation, and other related services for the entire NEES network.

NSF provides oversight to NEES under a cooperative agreement. NEES is reviewed through annual site visits. The NSF Program Manager for NEES is located in the Civil and Mechanical Systems (CMS) Division in the Directorate for Engineering (ENG). The NSF Deputy for Large Facility Projects provides advice and assistance.

Current Project Status: NEES completed its primary construction activities at the end of FY 2004. About $2.7 million in remaining FY 2004 MREFC funds were used to fund construction of deferred capabilities for NEES during FY 2005. This included four new capabilities for system integration (cyberinfrastructure) and new capabilities at 13 equipment sites. These activities will be completed by September 30, 2005. NEES opened for user research and education projects on October 1, 2004, under the management of NEESinc. Commensurate with opening, the first round of research awards were made by NSF in September/October 2004 to use the NEES facilities. Through a NSF cooperative agreement, NEESinc operates the 15 equipment sites and the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships. The NEES tsunami wave basin provides a national resource to calibrate and validate tsunami propagation and inundation modeling tools, model inundation patterns to understand where the threat is most significant,

and develop design criteria for coastal community shelters and other critical facilities. Researchers at this facility participated on a post-tsunami rapid-response reconnaissance team with respect to the 26 December 2004 Indian Ocean earthquake.

Funding Profile: NSF received $7.70 million in FY 2000 to initiate construction of NEES. Total MREFC funding for this project was $81.76 million during FY 2000-04, with an additional $1.10 million provided to the project through the Education and Human Resources (EHR) Account.

Appropriated and Requested MREFC Funds for NEES

(Dollars in Millions)

FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Total
$7.70	$28.14	$24.40	$13.47	$8.05	$81.76

NEES Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation			Operations & Maintenance		Totals			**Grand**
	R&RA	MREFC	R&RA	MREFC	EHR	R&RA	MREFC	R&RA	MREFC	EHR	**Total**
FY 1998 & Earlier	0.26							$0.26			**0.26**
FY 1999											
FY 2000		0.36		7.34					$7.70		**7.70**
FY 2001	0.44	0.03		28.11	1.10			$0.44	$28.14	$1.10	**29.68**
FY 2002				24.40					$24.40		**24.40**
FY 2003				13.47					$13.47		**13.47**
FY 2004				8.05					$8.05		**8.05**
FY 2005 Plan						19.54		$19.54			**19.54**
FY 2006 Request						20.52		$20.52			**20.52**
FY 2007 Estimate						21.27		$21.27			**21.27**
FY 2008 Estimate						22.17		$22.17			**22.17**
FY 2009 Estimate						23.02		$23.02			**23.02**
FY 2010 Estimate						23.60		$23.60			**23.60**
Subtotal, R&RA	$0.70					$130.12		$130.82			
Subtotal, MREFC		$0.39		$81.37					$81.76		
Subtotal, EHR					$1.10					$1.10	
Total, Each Stage		**$1.09**		**$81.37**			**$130.12**				**$213.68**

NOTE: The expected operational lifespan of this project is 10 years, from FY 2005 to FY 2014. NEES operations for FY 2005 – FY 2009 was approved by the National Science Board in May 2004 for up to $106.52 million total; approximately $21.3 million annually. Operations estimates for FY 2007 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

Information pertaining to the data in the table is provided below.

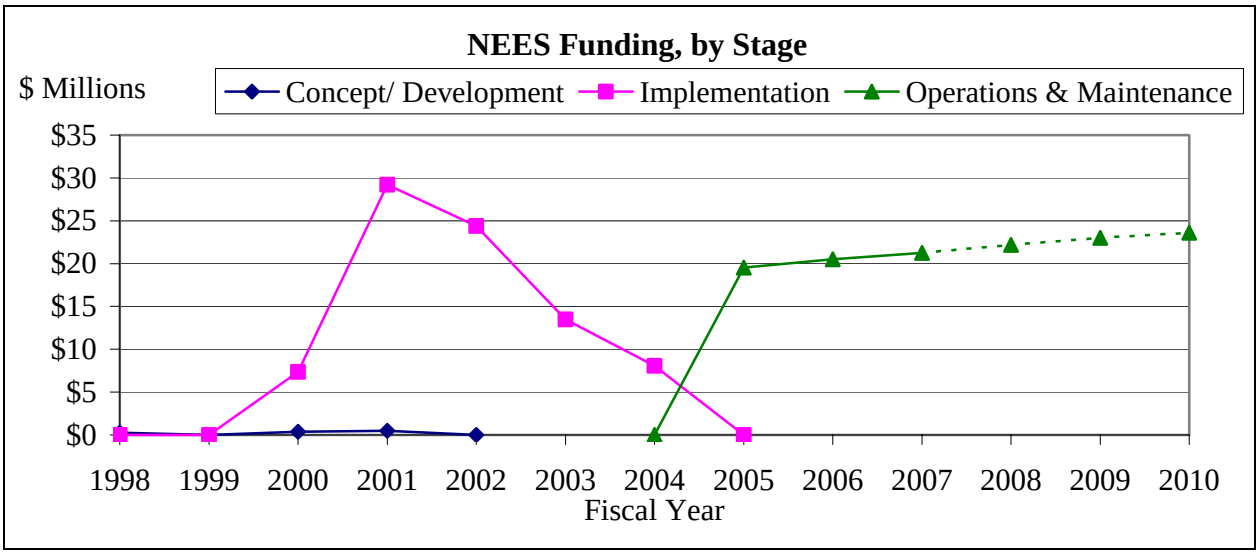
- Concept/Development: R&RA support for planning, design and development included early workshops on experimental needs of the earthquake engineering community and on refinement of ideas for experimental systems in FY 1995 and FY 1998. During this period, the community also developed an action plan at NSF's invitation. Additional R&RA support focused on an international workshop to foster long term working relationships for experimental earthquake

engineering research and national workshops and study to develop long-term NEES research concepts and plans (FY 2001). MREFC funds supported planning, design and development specifically for a scoping study of the NEES network system (user and system architecture requirements), including a community workshop for broader input on user requirements prior to the full system integration award being made by NSF.

- Implementation: MREFC funds during this phase support a range of equipment acquisition, as well as system integration and consortium development. To encourage the broadest participation for establishment of geographically distributed NEES equipment sites, the FY 2000 competitive program solicitation for NEES research equipment specifically encouraged participation from EPSCoR states. As a result of the merit review process, one award was made to an institution from an EPSCoR state for which the EPSCoR program provided partial funding through the EHR account in FY 2001.

- Operations and Maintenance: With completion of the construction period in FY 2004, NEES has now entered its 10-year operational period through FY 2014 and is managed by NEES Consortium, Inc. NEES Consortium, Inc., provides the leadership, management, and coordination for all the NEES resources and will establish a broad and integrated partnership that includes participation of the full membership of the earthquake engineering community, both within the U.S. and abroad.

As an Internet-based resource, access to the NEES network is 24/7 to anyone with Internet capabilities. The NEES experimental facilities are expected to be fully utilized annually as shared use research sites coordinated by NEES Consortium, Inc., and for research by personnel at the host institutions. NEES experimental resources and data are expected to be used annually by approximately 1000 U.S. researchers and students.



Future Science Support: Along with direct operations and maintenance support for NEES, NSF provides support for research performed at NEES equipment sites through ongoing research and education programs. The NEES cyberinfrastructure also provides a platform for the earthquake engineering community as well as other communities to develop new tools for shared cyberinfrastructure. In addition, NSF has initiated grand challenge, small group, and individual investigator research projects that will

utilize a number of NEES experimental sites, data, and computational resources to comprehensively address major research questions in earthquake engineering and seismic hazard mitigation. The annual support for such activities is estimated to be about $9.0 million annually.

Shared Cyberinfrastructure Tools

Project Description: In FY 2006, NSF will continue to provide support for shared cyberinfrastructure tools. Activities included in shared cyberinfrastructure tools enable the national community to access high-end computing, communications, networking, data storage, and information analysis resources, and complement other shared cyberinfrastructure investments made by the agency. Funding supports the provision of services that provide for the effective use of cyberinfrastructure resources by researchers and educators nationwide. NSF's coordinated investments in this area are facilitating development of technology and policy platforms that will provide for interoperability across science and engineering fields and across organizational, regional and national boundaries. Shared cyberinfrastructure tools build on the successes of the prior Partnerships for Advanced Computational Infrastructure (PACI), and incorporate the agency's ongoing investments in the Extensible Terascale Facility (ETF).

