MAJOR MULTI-USER RESEARCH FACILITIES $1,109,740,000

The FY 2007 request for Facilities totals $1,109.74 million, a $110.43 million increase, or 11.1 percent, over the FY 2006 Current Plan of $999.31 million. All operations and maintenance of multi-user facilities and research resources are funded through the Research and Related Activities (R&RA) account; most 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 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Facilities	475.13	514.32	580.30	65.98	12.8%
Polar Facilities and Logistics	277.91	301.82	339.64	37.82	12.5%
Federally Funded R&D Centers	178.07	183.17	189.80	6.63	3.6%
Total, Major Multi-user Research Facilities	$931.11	$999.31	$1,109.74	$110.43	11.1%

To describe the life-cycle of a facility, the Foundation has adopted a set of distinct stages in its Facilities Management and Oversight Guide[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 Director for Large Facility Projects (DDLFP) 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 Affairs, and the Office of Budget,

[1] The current version of the Facility Management and Oversight Guide can be found at www.nsf.gov/pubs/2003/nsf03049/nsf03049.pdf. The Facilities Management and Oversight Guide is currently being revised as part of an ongoing process to improve NSF's facility management and oversight; the revised "Facility Manual" is expected to be released during FY 2006. New guidelines for the development, review, and approval of major research facilities were released in September, 2005 and are available on the web: www.nsf.gov/bfa/docs/mrefcguidelines1206.pdf.

Finance and Award Management. The DDLFP also provides advice and assistance to directorates, divisions and program staff throughout the life cycle of a facility project.

Major Multi-User Research Facility Funding
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Facilities	$475.13	$514.32	$580.30	$65.98	12.8%
Academic Research Fleet	83.20	84.60	97.70	13.10	15.5%
Advanced Modular Incoherent Scatter Radar	10.50	8.00	-	-8.00	-100.0%
Cornell Electron Storage Ring	16.62	14.56	14.71	0.15	1.0%
Gemini Observatory	15.48	18.26	20.00	1.74	9.5%
Incorporated Research Institutes for Seismology	11.90	12.00	12.90	0.90	7.5%
Integrated Ocean Drilling Program	36.70	29.00	4.50	-24.50	-84.5%
Large Hadron Collider	10.51	13.36	18.00	4.64	34.7%
Laser Interferometer Gravitational Wave Observatory	32.00	31.68	33.00	1.32	4.2%
MREFC Facilities[1]	165.60	209.83	284.97	75.14	35.8%
National High Magnetic Field Laboratory	25.50	25.74	26.50	0.76	3.0%
National Nanofabrication Infrastructure Network	13.90	13.76	13.89	0.13	0.9%
National Superconducting Cyclotron Laboratory	17.50	17.32	17.60	0.28	1.6%
Network for Earthquake Engineering Simulation	17.94	20.31	21.27	0.96	4.7%
Other Facilities[2]	17.78	15.90	15.26	-0.64	-4.0%
Polar Facilities and Logistics[3]	$277.91	$301.82	$339.64	$37.82	**12.5%**
Antarctic Facilities and Logistics	155.73	199.96	218.09	18.13	9.1%
Polar Logistics	105.32	101.86	112.42	10.56	10.4%
South Pole Station[1]	16.86	-	9.13	9.13	N/A
Federally Funded R&D Centers[4]	$178.07	$183.17	$189.80	$6.63	**3.6%**
National Astronomy and Ionospheric Center	12.42	12.16	12.16	-	-
National Center for Atmospheric Research	80.68	83.36	86.85	3.49	4.2%
National Optical Astronomy Observatory	37.94	36.91	40.05	3.14	8.5%
National Radio Astronomy Observatory	47.03	50.74	50.74	-	-
Total	$931.11	$999.31	$1,109.74	$110.43	11.1%

[1]Funding levels for MREFC projects in this table include initial support for operations and maintenance provided through the R&RA account as well as implementation support provided through the MREFC account.

[2]Other Facilities includes support for the continued phase out of program and contract activities for the Ocean Drilling Program, predecessor to the IODP, and other physics and materials research facilities.

[3]Polar Facilities and Logistics excludes Polar Environment, Safety and Health, which is classified as a "tool" but not as a facility.

[4]Federally Funded R&D Centers does not include the Science and Technology Policy Institute, which is an FFRDC but not a research platform.

In September 2005, NSF released "A Joint National Science Board-National Science Foundation Management report on *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*." This "Setting Priorities" report outlines in general terms the changes NSF will implement to its large facilities process over the next year, and was developed largely in response to the February 2004 National Academies' report by the same name. That report recommended 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 continues to refine 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 2005 NSF Performance and Accountability Report (NSF-06-01). 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 26 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 about the structure and dynamics of the oceans. Through use of these facilities scientists contribute to advances made in areas such as climate variability, marine ecosystems, fisheries, and ocean-related natural hazards such as tsunamis.

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 via satellite 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 72 percent of the operating funds for the Fleet, while the remaining operating costs are divided proportionally among the other vessel using agencies. NSF also coordinates with ship-operating and ship user academic institutions through its connection with and support of UNOLS.