Principal Scientific Goals: Information technology has had widespread impact on science and engineering – simulation and modeling are now as important to discovery as theory and experimentation, advances in sensor technology and the availability of affordable mass data storage devices are making possible the collection, creation and federation of large complex datasets, and pervasive networking technology is enriching collaborations and providing broad access to a multitude of scientific resources. NSF continues to capitalize on the science and engineering opportunities provided by advances in information technology through support of a shared cyberinfrastructure that enriches discovery, learning and innovation in all science and engineering domains. Shared cyberinfrastructure tools activities support and/or integrate a diverse set of advanced computing engines, data archives and digital libraries, observing and sensor systems, and other research and education instrumentation that are critical to the work of the nation's science and engineering researchers and educators.

Principal Education Goals: NSF seeks to ensure that the broadest range of individuals, institutions and stakeholder communities are participating in the design, development, deployment and/or use of shared cyberinfrastructure tools. In FY 2006, the agency will support new efforts to prepare current and future generations of scientists and engineers to use, develop and support cyberinfrastructure as described in the CISE sub-chapter.

Partnerships and Connections to Industry: Cyberinfrastructure is by definition a partnership activity and involves a large number of academic, industry and government partner organizations, both foreign and domestic. NSF-supported shared cyberinfrastructure partners have enjoyed industrial strategic partnerships with Fortune 500 Companies, including Allstate Insurance Company; the Boeing Company; Caterpillar Inc.; Eastman Kodak Company; J. P. Morgan; Kellogg Company; Motorola, Inc.; Sears; Shell Oil Company; Arena Pharmaceuticals; BAE Systems; Brocade; Ceres, Inc; Computer Science Corp.; Pfizer; JVC; Lockheed Martin; and ESRI. They also have had strategic technology partnerships with a number of companies including ANSYS, Inc., Compaq (now Hewlett Packard), Cray Inc., IBM, Informix Corp., Intel, Microsoft Corp., Oracle, Qwest, SGI, Storage Tek, and Sun Microsystems.

Management and Oversight: NSF awards for support of shared cyberinfrastructure tools are made through cooperative agreements and grants. Investments in national supercomputing resources are being made through cooperative agreements with the National Center for Supercomputing Applications (NCSA), the San Diego Supercomputing Center (SDSC), the Pittsburgh Supercomputing Center (PSC), the Texas Advanced Computing Center (TACC) and other partner institutions in the Extensible Terascale

Facility. With upgrades in supercomputing capacity completed during FY 2004 and ongoing in FY 2005, NSF will double the computing cycles made available to the national science and engineering community. The National Resource Allocation Committee (NRAC) meets semi-annually to review and make recommendations on large supercomputing resource requests. In recognition of the expanding definition of cyberinfrastructure, during FY 2005 the NRAC process is being modified to include allocation of other shared cyberinfrastructure resources, with compute cycles no longer likely to be the only resources allocated. Cooperative agreement awardees submit annual reports and plans that are reviewed by committees of experts external to NSF. Committee recommendations are acted upon by the cognizant NSF program officer and reviewed by the Division Director. A Cyberinfrastructure User Advisory Committee (CUAC) is currently being established to provide input to NSF's shared cyberinfrastructure partners on the needs of the broad user community.

Current Status: The FY 2006 Request for shared cyberinfrastructure tools totals $114 million, out of a total of $176 million allocated to all shared cyberinfrastructure. Other activities reported as shared cyberinfrastructure but not included as "shared cyberinfrastructure tools" include workforce development activities and research to inform the development of information integration tools to manage scientific data.

Funding Profile: All funds for the operations and maintenance of shared cyberinfrastructure tools are being provided through the R&RA Account in CISE/SCI. In the past, NSF's main investments in shared cyberinfrastructure tools were made through the Partnerships for Advanced Computational Infrastructure (PACI), as described below.

Shared Cyberinfrastructure Funding Profile[1,2]

(Dollars in Millions)

	Implementation	Management, Operations & Maintenance	Total, NSF
FY 1998	21.30	38.80	$60.10
FY 1999	23.90	45.60	$69.50
FY 2000	27.20	42.80	$70.00
FY 2001	21.90	51.40	$73.30
FY 2002	25.90	49.37	$75.27
FY 2003	25.00	48.24	$73.24
FY 2004	30.50	80.16	$110.66
FY 2005 Current Plan	12.14	108.62	$120.76
FY 2006 Request	19.00	95.00	$114.00

[1]Funding for FY 1998 through FY 2004 represents fuding provided through the Partnerships for Advanced Computational Infrastructure (PACI) program.

[2]Funds provided in FY 2000-FY 2004 through the MREFC Account for Terascale Computing Systems are not included.

Information pertaining to the data in the table is provided below.

- Implementation: Concept planning for PACI was done in the 1995 to 1997 time frame. The PACI activity evolved between 1997 and 2003, in part due to continuing advances in IT and the national community's needs for access to advanced IT resources. Contributions made by PACI helped inform development of the shared cyberinfrastructure tools activity. The 2003 report of the NSF Advisory

Committee for Cyberinfrastructure is also informing the agency's plans for shared cyberinfrastructure tools. Implementation in the context of shared cyberinfrastructure tools includes acquisition and deployment of cyberinfrastructure hardware, such as high-end computing systems. In FY 2006, funds available will provide for selective cyberinfrastructure enhancements identified through an ongoing process being developed within NSF to identify agency-wide priorities.

- Management, Operations and Maintenance: The Management, Operations and Maintenance data describes support for IT professionals, the development and support of software tools, and the provision of networking infrastructure to ensure that effective cyberinfrastructure services are available to the national user community.

Renewal or Termination: With the conclusion of PACI, revised cooperative agreements with NCSA and SDSC have been developed to ensure the continuing provision of high-end computing resources and related services to the national community. These cooperative agreements extend through the end of FY 2007. Complementing the resources and services provided by NCSA and SDSC, in FY 2005 and beyond the Extensible Terascale Facility will provide cyberinfrastructure services to advance science and engineering research and education. The management and operations of the Extensible Terascale Facility will be funded in cooperative agreements extending through FY 2009. During FY 2005 and FY 2006, NSF will work with the national science and engineering community and its shared cyberinfrastructure partners in the development of a plan that will guide the agency's future implementation investments.

Associated Education Activities: To take advantage of the power of cyberinfrastructure and its potential to transform science and engineering research and education, NSF will expand the CI-TEAM program established in FY 2005 to prepare current and future generations of scientists and engineers to effectively leverage cyberinfrastructure to further their research and education agendas. The CI-TEAM activity builds upon the successes of PACI-EOT activities.

Science Support: Leading-edge shared cyberinfrastructure resources serve many areas of scientific and engineering research supported by the NSF. Annual support for research and education projects that take advantage of shared cyberinfrastructure tools is modestly estimated to be $200 million.

NSF's investments in the development and provision of shared cyberinfrastructure services and tools are made in partnership with a number of organizations around the nation, reflecting the pervasive impact of information technology and the growing capabilities and expertise now resident in a larger number of organizations. As such, the agency's investments in shared cyberinfrastructure tools are no longer best characterized as "facilities" investments. Consequently, in FY 2007 and beyond NSF will report its investments in shared cyberinfrastructure tools as Infrastructure and Instrumentation.

Terascale Computing Systems

Project Description: The NSF Terascale Computing Systems project funded the construction of the Extensible Terascale Facility (ETF). ETF, also commonly known as the Teragrid, provides the broad-based academic science and engineering community with access to scalable, balanced, terascale computing resources, including two 10+ teraflops supercomputing systems (one at the National Center for Supercomputing Applications and one scheduled to come on line in the spring of 2005 at the Pittsburgh Supercomputing Center) and over 35 teraflops across the ETF. Users also have access to at least 500 terabytes of storage at a single site (at the San Diego Supercomputing Center) and nearly 1 petabyte across the ETF. Using ETF, researchers and educators are able to conduct analyses at unprecedented scale, to merge multiple data resources seamlessly, and to advance discovery at the frontiers of science and engineering.

Principal Scientific Goals: To provide state-of-the-art cyberinfrastructure capabilities that position the nation's researchers and educators to address a broad range of state-of-the-art problems, including those commonly referred to as "grand challenge" problems, across all science and engineering fields. ETF's distributed architecture permits the seamless integration of large, managed scientific data archives; high-performance computational resources available within ETF can be used to mine, analyze, visualize, and perform related simulations on these data.

Principal Education Goals: To provide current and future generations of scientists and engineers with access to unique, state-of-the-art cyberinfrastructure that promises to advance discovery, learning and innovation across all fields.

Partnerships and Connections to Industry: Several companies have served as partners in the construction of ETF. Primary industrial partners include Cray, Force 10, Hewlett Packard, IBM, Intel, Juniper, Oracle, Qwest, and SUN Microsystems.

Management and Oversight: Management and oversight of this project is provided by a Program Director in the Shared Cyberinfrastructure (SCI) Division of the Directorate for Computer and Information Science and Engineering (CISE). An NSF Project Advisory Team (PAT) consisting of representatives from several NSF Directorates and Offices has also provided oversight. The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. During the construction phase, an external Technical Advisory Panel made periodic site visits to the ETF partner institutions to review construction progress and provide technical advice to the Program Director. The Technical Advisory Panel participated in resolution of major technical, managerial, or scheduling concerns; provided technical guidance/advice, especially with regard to the integration and coordination with other SCI-funded program activities; and reviewed and, where required, approved technical reports and information to be delivered by the awardees. The NSF Project Advisory Team will continue to assist the Program Director with management and oversight of ETF.

With the October 1, 2004 initiation of the operations phase of ETF, a new ETF management structure is being put in place. It consists of a single integrative activity, termed the Teragrid Grid Infrastructure Group (GIG), and nine coordinated resource provider (RP) activities, one at each of the nine participating sites. The GIG is designed with a single Project Director, supported by four technical Area Directors, a Program Manager and Science Coordinator, and an Executive Steering Committee. Each RP participates in a TeraGrid-wide Resource Provider Forum and participates in TeraGrid-wide operational structures of the GIG in areas such as coordinated operations, allocations, and security. All ten awardees, both the GIG and the nine RPs, report directly to a single NSF Program Director. A Cyberinfrastructure User Advisory Committee (CUAC) is currently being established to provide input to ETF and NSF's other shared cyberinfrastructure partners on the needs of the broad user community.

Current Project Status: The ETF construction phase was completed on September 30, 2004; ETF resources began allocated usage as part of "early operations" in October 2004. Allocations for ETF were included, for example, in the National Resource Allocation Committee's September 2004 allocations. The full operations phase for ETF is scheduled to begin in the spring of 2005.

Funding Profile: ETF was created through a coordinated series of investments as follows:

- In FY 2000, the Pittsburgh Supercomputing Center (PSC) built a Terascale Computing System (TCS) with peak performance of 6 teraflops.
- The Distributed Terascale Facility (DTF) was initiated in FY 2001 by a partnership including the National Center for Supercomputing Applications, the San Diego Supercomputer Center, Argonne

National Laboratory and the California Institute of Technology. Based on multiple Linux clusters, DTF linked its sites through a high-performance "DTF backplane".

- In FY 2002 NSF provided funding to enhance the TCS and DTF and initiated the creation of the ETF by extending the "DTF backplane" to TCS and by placing extensible hubs in Chicago and Los Angeles that permitted further expansion of this new distributed facility.
- In FY 2003 NSF made awards to extend the ETF to four additional sites - Indiana University, Purdue University, Oak Ridge National Laboratory, and the Texas Advanced Computing Center at the University of Texas at Austin. Via high-speed network connections, the Spallation Neutron Source at ORNL and other unique computational and data resources in Indiana and Texas were integrated into ETF for use by the nation's research and education community.
- In FY 2004, PSC received an award to acquire a 10 teraflops Cray Red Storm capability system that has the potential to be scalable to 150 teraflops. This acquisition constituted the final award funded from the MREFC account, Terascale Computing Systems.

Appropriated MREFC Funds for Terascale Computing Systems

(Dollars in Millions)

FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Total
$36.00	$44.90	$35.00	$9.94	$10.05	$135.89

ETF entered its operations phase on schedule in October 2004. A summary of the funding profile from FY 2000 through FY 2004 is provided below.

Terascale Computing Systems Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance[3]		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 1998	0.06						$0.06		**0.06**
FY 1999									
FY 2000				36.00				$36.00	**36.00**
FY 2001				44.90	2.37		$2.37	$44.90	**47.27**
FY 2002[1]					7.06		$7.06		**7.06**
FY 2003				44.94	11.17		$11.17	$44.94	**56.11**
FY 2004[2]				10.05				$10.05	**10.05**
Subtotal, R&RA	$0.06				$20.60		$20.66		
Subtotal, MREFC				$135.89				$135.89	
Total, Each Stage		**$0.06**		**$135.89**		**$20.60**			**$156.55**

[1]FY 2002 MREFC funding for Terascale was carried over into FY 2003 due to the NSB meeting schedule.

[2]FY 2004 funding includes implementation funds totaling $110,000 carried over from FY 2003.

For further information on shared cyberinfrastructure facilities and tools, please refer to the Shared Cyberinfrastructure section of this chapter.

Information pertaining to the data in the table is provided below.

- Concept/Development: Planning for the Terascale Computing Systems MREFC project began in 1998, with a series of three workshops held at NSF to assess the need within the academic research community for computational resources with multi-teraflop capability.

- Implementation: TCS was funded at Pittsburgh Supercomputing Center in FY 2000. It was fully operational in the first quarter of 2002. Funding for DTF was provided to the San Diego Supercomputing Center and the National Center for Supercomputing Applications in FY 2001. Construction of DTF continued through FY 2003. Funds in FY 2002 were used to enhance and augment TCS and DTF, fully integrate TCS and DTF into a single grid-enabled facility, and enable the DTF to extend beyond the five initial sites. ETF was thereby created. Funds in FY 2003 supported connections to four additional ETF sites. Funds in FY 2004 were used to acquire a prototype 10 teraflops capability system at the Pittsburgh Supercomputing Center.

- Management and Operations: The ETF facility incurred operations costs of approximately $10 million in FY 2004. Management and operations costs in FY 2005 and FY 2006 are estimated to be $30 million, as ETF enters its full management and operations phase. Estimates for FY 2007 and beyond are developed for planning purposes and are based on current cost profiles.

Future Science Support: NSF will support science and engineering research and education enabled by ETF through ongoing research and education programs. Annual support for research and education using the ETF is estimated to be about $200 million.

Other Facilities

Other Facilities support, $39.62 million in FY 2006, includes continued support for the Network for Computational Nanotechnology (NCN), which focuses on modeling and simulation of chemical, biological and pharmaceutical systems, and the continued phase-out of program and contract activities for the Ocean Drilling Program. Other items within this category include facilities for computational sciences, physics, materials research, ocean sciences, atmospheric sciences, and earth sciences.

POLAR FACILITIES AND LOGISTICS[3]

Antarctic Facilities and Operations

Project Description: Antarctic Facilities and Operations provide the basic infrastructure and transportation support for all U.S. research conducted in Antarctica, including that funded by U.S. mission agencies, for year-round work at three U.S. stations, two research ships, and a variety of remote field camps. All life support is provided by NSF, including facilities infrastructure, communications, and utilities (water and power), and health and safety infrastructure.

Principal Scientific Goals: Antarctic Facilities and Operations provides science support in Antarctica, ranging from astrophysics to microbiology and climatology; provides environmental stewardship, and maintains U.S. presence in Antarctica in accord with U.S. policy.

[3] The South Pole Station Modernization project included initial support for operations and maintenance funded through the R&RA Account as well as construction, acquisition and commissioning costs funded through the MREFC Account. A complete discussion of this project may be found in the MREFC chapter.

Principal Education Goals: By maintaining and operating the three U.S. stations in Antarctica, Antarctic Facilities and Operations support all scientific work performed by U.S. scientists in Antarctica. Specific science and education goals are managed by the science programs.

Partnerships and Connections to Industry: There are approximately 385 separate subcontractors for supplies and technical services. The U.S. Antarctic Program prime support contractor is Raytheon Polar Services Company (RPSC).