Management and Oversight: NSF provides oversight to the Academic Research Fleet through cooperative agreements with each ship-operating institution and the UNOLS Office. 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 (OCE) and in NOAA and ONR 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: 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 other ocean agencies and the ocean science community, the Federal Oceanographic Facilities Committee (FOFC) is currently revising the 2001 report on long-range plans for renewal of the federal and academic oceanographic research and survey fleet, which will be published this year. The FY 2007 request for operation of the Academic Research Fleet totals $77.50 million, up $4.50 million from

the FY 2006 Current Plan. In addition, several activities are requested or underway to support the upgrade of the U.S. Academic Research Fleet.

FY 2007 will see continued development and construction of a new deep submergence capability to replace the pioneering submersible human occupied vehicle (HOV) ALVIN. This project, begun in FY 2004, will take six years in total and cost approximately $22.83 million. The FY 2007 support for this effort is $5.10 million. Also underway is the conversion of a seismic research vessel acquired with NSF funds in FY 2004 (renamed the R/V Langseth), with state-of-the-art 3-D seafloor surveying equipment, to replace the aging R/V Maurice Ewing. A third project currently underway is the design and potential construction of a series of up to three Regional Class Research Vessels (RCRVs), utilizing the experience in ship building and contracting of the Naval Sea Systems Command (NAVSEA). These ships will be built sequentially over a period of six years starting in FY 2007 with the first year of construction, FY 2007, planned for $15.10 million. A design competition is currently underway. 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**
	HOV	Langseth	RCRV	Other		
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	3.00	6.24	0.30	0.46	72.50	$82.50
FY 2005	2.23	8.00	2.00		70.97	$83.20
FY 2006 Current Plan	5.50	2.50	3.60		73.00	$84.60
FY 2007 Request	5.10		15.10		77.50	$97.70
FY 2008 Estimate	3.00		12.00		79.80	$94.80
FY 2009 Estimate	3.00		13.09		82.20	$98.29
FY 2010 Estimate			14.11		84.66	$98.77
FY 2011 Estimate			14.13		87.19	$101.32
FY 2012 Estimate			14.20		90.00	$104.20

NOTE: Operations estimates for FY 2008 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 past 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. More recently, planning has included 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, FOFC prepared a

report titled "Charting the Future for the National Academic Research Fleet", which defined a federal interagency renewal strategy for the national academic research fleet. The report is currently being revised by FOFC; however, significant changes for renewal of the academic fleet are not anticipated. Major upgrade expenditures indicated in implementation requests for FY 2007 and out-years are for continuation of development of a new deep submergence vehicle and replacement of Regional Class ships. The reconfiguration of a recently acquired seismic research vessel will be completed in FY 2006. All implementation activities for the Academic Research Fleet have been funded through the R&RA account.

- 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 2,600 users per year, which is based on the total number of individual researchers, postdoctoral associates, graduate and undergraduate students, teachers, K-12 students and observers who have participated in cruises.

Science Support: Through the existing interagency MOU, which enables the efficient operation of the academic fleet, NSF pays only for ship time used by NSF-funded awards.

Advanced Modular Incoherent Scatter Radar (AMISR)

Project Description: The Advanced Modular Incoherent Scatter Radar 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 4,096 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.

Principal Scientific Goals: Long-term measurements of atmospheric parameters will help us 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 the first 4,000 units was manufactured by Comtech PST, a company based in Melville, New York. The remaining amplifiers will be manufactured by Sanmina. The construction of the AMISR support structure and the foundation work in Alaska was performed by VECO Corp., an Alaska-based company that specializes in management, engineering design and construction for the oil and power industries. The support structure at Resolute Bay will be built by a Canadian company, ATCO Frontec using the VECO design.

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 (in GEO). A Project Advisory Team has been appointed, which includes the Deputy Director 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. A prototype system using 8 AMISR panels has been deployed at the Jicamarca Radio Observatory in Peru, and based on satisfactory test results, an additional 16 panels were produced and shipped to Gakona, Alaska, in early in 2005 for further on-site testing. Both prototype systems are now being used for scientific studies.

The first 32 panels of the AMISR system at Poker Flat, Alaska, were installed in November 2005 and used for interference testing in partnership with Air Force personnel from Clear Air Force Station. No interference was observed and SRI received official certification to continue testing the 32 panels at Poker Flat. The remaining 96 panels will be assembled at SRI and shipped to Alaska in Spring 2006, completing the first AMISR face. Construction of the AMISR support structure at Resolute Bay is underway, and completed panels for the two AMISR faces being deployed at Resolute Bay are scheduled to be shipped to Resolute Bay in August 2006.