Management and Oversight: The Office of Polar Programs (OPP) has the overall management responsibility for Antarctic Facilities and Operations. The performance of the support contractor is evaluated every year by an Award Fee Board, with representatives from OPP and the Budget, Finance and Award Management. In addition, performance is reviewed by Committees of Visitors and the OPP Advisory Committee.

Antarctic Facilities and Operations also includes management of South Pole Station Modernization, an activity funded out of the Major Research Equipment and Facilities Construction (MREFC) Account from FY 1998. The new station will provide the infrastructure required for imaginative new science on the drawing board.

Current Project Status: All three Antarctic stations are currently operating as normal.

Funding Profile: All funding for Antarctic Facilities and Operations has been provided through the R&RA Account. Support for South Pole Station Modernization, the South Pole Safety and Environment, and the Polar Aircraft Upgrades projects are found in the MREFC Section.

Antarctic Facilities and Operations Funding Profile

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001		117.96	117.96
FY 2002		126.15	126.15
FY 2003		143.93	143.93
FY 2004		151.11	151.11
FY 2005 Current Plan		152.55	152.55
FY 2006 Request		196.32	196.32
FY 2007 Estimate		202.20	202.20
FY 2008 Estimate		208.30	208.30
FY 2009 Estimate		214.50	214.50
FY 2010 Estimate		220.90	220.90

NOTE: Estimates for FY 2007 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available. Beginning in FY 2006, Antarctic facilities and operations support includes $48 million for NSF to assume the responsibility, from the U.S. Coast Guard, for funding the costs of icebreakers needed for the support of scientific research in polar regions.

Information pertaining to the data in the table is included below.

- Operations and Maintenance: The Office of Polar Programs (OPP) contracts with a prime support contractor for science support, and operations and maintenance of the Antarctic stations and related infrastructure in New Zealand and Chile, as well as leasing of research vessels and fixed-wing aircraft used in support of research. The contractor is selected through a competitive bidding process. Other agencies and contractors also provide technical support in areas of expertise such as engineering, construction and communications.

Renewal or Termination: Not applicable to the facilities themselves. The current Antarctic support contract was recompeted and awarded in FY 2000. After a five-month phase-in period the contractor assumed responsibility for operations in March 2000. The contract's ten year performance period is segregated into a five-year initial period and a five-year optional period. NSF is presently considering whether to exercise its option to extend the performance period.

Associated Research and Education Activities: The Antarctic infrastructure makes science in Antarctica possible - ranging from astrophysics to microbiology and climatology - and maintains U.S. presence in Antarctica in accord with U.S. policy. Research is funded through the Antarctic Research Grants Program at NSF and through other federal agencies funding research in Antarctica.

Science Support: OPP's prime support contractor provides science support, as well as operations and maintenance of the facilities.

Polar Logistics

Arctic research support and logistics is driven by and responsive to the science supported in U.S. Arctic Research programs. Funding for logistics is provided directly to grantees or to key organizations that provide or manage Arctic research support and logistics. Major components include: access to U.S. Coast Guard and other icebreakers, University-National Oceanographic Laboratory vessels and coastal boats, and support on the U.S. Coast Guard Cutter Healy; access to fixed and rotary-wing airlift support; upgrades at Toolik Field Station, University of Alaska, Fairbanks' field station for ecological research on Alaska's North Slope; safety training for field researchers and funding for field safety experts, global satellite telephones for emergency response, and improved logistics coordination; development of a network of strategically placed U.S. Long-Term Observatories linked to similar efforts in Europe and Canada; and installation of a modern local area network in Barrow/Naval Arctic Research Laboratory with improved access to the Internet.

U.S. Antarctic Logistical Support is provided by U.S. Department of Defense (DoD) components. Major elements include: Military personnel of the 109th Airlift Wing (AW) of the New York Air National Guard; 109th AW LC-130 flight activity and aircraft maintenance; transportation and training of personnel in connection with the U.S. Antarctic Program; logistics facilities of the Air Force Detachment 13 in Christchurch, New Zealand and the 109th Airlift Wing in Scotia, New York; air traffic control, weather forecasting, and electronic equipment maintenance; charter of Air Mobility Command Airlift and Military Sealift Command ships for the re-supply of McMurdo Station; fuel purchased from the Defense Logistics Agency; and use of Department of Defense satellites for communications.

NSF is requesting $104.31 million for Polar Logistics, a decrease of $600,000 from the FY 2005 Current Plan of $104.91 million. Arctic Logistics support decreases to $36.79 million, but will provide continuing support for research projects throughout the Arctic including Alaska, Canada, the Arctic Ocean, Greenland, Scandinavia and Russia; support for Toolik Field Station, University of Alaska, Fairbanks' field station for ecological research on Alaska's North Slope; and continuing support for a cooperative agreement with the Barrow Arctic Science Consortium. Support provided by DoD for the U.S. Antarctic Logistics program is level in FY 2005, at $67.52 million.

Polar Icebreaking

With the FY 2006 Budget Request, NSF will assume the responsibility, from the U.S. Coast Guard, for funding the costs of icebreakers that support scientific research in polar regions.

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS

National Astronomy and Ionospheric Center

Project Description: The NAIC is a visitor-oriented national research center, supported by NSF and focusing on radio and radar astronomy and atmospheric sciences. Its principal observing facility is the world's largest radio/radar telescope, a 305m-diameter spheroid constructed within a karst depression in western Puerto Rico near the town of Arecibo. The facility itself is called the Arecibo Observatory. The NAIC is operated by Cornell University for NSF under a cooperative agreement. NAIC provides telescope users with a wide range of research and observing instrumentation. The center has a permanent staff of scientists, engineers, and technicians who are available to help visiting investigators with their observation programs.

Principal Scientific Goals: The NAIC was founded to advance the study of basic research in Radio Astronomy, Solar System Radar Astronomy, and Ionospheric Physics.

Principal Education Goals: NAIC's primary education goal is to support and enhance the education of graduate and undergraduate student researchers. Arecibo was one of NSF's first sites for the Research Experiences for Undergraduates (REU) program. At Arecibo, graduate students receive training through use of the facility for Ph.D. research. NAIC also sponsors a major outreach program in Puerto Rico via a modern Visitor's Center, a new Learning Center, and summer workshops for K-12 teachers. In addition NAIC holds, in collaboration with NRAO, a summer school on single-dish radio astronomy techniques. This is a continuing bi-yearly school alternating between NRAO sites and Arecibo.

Partnerships and Connections to Industry: NAIC currently has partnerships with NASA, NRAO, Penn State and other Universities, and the Angel Ramos Foundation of Puerto Rico (a private organization).

Management and Oversight: NAIC is one of four National Centers in astronomy supported by the Astronomical Sciences Division (AST) in the Directorate for Mathematics and Physical Sciences (MPS). Management is via a cooperative agreement with Cornell University. This agreement requires that an annual progress report and program plan be submitted to and approved by NSF. Bi-weekly teleconferences are maintained between the NSF program manager and the NAIC Director. The program manager visits the Observatory several times per year. Arecibo Visiting Committee meetings (commissioned by Cornell) are attended by the NSF program manager, and committee reports are made available to NSF. Yearly status reports and long-range plans are presented by NAIC/Cornell representatives in visits to NSF. Management reviews by external review panels for NSF are held typically three years into a 5-year cooperative agreement.

Current Project Status: A solicitation for the management of NAIC was issued in November 2003. Two proposals were received, and a panel meeting was held June 14-16, 2004. The results of the competition have not yet been announced. The cooperative agreement with Cornell to manage NAIC has been extended through March 2005, pending results of the competition. The FY 2006 Request for NAIC totals $10.60 million, an increase of $80,000 over the FY 2005 budget of $10.52 million.

Funding Profile: All funding for NAIC to date has been provided through the R&RA Account.

NAIC Funding Profile
(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	1.10	9.00	$10.10
FY 2002		11.00	$11.00
FY 2003		12.63	$12.63
FY 2004		12.34	$12.34
FY 2005 Current Plan		12.42	$12.42
FY 2006 Request		12.50	$12.50
FY 2007 Estimate		12.50	$12.50
FY 2008 Estimate		12.50	$12.50
FY 2009 Estimate		12.50	$12.50
FY 2010 Estimate		12.50	$12.50

The current Cooperative Agreement was to expire in FY 2004; it has been extended to March 2005 pending results of a competition. Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Implementation: All construction and commissioning occurred before this reporting period. Construction of the Arecibo Observatory by the Air Force was completed in 1963. NSF took over funding for operations in 1970. The primary NSF-funded upgrade during the period reported was installation of a Gregorian feed system to enhance telescope efficiency and increase useable bandwidth.

- Operations and Maintenance: In-house research accounts for about 6 percent of the total operations budget of NAIC. Most of this research concerns traditional radio-astronomical observations (interstellar gas, galaxies, pulsars) and radar astronomy of solar system objects (asteroids, planetary surfaces and moons). This research furthers the scientific mission of the facility and maintains a scientifically competent staff. The planetary radar program, which has been funded by NASA since 1974, is in a period of transition. NASA has decided to ramp down and then terminate its support by the end of FY 2005.

Renewal or Termination: The cooperative agreement with Cornell to manage NAIC was to expire in September 2004; it was extended to March 2005, pending results of the competition for management of NAIC.

Associated Research and Education Activities: Teacher training is conducted in intensive workshops, held in the past at the Visitor's Center, and as of 2002 in the new Learning Center (both built with funding from the Angel Ramos Foundation of Puerto Rico). Arecibo attracts roughly 120,000 visitors per year, with many K-12 school groups visiting from across the island. Many graduate students use NAIC for dissertation research and Research Experiences for Undergraduates (REU) students also use the telescope as part of their summer research experience. Support for REU is at the level of roughly $50,000 per year.

Science Support: In addition to MPS funding, the Atmospheric Sciences Division in the Directorate for Geoscience expects to provide $1.70 million in FY 2005 and $1.70 million in FY 2006 for ionospheric research and staff support. NSF does not provide individual investigator awards targeted specifically for use of NAIC. Many users are supported through NSF or NASA grants which pursue scientific programs that require use of NAIC.

National Center for Atmospheric Research

Project Description: National Center for Atmospheric Research (NCAR) is a federally funded research and development center (FFRDC) serving a broad research community, including atmospheric scientists as well as researchers in complementary areas of the environmental and geosciences. Facilities available to university, NCAR, and other researchers include a world-class supercomputing facility providing services well suited for the development, validation and execution of large computational models in the atmospheric, oceanic and related sciences. NCAR is also responsible for the curation, archiving and manipulation of large data sets, NCAR's aviation infrastructure provides research aircraft, which can be equipped with sensors to measure dynamic physical and chemical states of atmospheric phenomena at local, regional and global scales. In addition, airborne and portable ground-based radar systems are available for atmospheric research as are other surface sensing systems. NCAR operates the several facilities of the High Altitude Observatory (HAO) that are dedicated to the study of the sun, solar phenomena, space weather, and the responses of the upper atmosphere to the sun's output. As a NSF sponsored facility NCAR is committed to the dissemination of newly discovered knowledge in all the above areas.

Principal Scientific Goals: As an internationally recognized center of excellence, NCAR scientific research programs include the following areas: large-scale atmospheric and ocean dynamics that contribute to an understanding of the past and present climate processes and global climate change, including interactions with other of the Earth's environmental systems; global and regional atmospheric chemistry including atmospheric connections to geochemical and biogeochemical cycles; the variable nature of the Sun and the physics of the corona and their interaction with the earth's magnetic field; the physics of clouds, thunderstorms, precipitation formation, and the interactions and effects on larger-scale weather; and the examination of human society's impact on and response to global environmental change. In addition, NCAR provides fellowships, internships, workshops and colloquia for a complete range of visiting scientists to conduct research and interact with NCAR scientists.

Principal Education Goals: NCAR disseminates knowledge of the geosciences to the general public, K-12 schools, teachers and students, to undergraduate, and graduate institutions, to postdoctoral and career scientists and researchers, as well as to policy and decisions makers. One way this is achieved is via educational tours and exhibits reaching tens of thousands of people every year. Professional training courses, innovative and award-winning science education websites as well as the directed activities of the Office of Education and Outreach are further examples of how NSF's goal of integrating research and education is attained through NCAR activities.

Partnerships: Research collaborations among NCAR staff and university colleagues are integral to its success as an institution, and as a focus and meeting point for the broader atmospheric and related sciences community. NCAR fosters and strongly supports these interactions through many approaches devised and refined over the course of 43 years. Notable recent examples include the community models, extensive collaboration with university partners (e.g. 748 peer-reviewed papers in FY 2004 that were co-authored by NCAR and university-based scientists), and extensive collaboration with non-academic scientists nationally and internationally.

Connections to Industry: NCAR works to develop new collaborations and partnerships with the private sector through directed research and technology transfer. These activities span improved capabilities for detecting, warning and forecasting mesoscale weather phenomena of economic and social importance to the private and public sectors to longer term economic consideration of climate change issues.

Management and Oversight: NCAR is managed by the University Corporation for Atmospheric Research (UCAR), a university-governed and university-serving organization comprised of over 68 Ph.D. granting academic institutions, with NCAR as its major engine of basic and applied research. UCAR works in partnership with NSF, the university community, and its other research sponsors such as NASA, NOAA, DOE, EPA, and the FAA whenever such research collaboration enhances NCAR's basic NSF-supported research goals or facilities missions. NSF's Division of Atmospheric Sciences (GEO) along with the Division of Grants and Agreements (DGA), provide oversight of this facility via a cooperative agreement with the managing institution, UCAR.

Current Project Status: With the completion of a strategic plan "NCAR as Integrator," in FY 2001, NCAR embarked on a plan to implement 27 strategic initiatives that collectively have a wide range in scientific scope. Examples include the water cycle across scales, biogeosciences, data assimilation, and undergraduate leadership workshops. In addition, NCAR is managing the acquisition of the Major Research Equipment and Facilities Construction (MREFC) project High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER), has contracted with Gulfstream, Inc. and Lockheed-Martin to procure a modified G-V aircraft that will begin scientific operations in FY 2005. (Further information on the capabilities of HIAPER follow the NCAR section).

Funding Profile: All funds for NCAR during this time frame have been provided through the R&RA Account.

NCAR Funding Profile

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	7.53	70.50	$78.03
FY 2002	3.75	73.84	$77.59
FY 2003	4.50	76.30	$80.80
FY 2004	4.61	78.31	$82.92
FY 2005 Current Plan	4.73	76.49	$81.22
FY 2006 Request	4.85	77.42	$82.27
FY 2007 Estimate	4.97	78.56	$83.53
FY 2008 Estimate	4.30	81.73	$86.03
FY 2009 Estimate	4.44	81.73	$86.17
FY 2010 Estimate	4.58	81.73	$86.31

NOTE: MPS contributions for statistics and modeling are included. Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Implementation: In FY 1999-2003, a project to refurbish the Mesa Lab building located in Boulder, CO, was funded and project tasks undertaken. The refurbishment included long-sought for upgrades of various facets of NCAR's Mesa Lab facilities such as handicap accessibility, wiring systems, structural and utilities upgrades.

- Operations and Maintenance: This funding supports the operation of the NCAR facilities, including supercomputers, instrumented research aircraft and associated flight costs, and ground-based portable observing systems. Routine maintenance costs of the aircraft and facilities are also covered under this category. In addition, approximately half of the management, operations and maintenance amount is used to support science conducted by NCAR scientists.

Renewal or Termination: The management of NCAR will be competed before the end of the current cooperative agreement, September 30, 2008. In addition, a mid-award review of both science activities as well as management effectiveness will be performed. Future funding levels beyond FY 2005 will be dependent on the outcome of those reviews and on the continuous oversight provided by NSF. Proposals for the next funding award, beyond FY 2008, will be subject to NSF's standard merit review procedures, and will be reviewed by both individual expert reviewers as well as a focus panel composed of preeminent researchers and managers.

Associated Research and Education Activities: NCAR employs a large number of scientists who pursue research objectives individually and in groups. In addition, numerous external researchers use NCAR facilities to further their research objectives. NCAR has recently created an expanded and updated visitor area where various hands-on displays for K-12 when schoolchildren or citizens come to visit the Mesa Laboratory. Lectures and demonstrations are also provided for visiting students and teachers. Teachers listed in the table below are those K-12 instructors coming to attend a workshop or bring students to learn about atmospheric sciences. Undergraduate and graduate students are those who arrive at NCAR for a temporary stay to do specific research that usually lasts three months to a year or two at most.