Future milestones for the project are outlined below:

FY 2006 Milestones:
- Poker Flat Activities
  - Complete and install remaining 96 panels
  - Poker Flat (1 face) constructed
  - Poker Flat system test complete and operational
- Resolute Bay Activities:
  - 256 panels integrated and tested at SRI
  - 256 panels along with foundation materials, support scaffolding and distribution shelters shipped to Resolute Bay via sealift
  - Installation of 256 panels at Resolute Bay begins

FY 2007 Milestones:
- Poker Flat Activities
  - Operations phase
- Resolute Bay Activities:
  - Installation of 256 panels on two faces completed
  - 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		10.00	0.50	$10.50
FY 2006 Current Plan		8.00	2.70	$10.70
FY 2007 Request			3.00	$3.00
FY 2008 Estimate			3.00	$3.00
FY 2009 Estimate			3.07	$3.07
FY 2010 Estimate			3.15	$3.15
FY 2011 Estimate			3.22	$3.22
FY 2012 Estimate			3.30	$3.30

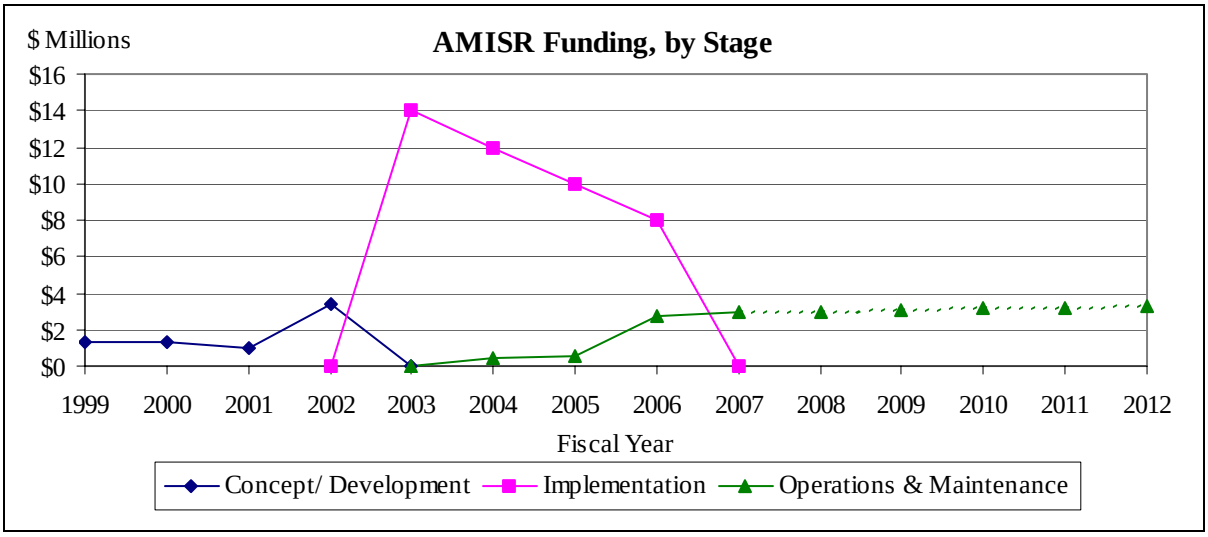
NOTE: A steady state of about $3 million in operations support is expected to occur in or about FY 2008. The expected operational lifespan of this project is 40 years, beginning in FY 2007. Operations estimates for FY 2008 and beyond have been developed based on current cost profiles and are not intended 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 AMISR face at Resolute Bay will be operational by spring 2006. The two remaining faces will be deployed at Resolute Bay in 2007.

- Operations and Maintenance: SRI has submitted 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 MIT, and the University of Western Ontario. 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 (CESR)

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 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 the Stanford Linear Accelerator Center (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 the 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 is provided through the Division of Physics (PHY) of the Directorate for Mathematical and Physical Sciences (MPS) and by periodic 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 (DMR) of MPS, the Directorate for Biological Sciences (BIO), and by the National Institutes of Health (NIH). Those organizations provide management oversight for CHESS through regular site visits. DMR will provide $3.90 million to CHESS in FY 2007; BIO will provide $800,000.

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 2007 Request for CESR totals $14.71 million. It is expected that the CESR-c and CLEO-c projects will cease by FY 2009.

Funding Profile: The FY 2003 – FY 2009 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 Actual		16.62	$16.62
FY 2006 Current Plan		14.56	$14.56
FY 2007 Request		14.71	$14.71
FY 2008 Estimate		15.00	$15.00
FY 2009 Estimate		10.00	$10.00
FY 2010 Estimate		-	-

NOTE: Operations estimates for FY 2008 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 8,000 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 120 elementary and middle school students and 300 high school students were involved in activities hosted by the Laboratory for Elementary-Particle Physics. Over 450 people toured the Wilson Laboratory facility during this time frame;
- Approximately 65 undergraduate students participated in laboratory research or worked as technicians or in technical capacities such as computer operations;
- The Laboratory hosted 19 Research Experiences for Undergraduates (REU) and two Research Experiences for Teachers (RET) participants in collaboration with Wayne State University and George Mason University during the summer of 2005; and
- The laboratory trains graduate students in accelerator physics and has supported the development of superconducting radio frequency accelerating cavities.

Science Support: Approximately $3.0 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.

Gemini North dome/enclosure with setting sun (to left) lighting up bottom half of telescope through thermal vents (fully open). The observing slit is partially open revealing the truss and top end of the telescope. Credit: *Gemini Observatory/AURA*

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.

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 Director of the Gemini Observatory 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 in 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 established an independent Visiting Committee that advises 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 2006. Under the terms of the international agreement, the partnership, after a management review, determined that it would not compete the management of the Observatory at this time. A proposal from AURA for operations during the period 2006 to 2010 was reviewed and an award to AURA for the next five years of operations has been approved by the National Science Board.

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 2007 Request totals $20.0 million, an increase of $1.74 million over the FY 2006 Current Plan of $18.26 million. Included in this total is enhanced operational and visitor support, as well as the continuation of funding of a new generation of advanced instrumentation and $1.0 million as the remaining contribution to the return of the U.S. share of Chilean capital.

Gemini Funding Profile
(Obligated Dollars and Estimates in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		Grand Total
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	
FY 1999 & Earlier	12.00		47.00	45.00	22.91		81.91	45.00	$126.91
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 Actual					15.48		15.48	-	$15.48
FY 2006 Current Plan					18.26		18.26	-	$18.26
FY 2007 Request					20.00		20.00	-	$20.00
FY 2008 Estimate					24.69		24.69	-	$24.69
FY 2009 Estimate					25.07		25.07	-	$25.07
FY 2010 Estimate					25.46		25.46	-	$25.46
FY 2011 Estimate					26.50		26.50	-	$26.50
FY 2012 Estimate					27.16		27.16	-	$27.16
Subtotal, R&RA	$12.00		$47.00		$261.82		$320.82		
Subtotal, MREFC		-		$45.00		-		$45.00	
Total, Each Stage		$12.00		$92.00		$261.82			$365.82

NOTE: Reporting of costs in the categories of implementation and operations and maintenance is as considered and reported by NSF in its response to OIG report 01-2001. FY 2005 - 2007 funding includes the cost of the Chilean capital return, consistent with the U.S. assumption of a portion of the Chilean share. FY 2005 funding includes one time costs of $0.55 million for improved internet connectivity and instrumentation. Funding under the current cooperative agreement ends in FY 2005. The figures for FY 2006-2011 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. A steady state of about $25 million annually (plus inflation) is anticipated for the U.S. share of operations.

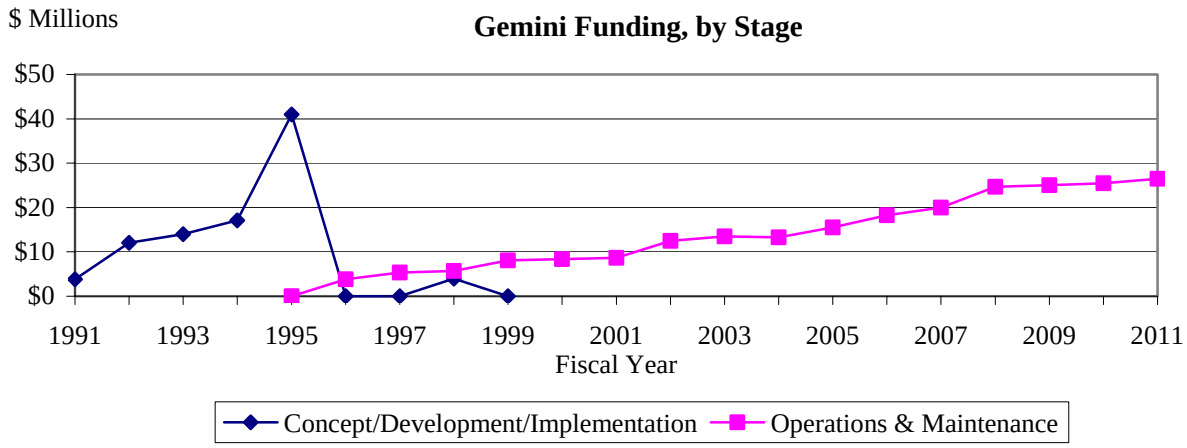
Information pertaining to the data in the table is included below.

- 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 $92.0 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 2005-2007, 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 expires in FY 2006. Under the terms of the international agreement, the partnership determined that it did not wish to compete the management of the Observatory at this time. A proposal from AURA covering operations from 2006-2010 was reviewed and an award for the next five years of operations has been approved by the National Science Board.

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 $5.0 million.

Incorporated Research Institutes for Seismology (IRIS)

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 the USArray component 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 138 permanently installed digital seismic stations, most of which have real-time data access; (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.

Real-time data from the IRIS GSN forged the critical core of the early warning of the December 26, 2004 Sumatran Earthquake by the Pacific Tsunami Warning Center (PTWC). Within 8 minutes of the initial rupture of the magnitude 9 earthquake, GSN data flashed electronically via satellite and the Internet to the GSN Data Collection Center and then to the PTWC and the USGS National Earthquake Information Center.

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 from around 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 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 (in GEO), 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-two 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 GSN, PASSCAL, and a DMS. During the last cooperative agreement period, IRIS initiated a new Education and Outreach (E&O) program. The FY 2007 Request for IRIS totals $12.90 million, an increase of $900,000 over the FY 2006 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	2.85	9.05	$11.90
FY 2006 Current Plan	3.00	9.00	$12.00
FY 2007 Request	3.10	9.80	$12.90
FY 2008 Estimate	3.20	10.00	$13.20
FY 2009 Estimate	3.30	10.50	$13.80
FY 2010 Estimate	3.30	11.00	$14.30
FY 2011 Estimate	3.17	11.50	$14.67
FY 2012 Estimate	3.28	12.00	$15.28

NOTE: Operations estimates for FY 2008 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; the Global Seismographic Network (GSN); and the Data Management System in Seattle, WA.