Direct Impact of NCAR's Participation in Education Activities

Year	K-12	Undergrad	Graduate	Teachers
FY 1994	3,799	*23*	*66*	108
FY 1995	8,477	*23*	*66*	100
FY 1996	5,926	*25*	*65*	47
FY 1997	7,067	*25*	*67*	32
FY 1998	7,063	*26*	*68*	264
FY 1999	9,569	*24*	*69*	90
FY 2000	9,894	*24*	*69*	92
FY 2001	8,995	23	63	101
FY 2002	9,424	*67*	*57*	865[a]
FY 2003	7,295[a,b]	*85*	*109*	815[a]
FY 2004	8,505	*81*	*125*	1,381

NOTE: All numbers in italics are estimates.

[a] The increased number of teachers in FY 2002 includes participants at a series of workshops.

[b] The decreased number in FY 2003 reflects partial closure of Mesa Lab facilities tours during refurbishment.

Science Support: NSF-supported researchers with grants totaling approximately $25 million per year used the aircraft and observational facilities operated by NCAR in FY 2004. This support comes from programs within the Atmospheric Sciences Division for proposals submitted for use of the NCAR aircraft during field campaigns. Additional use of NCAR observational facilities by other NSF funded activities such as oceanography and polar programs, along with NSF wide Priority Areas such as Biocomplexity in the Environment also contribute to this support. NSF-supported researchers with grants totaling approximately $30 million per year used the computational resources of NCAR for a wide range of modeling, simulation and data assimilation tasks. Many principal investigators additionally request computing time at the NCAR facility to accomplish analyses required to evaluate results from their completed field and observational work.

High-performance Instrumented Airborne Platform for Environmental Research (HIAPER)

Project Description: This project is the acquisition, modification and instrumentation of a high altitude research aircraft capable of conducting science at or near the tropopause (~50,000 ft) with an extensive scientific payload and a flight range in excess of 6,000 nautical miles. The aircraft will fly approximately 400-500-research flight hours each year, with extensive mission specific outfitting preceding each research campaign. The remaining time will be devoted to aircraft maintenance and technology refreshment of the platform infrastructure. HIAPER will be a national facility, available to the university community as well as to NSF's federal partners such as the National Oceanographic and Atmospheric Administration, the National Aeronautics and Space Administration, the Office of Naval Research and the Department of Energy under existing interagency agreements. HIAPER will be based at NCAR's Research Aviation Facility, Jefferson County Airport, Broomfield, Colorado. Deployments of the aircraft will occur worldwide.

HIAPER is pictured above, on its rollout from the paint hangar at Gulfstream. *Credit: NCAR*

The HIAPER project will conclude this year, and the aircraft will transition to progressive science missions to test and evaluate the platform in the summer; full operations are anticipated by the conclusion of FY 2005. Once the aircraft has been formally accepted, it will no longer be reported separately, but as part of the activities of the aircraft's operator, NCAR.

Principal Scientific Goals: HIAPER will be a research platform with altitude, range, and endurance capabilities that will enable investigators to perform critical earth system science research. With a maximum altitude for the aircraft of 51,000 feet, the ability to carry significant payloads to such high altitudes will enable scientists to conduct important atmospheric studies in and near the tropopause. The modified aircraft will be capable of covering a range of 6,000 nautical miles in a single flight, which will allow for such varied missions as research flights covering the borders of the continental U.S., the world's large ocean basins, and even studies of the South Pole environment conducted from South America or New Zealand. The platform will serve the entire geosciences community: atmosphere, cryosphere, biosphere, and hydrosphere.

Principal Education Goals: To engage science and non-science students and the broader public in atmospheric and geosciences discovery through the use of technology to create a HIAPER "tele-presence" in real or retrospective time with the aim of integrating research and education.

Partnerships and Connections to Industry: The airframe has been acquired from Gulfstream Corporation, with selected airframe modifications provided by Lockheed-Martin Corporation. Additional support was received from Aeromet Corporation. There was also significant participation from smaller private firms in research instrumentation development.

Management and Oversight: At NSF a Program Officer in the Atmospheric Sciences (ATM) Division in the Directorate for Geosciences (GEO) oversees the HIAPER project. The NSF Program Officer receives advice and oversight support from a NSF Project Advisory Team (PAT), which consists of representatives from GEO, the Office of General Counsel, the Office of Budget, Finance and Award Management (BFA), the Directorate for Mathematical and Physical Sciences (MPS), and the Office of Polar Programs. The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. At NCAR a Project Director manages the day to day activities of HIAPER, and a separate HIAPER Advisory Committee (HAC), consisting of representatives of the university research community, national laboratories, the University Corporation for Atmospheric Research (UCAR), NCAR and NSF provides advice and recommendations to the NCAR Director, to whom the HIAPER Project Director reports.

Current Project Status: In late December 2001 UCAR and Gulfstream Aircraft Corporation (GAC), a subsidiary of General Dynamics, signed a contract for the acquisition of a Gulfstream V. The green airframe was delivered to Lockheed-Martin in June 2002 for extensive airframe structural modifications to meet science requirements. By October 2004 all the structural modifications were completed and the aircraft was ferried back to Savannah (Gulfstream) for painting and final infrastructure installations. The painting was completed in December and HIAPER exited the paint hangar on 21 December 2004 with its final paint scheme. Installation of interior infrastructure is in progress; UCAR accepts the aircraft on behalf of NSF on 17 February 2005 and the aircraft ferries to NCAR on 18 February 2005. Once at NCAR the Research Aviation Facility will complete the scientific infrastructure and also work with the instrument developers on instrument integration issues as they arise.

Milestones for the project are outlined below:

FY 2005 Milestones:
- Receipt/acceptance of modified aircraft by UCAR
- Research Infrastructure and Data Systems Installed
- Preparation for Deployments and initial progressive science mission flights

FY 2006 Milestone:
- First Deployment

Funding Profile: Funds were appropriated by the Congress beginning in FY 2000. The total estimated construction cost for the project is $81.50 million.

Appropriated MREFC Funds for HIAPER
(Dollars in Millions)

FY 2000	FY 2001	FY 2002	FY 2003	Total
$8.50	$12.47	$35.00	$25.53	$81.50

HIAPER Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 1997 & Earlier									
FY 1998	0.30						0.30		$0.30
FY 1999	0.40						0.40		$0.40
FY 2000		0.50		8.00				8.50	$8.50
FY 2001		0.40		12.07				12.47	$12.47
FY 2002				35.00				35.00	$35.00
FY 2003				12.99				12.99	$12.99
FY 2004				12.54				12.54	$12.54
FY 2005 Current Plan					2.00		2.00		$2.00
FY 2006 Request					5.00		5.00		$5.00
Subtotal, R&RA	$0.70				$7.00		$7.70		
Subtotal, MREFC		$0.90		$80.60				$81.50	
Total, Each Stage		**$1.60**		**$80.60**		**$7.00**			**$89.20**

NOTE: The expected operational lifespan is 25 years, pending the full integration of scientific instrumentation. A steady state of about $5.0 million in operations support will occur in FY 2006.

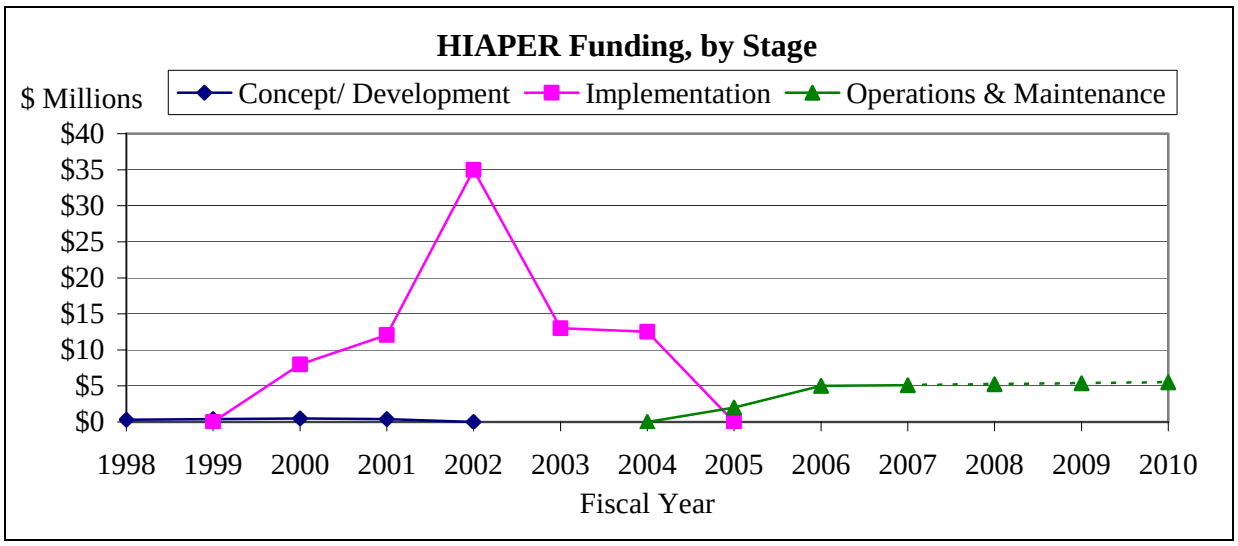
Information pertaining to the data in the table is provided below.

- Concept/Development: Initial R&RA funding of approximately $700,000 provided support for workshops to identify the highest priority performance characteristics and platform requirements, and for other workshops, reviews and best practices consultations with federal and nonfederal experts. MREFC funds obligated during this phase of the project include support for the preparation of the Request for Proposals. After the proposal was received at UCAR, an evaluation and selection team was formed to determine if the proposal met the requirements in the RFP.

- Implementation: The total construction cost for the project is $81.50 million. The full-appropriated amounts for FY 2000-02 were required in order to acquire and modify the airframe. Funding was provided to Gulfstream to secure a production slot, and the remainder of the funds was held until the contract was negotiated, approved by NSF and signed by UCAR and GAC. Subsequent funding enabled project completion.

- Operations and Maintenance: The aircraft will be maintained and operated by the Research Aviation Facility at NCAR. The intent is to operate the aircraft as a fully certified (FAA Airworthiness Certification) platform rather than a public use aircraft. Additional follow-on instrumentation will be developed during the operational phase of HIAPER, funded by the R&RA grants program within

ATM, or other activities within NSF or its federal partners. HIAPER, in contrast to many research facilities, will accommodate instrumentation from other agencies, international partners as well as new instruments that are developed over the 25-year operational time period. Instruments for HIAPER typically will be modular and able fly on a variety of platforms, not exclusively HIAPER.



Future Science Support: Along with direct operations and maintenance support for HIAPER, NSF will support research performed at the facility, through ongoing research and education programs. The annual support for such activities is estimated to be about $10 to $12 million, once the facility reaches full operations.

National Optical Astronomy Observatory

Project Description: The National Optical Astronomy Observatory was established in 1982 by uniting the operations of the Kitt Peak National Observatory in Arizona and the Cerro Tololo Inter-American Observatory in Chile. NOAO is a federally funded research and development center (FFRDC) for research in ground-based nighttime optical and infrared astronomy. NOAO also represents the U.S. astronomical community in the International Gemini Observatory. The National Solar Observatory (NSO), once administratively part of NOAO but now with an independent management structure, makes available to qualified scientists the world's largest collection of optical and infrared solar telescopes and auxiliary instrumentation for observation of the solar photosphere, chromosphere, and corona. The NSO operates facilities in Sunspot, New Mexico and Tucson, Arizona as well as a coordinated worldwide network of six telescopes (GONG) specifically designed to study solar oscillations. As national facilities, NOAO and NSO telescopes are open to all astronomers regardless of institutional affiliation on the basis of peer-reviewed observing proposals.

Principal Scientific Goals: NOAO supports basic research in astronomy and solar physics by providing the best ground-based astronomical telescopes to the nation's astronomers, promoting public understanding and support of science, and advancing all aspects of U.S. ground-based astronomical research.

Principal Education Goals: NOAO promotes and enhances the education of undergraduate and graduate student researchers and outreach training and curriculum development for K-12 teachers. Approximately 15 percent of all NOAO and NSO users are graduate students. Some recent examples of outreach

activities include: Project ASTRO, which matches astronomers with 4th to 9th grade teachers and community educators in the Tucson and Sunspot areas who want to enrich their astronomy and science teaching; and the use of Astronomy in the Teacher Leaders in Research-Based Science Education (TLRBSE), a summer workshop for middle and high school teachers.

Partnerships and Connections to Industry: Thirty-one U.S. Member Institutions and five International Affiliate Members comprise the Member Institutions of the Association of Universities for Research in Astronomy (AURA), Inc., the management organization for NOAO. Other partners include the USAF Office of Scientific Research, NASA, and industrial vendors. Development of new telescopes, instrumentation, and sensor techniques is done in partnership with relevant industry, through subawards to various large and small aerospace, optical fabrication, and IT companies.

Management and Oversight: Management is through a cooperative agreement with AURA. Separate Directors for NOAO and NSO report to the President of AURA. Oversight is through detailed annual program plans and long range plans for NOAO and NSO, plus quarterly and annual reports. NSF conducts periodic reviews of AURA management by external committees. Ongoing oversight and evaluation is by an assigned NSF program director in the Astronomy Division (AST) in the Directorate for Mathematical and Physical Sciences (MPS) and by a standing external committee for NOAO.

Current Project Status: Cooperative agreements for continuing management and operations are for terms of five years; a new agreement was competed and awarded to AURA October 1, 2002. A management review will be carried out this year, three years into the current cooperative agreement. The FY 2006 Request for NOAO totals $37.36 million, a decrease of $560,000 from the FY 2005 Current Plan budget of $37.92 million. NOAO funding includes $35.0 million for NOAO and NSO telescopes (an increase of $280,000 over their FY 2005 base), plus $2.0 million for the Telescope System Instrumentation Program (TSIP) and $360,000 for the Adaptive Optics Development Program (AODP) that are administered for the community through NOAO. TSIP, funded level with the FY 2005 Current Plan, is a program to unify the privately held and the national optical and infrared observatory facilities by funding instrument development and construction at the private observatories in return for observing time on those facilities which is in turn allocated to the astronomical community at large on the basis of peer-reviewed observing proposals. AODP, reduced from its FY 2005 level by $840,000, is funded at a level sufficient to cover existing commitments only. NSO is nearing the completion of the design and development phase for the Advanced Technology Solar Telescope and a proposal for its construction was submitted in late calendar year 2003 and is currently under review. NOAO is actively participating in the development of both the Giant Segmented Mirror Telescope and the Large Synoptic Survey Telescope, both of which are high priority recommendations of the Decadal Survey conducted by the NRC's Astronomy and Astrophysics Survey Committee.

Funding Profile: All funding for NOAO to date has been provided through the R&RA Account.

NOAO Funding Profile
(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001		31.20	$31.20
FY 2002[1]		36.82	$36.82
FY 2003[1]		39.64	$39.64
FY 2004[1]		41.35	$41.35
FY 2005 Current Plan		37.92	$37.92
FY 2006 Request		37.36	$37.36
FY 2007 Estimate		39.00	$39.00
FY 2008 Estimate		39.00	$39.00
FY 2009 Estimate		39.00	$39.00
FY 2010 Estimate		39.00	$39.00

The current Cooperative Agreement expires in FY 2006. Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

[1]In FY 2002-4, data include $4.0 million for Telescope System Instrumentation Program (TSIP). Support for TSIP dropped to $2.0 million in FY 2005-6. AODP funds are included at a level of $3 million in FY 2003 and FY 2004, $1.20 million in FY 2005 and $360,000 in FY 2006.

Information pertaining to the data in the table is included below.

- Implementation: All construction and commissioning of major telescopes occurred before this reporting period. Recent upgrades have been made in the National Solar Observatory facilities, with the completion and commissioning of the Synoptic Optical Long-term Investigations of the Sun (SOLIS) telescope in 2003.

- Operations and Maintenance: The management and operations budget primarily maintains and utilizes existing facilities and develops new instrumentation for existing telescopes in support of research by the national astronomical community. Basic research by in-house scientific staff accounts for approximately 9 percent of the total budget.

Renewal or Termination: The current cooperative agreement expires in FY 2006. A management review will be carried out this year, three years into the current cooperative agreement, on the basis of which NSF will decide whether to renew or recompete the program. Funding amounts for FY 2007 and beyond will be determined through negotiation based on proposals received at this time.