- 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 were stipulated in the last 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 allow the submission of a renewal proposal rather than to recompete the operation of this facility. A renewal proposal was submitted in September 2005 from the IRIS Consortium for continued management of the IRIS facilities and is under review.

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. The website visitors data in the table below indicate a yearly sum of unique visitors each month and shows the large increase in public interest after the Sumatra earthquake and tsunami. The large increase in posters distributed in FY 2005 is due to a new poster featuring seismic data from GSN recordings of the Sumatra earthquake, and from IRIS contributing a

poster to American Geological Institute's Earth Science Week packet. IRIS partnered with the National Earth Science Teachers Association (NESTA) in FY 2005 to produce a seismology/IRIS focused issue of their journal *The Earth Scientist*. The journal has a regular distribution of 1,100 members and over 2,000 total copies were distributed in FY 2005. Seventeen public IRIS/SSA distinguished lectures were given to audiences of up to 400 in FY 2005. IRIS holds a variety of professional development workshops each year for K-12 teachers and/or college faculty, varying in length from 1 hour to 4 days; in FY 2005, 6 such workshops were held. The K-12 students number assumes each teacher interacts with 80 students per year and continues to teach new students each year. In addition IRIS sponsored a 2-day workshop for 16 undergraduate and graduate students to provide training in the use of the Seismic Processing Workshop (SPW) software. The museum display visitors number is the total number of visitors to the museums that have an IRIS/USGS display.

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
FY 2005	43,000	9	20	110	0	15,500,000	20,000	1,400,000

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 (IODP)

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 *IODP 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, is undergoing testing in 2006 and 2007, and will be available for IODP operations in Fall 2007. NSF's contribution includes rebuilding the ODP drillship *JOIDES Resolution* to serve as the light Scientific Ocean Drilling Vessel (SODV) drillship, using $115 million in FY2005-07 MREFC funds. An initial period of *JOIDES Resolution* operations extended from June 2004 to January 2006; MREFC SODV shipyard conversion will begin in Fall 2006. Delivery of the rebuilt *JOIDES Resolution* to IODP is expected in August 2007, and it is likely that the ship will be renamed to reflect its greatly enhanced capabilities. The European Consortium for Ocean Research Drilling (ECORD), composed of 17 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 Australia and several potential additional 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 *IODP Initial Science Plan: 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 16 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 and Australia may join in the near 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 Agency for Marine-Earth Science and Technology (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 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 (in GEO) 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, and another oversees the MREFC SODV activity.

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 continued into early FY 2006. The NSF-supplied light SODV drillship, converted using MREFC funds for IODP needs, will begin drilling in late FY 2007. The heavy drillship *Chikyu* is expected to begin scientific drilling operations in late FY 2007. European-funded drilling expeditions have occurred in two places: the northern Arctic, where several icebreakers, one modified for drilling, were used in late FY 2004 and early FY 2005; and in shallow coral reefs around Tahiti in late FY 2005 and early 2006. Future European-funded drilling is expected off of New Jersey on the U.S. east coast margin.

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 $25.80 million in FY 2007 for operation of the IODP program through the R&RA account (IODP SODV Operations & Maintenance and IODP Central Support).

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
(Obligated Dollars and Estimates in Millions)

	ODP Operations & Maintenance	SODV Operations & Maintenance	IODP Operational Support	Total, NSF
FY 1997	27.09			$27.09
FY 1998	26.95			$26.95
FY 1999	28.13			$28.13
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		3.30	$35.30
FY 2004	-		35.75	$35.75
FY 2005	3.49		36.70	$40.19
FY 2006 Current Plan	2.80		29.00	$31.80
FY 2007 Request	2.00	21.30	4.50	$27.80
FY 2008 Estimate		57.00	4.64	$61.64
FY 2009 Estimate		58.60	4.77	$63.37
FY 2010 Estimate		60.70	4.92	$65.62
FY 2011 Estimate		62.00	5.06	$67.06
FY 2012 Estimate		64.00	5.40	$69.40

NOTE: Operations estimates for FY 2008 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.

- 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: 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- many graduate students have sailed on the JOIDES Resolution.
- Finally, a highly successful "School of Rock" educator workshop was recently held aboard the JOIDES Resolution during a 16 day transit; participation by middle and high school teachers, museum educators and exhibit designers, and other educational professionals led to broadly-viewed daily webcasts as well as development of new curricular and museum outreach materials.

A breakdown by year and by category is reflected in the table below.

ODP/IODP 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	6,500	8,500	9,500	7,500
FY 2006 Estimate	130,000	8,500	9,500	21,000

Science Support: Over 2000 scientists from forty nations have participated on ODP and IODP cruises since 1985. About 900 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 1,700+ direct U.S. users of ODP materials approach 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 (LHC)

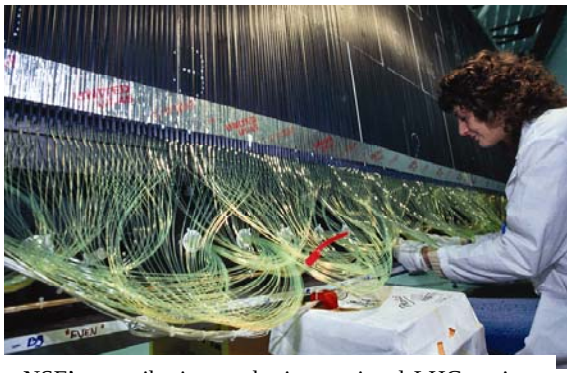
Project Description: The LHC will be the premier facility in the world for research in elementary particle physics. The facility will consist of a superconducting particle accelerator providing two, counter-rotating beams of protons, each beam having an energy up to 7 TeV ($1TeV=10^{12}$ electron volts). 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 Major Research Equipment and Facilities Construction (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 the Department of Energy (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.

U.S. LHC maintenance and operations, software and computing activities, funded through the R&RA account, is now ramping up with awards to UCLA (for CMS) and to Columbia University (for ATLAS). This includes 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.



NSF's contribution to the international LHC project includes the construction of two detectors, the ATLAS and the CMS. The ATLAS tile calorimeter will collect the energy released in the LHC´s proton-proton collisions. Special plastic manufacturing techniques have been adapted to mass produce the ATLAS elements.

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 (in 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 Director for Large Facilities Projects, the Office of the General Counsel, the Office of Legislative and Public Affairs, the Office of International Science and Engineering 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.

The NSF-supported components of the ATLAS and CMS detectors were scheduled for completion in FY 2005; final appropriations of MREFC construction funding were received in FY 2003. The U.S. ATLAS construction project, as of July 2005, was 96 percent complete, as measured by Earned Value. The U.S. CMS project was also 96 percent complete. Milestones for both projects have been 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 aimed for the completion of at least 97 percent of the U.S. deliverables by the end of FY 2005, the so-called CD-4A (Critical Decision) completion milestone, which was achieved, with the remaining items linked to the installation schedule.

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

FY 2006 Milestones:
Continue ATLAS and CMS detector installation and testing in underground halls.

US ATLAS
Finish installation of Trigger and Data Acquisition system; and
Complete production of Muon Cathode Strip Chamber Readout.

US CMS
Complete delivery of Electromagnetic (EM) Calorimeter Optical Links;
Finish Trigger Installation;
Complete the ECAL Front-end electronics production; and
50 percent of Silicon Tracker Rods completed

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, 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 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 in construction, although one NSF-supported group has recently joined the LHC-B experiment and is participating in monitoring and detector upgrade R&D.

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 2001& Earlier	8.69		0.15	54.26			8.84	54.26	$63.10
FY 2002	1.60			16.90			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 Actual					10.51		10.51	-	$10.51
FY 2006 Plan					13.36		13.36	-	$13.36
FY 2007 Request					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
FY 2011 Estimate					18.00		18.00	-	$18.00
FY 2012 Estimate					18.00		18.00	-	$18.00
Subtotal, R&RA	$10.29		$0.15		$143.87		$154.31		
Subtotal, MREFC		-		$80.85		-		$80.85	
Total, Each Stage		$10.29		$81.00		$143.87			$235.16

NOTE: The estimated operational lifespan of this project is approximately 20 years. Operations and Maintenance Estimates for FY 2008 and beyond are under negotiation with DOE. They are subject to the availability of funds and appropriate program balance and may not reflect actual budget requirements. For FY 2002 and earlier, R&RA funds totaling $4.59 million for Concept/Development were listed in the Operations and Maintenance in the budgets for FY 2006 and earlier. This has been corrected in the present table.

[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.

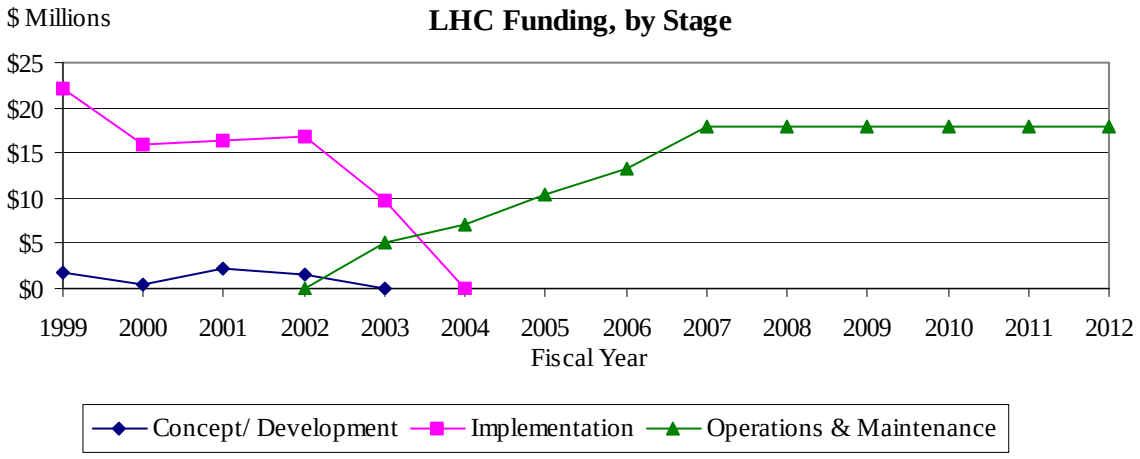
- Concept/Development: The LHC has been under discussion since FY 1989. NSF funding in FY 1996-99 supported technical design studies.