Associated Research and Educational Activities: Teacher training includes participation of more than 350 teachers in Project ASTRO; intensive (multi-week) training of about 25 teachers per year through Teacher Learning through Research Based Science Education; and Research Experience for Teachers. K-12 numbers are not tracked but it is estimated that school groups make up about 10 percent of the roughly 85,000 visitors per year to public visitor centers at NOAO and NSO. Instructional materials are developed in collaboration with the Lawrence Hall of Science Great Explorations in Science and Math (GEMS) program. The "Hands on Optics" program, aimed at middle school students, is being developed by NOAO in collaboration with the Optical Society of America and the International Society for Optical Engineering. NOAO hosts the "Astronomy Education Review," a refereed, on-line journal

(http://aer.noao.edu) that disseminates information about astronomy and space science education. Observational facilities are also used by approximately 200 graduate students each year and by undergraduate students participating in the REU program, university-sponsored research, and the Practicas de Investigacion de Astronomia program (Chile).

Science Support: In addition to the funds listed above, approximately $500,000 per year is provided in total from the NSF Division of Elementary, Secondary and Informal Education (EHR), the NSF Division of Atmospheric Sciences (GEO), the Program for Education and Special Programs in the Astronomy Division (REU and teacher enhancement) (MPS), and the Office of International Science and Engineering (REU). For all NOAO and NSO telescopes, a peer-review telescope allocation committee provides merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of NOAO. Most users are supported through NSF or NASA grants to pursue scientific programs that require use of NOAO.

National Radio Astronomy Observatory

Project Description: The National Radio Astronomy Observatory (NRAO) is a federally funded research and development center (FFRDC) that provides state-of-the-art radio telescope facilities for use by the scientific community. NRAO conceives, designs, builds, operates and maintains radio telescopes used by scientists from around the world to study virtually all types of astronomical objects known, from planets and comets in our own Solar System to quasars and galaxies billions of light-years away. NRAO operates major radio telescopes at Green Bank, West Virginia, at Socorro, New Mexico, and at ten telescope array sites spanning the U.S. from the Virgin Islands to Hawaii. NRAO's headquarters are in Charlottesville, Virginia. These federally funded, ground-based observing facilities for radio astronomy are available to any qualified astronomer, regardless of affiliation or nationality, on the basis of scientific peer-reviewed proposals.

Principal Scientific Goals: NRAO supports and advances basic research in the astronomical sciences, including understanding: the geometry and the matter content of the universe; the formation of galaxies, stars and planets; and the nature of black holes.

Principal Education Goals: NRAO supports and enhances the education of undergraduate and graduate student researchers and outreach training for K-12 teachers. The primary education goal is to support the development of a scientifically and technically literate society through a comprehensive outreach program in which information about radio astronomy is made available to the public through the world-wide web and news media. NRAO sites support visitor/education centers; and educational programs are developed in partnership with other institutions. NRAO also supports undergraduate, graduate and post-doctoral students in radio-astronomy scientific research, the design, construction, test and implementation of innovative scientific instruments and telescopes for radio-astronomy and of software tools for the scientific data analysis and for the interpretation of radio-astronomical data.

Partnerships and Connections to Industry: To make the observations needed to sustain radio astronomy research, 2,000 scientists from over 150 institutions around the world partner with NRAO. Numerous other U.S. universities, NASA, foreign scientific and technical institutes and industrial vendors are also partners. The development of new telescopes, instrumentation, and sensor techniques is completed in partnership with relevant industry, through competitive subawards to various large and small aerospace companies, radio antenna manufacturing firms, and specialized electronics and computer software companies.

Management and Oversight: Management is through a cooperative agreement with Associated Universities Incorporated (AUI). The NRAO director reports to the President of AUI. Oversight is through detailed annual program plans and long range plans for NRAO, plus monthly, quarterly, and annual reports. NSF conducts periodic reviews of AUI management by external committees. Ongoing oversight and evaluation is by an assigned NSF program director in the Astronomy Division (AST) in the Directorate for Mathematical and Physical Sciences (MPS) and by a standing external committee for NRAO.

Current Project Status: Cooperative agreements for continuing management and operations are for terms of five years. The present Cooperative Agreement was extended through March 31, 2006, by action of the National Science Board. The recommended funding level for the cooperative agreement beyond March 31, 2006, will be addressed subsequent to community recommendations on the scope and balance of the Division of Astronomical Sciences' total program, expected to be provided during the second quarter of 2005. The VLA is undergoing an upgrade of its electronics and communications systems. The upgrade, carried out within the funds appropriated to NRAO, will significantly enhance the capabilities of the VLA as currently configured, and also provides the base for a possible major upgrade, generally described as the Expanded Very Large Array (EVLA). The NRAO is also engaged in construction of the international Atacama Large Millimeter Array (ALMA), a millimeter/submillimeter interferometer, which was approved as a Major Research Equipment and Facilities Construction project by the National Science Board in winter 2001. NRAO is the U.S. implementing organization of the ALMA project. The FY 2006 Request for NRAO totals $47.40 million, an increase of $370,000 from the FY 2005 Current Plan of $47.03 million.

Funding Profile: All funding for NRAO to date, excluding construction funding for ALMA, which is managed by NRAO, has been provided through the R&RA Account.

NRAO Funding Profile

(Dollars in Millions)

	Implementation	Operations & Maintenance	Total, NSF
FY 2001	5.00	47.10	$52.10
FY 2002	5.00	35.43	$40.43
FY 2003	5.00	40.33	$45.33
FY 2004	9.34	45.64	$54.98
FY 2005 Current Plan	6.34	40.69	$47.03
FY 2006 Request	5.00	42.40	$47.40
FY 2007 Estimate	5.00	41.50	$46.50
FY 2008 Estimate	4.32	41.50	$45.82
FY 2009 Estimate	4.32	41.50	$45.82
FY 2010 Estimate	4.32	41.50	$45.82

The current Cooperative Agreement expires in FY 2006. Operations estimates for FY 2007 and beyond have been developed based on current cost profiles and are not intended to reflect actual budget requirements. They will be updated as new information becomes available.

Information pertaining to the data in the table is included below.

- Implementation: All construction and commissioning of NRAO telescopes occurred before this reporting period. The Observatory is now engaged in an upgrade to the 25-year-old Very Large Array (VLA) radio telescope located in Soccoro, NM, an upgrade that will enhance the capabilities of the current VLA as well as provide basic underpinnings for a possible future project known as the Expanded Very Large Array (EVLA).

- Operations and Maintenance: Funding for management, operations and maintenance primarily maintains and utilizes existing facilities and develops new instrumentation for existing telescopes in support of research by the national astronomical community. Basic research by in-house staff is less than 5 percent of the total budget.

- ALMA operations: The funding profile for the ALMA activity includes early operations funding beginning in FY 2005 at $1 million. These additional funds are not explicitly included in the table above, but are expected to be part of the NRAO operating expenditures beginning in FY 2005. Further information on the ALMA project can be found in the MREFC chapter.

Renewal or Termination: The current cooperative agreement expires in FY 2006. A renewal proposal from AUI for operations of NRAO will form the basis of a new 5-year cooperative agreement and funding amounts for FY 2007 and beyond will be determined through negotiation at that time.

Associated Research and Education Activities: NRAO conducts an active educational and public outreach program. The observatories host a combined total of approximately 50,000 visitors each year to the Green Bank and Very Large Array facilities, including school field trips for K-12 students. The Green Bank observatory recently completed the construction of a bunkhouse to house student groups on overnight trips. Observatory professional scientific and engineering staff also visit classrooms regularly to provide special instruction in the astronomical and radio sciences. Observational facilities are used by graduate students carrying out dissertation research and those on work experience programs and by undergraduate students participating in the REU program.

Science Support: In addition to the funding listed above, approximately $500,000 per year is provided in total from the NSF Division of Elementary, Secondary and Information Education in EHR and the Program for Education and Special Programs in the Astronomy Division. A peer-review telescope allocation committee provides merit-based telescope time but no financial support. NSF does not provide individual investigator awards targeted specifically for use of NRAO. Many users are supported through NSF or NASA grants to pursue scientific programs that require use of NRAO.