- 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 by the end of 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 2007 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 and maintenance 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.

Software and Computing: Both US ATLAS and US CMS are active members in the US Grid activity that is providing computing resources to several sciences in addition to the LHC collaborations. In addition, both collaborations have now selected their initial set of "Tier-2 centers" which are primarily funded by NSF to provide data analysis capabilities for university researchers.



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 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 (LIGO)

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; Hanford has a second interferometer in the same housing. 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 on the order of one part in 10^{21}, meaning that the expected change in the apparent 4-km length is only on the order of 4×10^{-18} meters or about 1/1000th 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 Major Research Equipment and Facilities Construction (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. Furthermore, even though 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.

Aerial view of the LIGO facility in Hanford, WA. *Credit: www.ligo.caltech.edu*

Principal Education Goals: LIGO plays a significant role in the training of Ph.D. graduates for the country's workforce. Following the beginning of LIGO science runs in FY 2002, the number of graduate students has grown and will continue to do so. 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 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 Systemic Initiative Program. Construction began on the center in early FY 2006.

Connections to Industry and to Other Federal Agencies: 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). LIGO is cooperating with the Defense Intelligence Agency on research on LIGO interferometers as impulse seismic event detectors.

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. Four science runs have been performed: S-1, in the period from August 23, 2002 to September 9, 2002, with a sensitivity of about a factor of 100 from the design goal; S-2 lasted 59 days from February 14, 2003 to April 14, 2003, with a sensitivity of about a factor of 10 from the design goal; S-3 in the period from October 31, 2003 to January 8, 2004, with a sensitivity of about a factor of 3.5 from the design goal; and S-4 from February 22, 2005 to March 23, 2005. The improvements achieved in S-4 were remarkable. The addition of the Hydraulic External Pre-Isolation (HEPI) system to the Livingston interferometer to eliminate interference from anthropogenic noise sources was totally successful, as indicated in the improvement of the Livingston duty cycle from 21.8 percent in S-3 to 74.5 percent in S-4 leading to more than a 50 percent triple coincidence operation during the run. In addition, during S-4 all three interferometers showed high sensitivity, achieving levels within a factor of 2 of design sensitivity. Further improvements have culminated with the start of the long S-5 science run, which began on 4 November 2005 and is expected to last for eighteen months, operating with a sensitivity somewhat better than the design goal. The FY 2007 Request for LIGO is for $33 million. 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.

The LIGO site in Livingston Parish, LA, was shut down in preparation for Hurricane Katrina, in accordance with established emergency preparedness procedures, and suffered very minor damage. The facility is participating in the S-5 science run with no loss of sensitivity.

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
(Obligated Dollars and Estimates 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 Actual					32.00		32.00	-	$32.00
FY 2006 Current Plan					31.68		31.68	-	$31.68
FY 2007 Request					33.00		33.00	-	$33.00
FY 2008 Estimate					26.55		26.55	-	$26.55
FY 2009 Estimate					26.78		26.78	-	$26.78
FY 2010 Estimate					24.42		24.42	-	$24.42
FY 2011 Estimate					23.70		23.70	-	$23.70
FY 2012 Estimate					20.94		20.94	-	$20.94
Subtotal, R&RA	$47.56		$35.90		$362.57		$446.03		
Subtotal, MREFC		-		$236.00		-		$236.00	
Total, Each Stage		$47.56		$271.90		$362.57			$682.03

NOTE: The expected operational lifespan of this project is about 20 years. The decreases beginning in FY 2008 reflect the initiation of construction of Advanced LIGO, scheduled to begin that year. LIGO activities will continue during the construction of AdvLIGO. These operations estimates are developed strictly for planning purposes and are based on current cost profiles; they will be updated as new information becomes available. For more information on future operations of the upgraded facility, please consult the MREFC chapter of this document.

Detailed 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. Note that the M&O figures for LIGO in FY 2008 through FY 2012 are the same as those shown for AdvLIGO in the MREFC section.

Renewal or Termination: The cooperative agreement for the support of LIGO operations expires in FY 2006. NSF is planning to make a two-year extension to LIGO for FY 2007 and FY 2008 to continue operations, including the current extended science run, and to conduct research in preparation for Advanced LIGO.

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 Experiences for Teachers (RET) Program, a set of "scientist-teacher-student" research projects in support of LIGO, and participation in the Summer Undergraduates Research Fellowships/Research Experiences for Undergraduates (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 include 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 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 Systemic Initiative Program. Construction of the center began in early FY 2006. Outreach coordinators have recently been hired 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 $5.0 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 40 collaborating institutions with over 500 participating scientists. A Memorandum of Understanding (MOU) between the LIGO Laboratory and each institution determines the role and membership responsibilities of each participating 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, the FY 2007 Budget requests funding for the Atacama Large Millimeter Array ($47.89 million); EarthScope ($27.40 million); the IceCube Neutrino Observatory ($28.65 million); the National Ecological Observatory Network ($12.0 million); the Scientific Ocean Drilling Vessel ($42.88 million); and the South Pole Station Modernization Project ($9.13 million). An additional $3.0 million is requested to reimburse the DOJ Judgment Fund for a settlement related to the Polar Aircraft Upgrades project. NSF's second priority are those projects that have received NSB-approval for inclusion in a budget request but which have not yet received funding. NSF is requesting funding for two new starts in FY 2007. In priority order, these are the Alaska Region Research Vessel ($56.0 million) and the Ocean Observatories Initiative ($13.50 million). Finally, NSF is requesting funding for one new start in FY 2008: Advanced LIGO ($28.48 million in FY 2008).

For additional information of projects funded through the MREFC account, please see the MREFC chapter of this document.

National High Magnetic Field Laboratory (NHMFL)

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-review 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 2005, its regional K-12 outreach efforts engaged over 6500 students from Florida and neighboring Georgia in hands-on science activities and tours of the laboratory.

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 such as the advancement of conducting materials for magnets, including high quality Copper-Niobium micro-composite wires with outstanding characteristics (strength, conductivity, and resistive ratio) that are now available for the construction of high field coils. These technology projects cover the range of analysis, design, materials, component development and testing, coil fabrication, cryogenics, and system integration and testing.

The laboratory is involved in numerous consortia, as one of its mission objectives is "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 2004, the laboratory collaborated with 24 private sector companies, 12 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 6,000 students, teachers and members of the general public. In addition, in 2005, the NHMFL launched a College Outreach-Workforce Initiative (CO-WIN) Program to broaden participation in the NHMFL programs. This has included outreach to around 200 undergraduates at Historically Black Colleges or Universities (HBCU's).

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 the facility was dedicated and opened 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 Affairs 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, 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, represents 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.

The National Facilities Program Director in NSF's Division of Materials Research (in MPS) has primary responsibility for NSF administration and oversight of the NHMFL 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.

Current Project Status: When first established in 1990, the primary emphasis of the NHMFL was magnet technology and development in order to provide high magnetic fields for users. An extensive suite of instrumentation for high-field research is now in place. Major projects completed include a continuous-field 45 Tesla hybrid magnet in operation since 2003 and a 900 Megahertz (MHz) ultra-wide-bore nuclear magnetic resonance (NMR) magnet open for use since July 2005. The NHMFL is now moving to a new phase with emphasis on service to users in combination with in-house and collaborative research and an extensive set of educational programs. The magnet technology activity has moved towards the development of new energy efficient magnets and to making high magnetic fields available at the nation's premier neutron and photon sources.

The FY 2007 Request for the NHMFL totals $26.50 million, including support for the National High Field Mass Spectrometry Facility (NHFMS) from the MPS Division of Chemistry.

Renewal or Re-Competition: NSF renewed support for the NHMFL in 1996 and again in 2001 following comprehensive external reviews. The current five-year cooperative agreement for the support of NHMFL operations was due to expire in FY 2005. In FY 2004, the National Science Board (NSB) approved a two-year extension through December 2007 "to allow time for a National Academy of Sciences panel to complete a report on high magnetic field science and technology and for the National Science Foundation (NSF) to convene a 'blue-ribbon' panel to recommend the best course of action concerning re-competition

of the NHMFL." Both panels have now completed their work[1]. NSF is currently examining options for further support of the NHMFL either by renewal or through recompetition.

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	6.50	17.43	$23.93
FY 2004	3.44	21.06	$24.50
FY 2005	3.83	21.67	$25.50
FY 2006 Current Plan	3.90	21.84	$25.74
FY 2007 Request	4.00	22.50	$26.50
FY 2008 Estimate	4.00	22.50	$26.50
FY 2009 Estimate	4.00	22.50	$26.50
FY 2010 Estimate	4.00	22.50	$26.50
FY 2011 Estimate	4.00	22.50	$26.50
FY 2012 Estimate	4.00	22.50	$26.50

The data are presented as being either implementation (permanent equipment) or operations and maintenance (non-permanent equipment). Estimates for FY 2008 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.

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 is currently available to users through a competitive peer review process. There has been significant progress in the DC and pulse user magnet facilities in achievable field, bore, homogeneity and cooling time upgrades to the standard magnet systems. A construction proposal for the Series-Connected Hybrid (SCH) is currently under review by NSF. SCH will provide combined high DC field and high homogeneity at much lower power than current magnets. As the lead institution for magnet technology development, in FY 2004 the NHMFL designed and built 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

[1]Information on these panels may be found on the following websites: http://www.nsf.gov/attachments/102806/public/HighMagneticFieldsReport.pdf (a report of the NHMFL review panel lead by Dr. Robert Richardson on behalf of the MPS Advisory Committee); and http://www7.nationalacademies.org/bpa/COHMAG_committee.html (a report prepared by the Committee on Opportunities in High Magnetic Field Science).

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. A conceptual engineering design proposal for a special high-field magnet for neutron scattering experiments at the Spallation Neutron Source is currently under review by NSF.

The NHMFL's Ion Cyclotron Resonsance (ICR) Program has two Fourier Transform-Ion Cyclotron Resonance (FT-ICR) mass spectrometers available to users. A 14.5 Tesla system is the highest field FT-ICR mass spectrometer in the world, and it is being 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 and continues through 2007 has 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.

Associated Research and Education Activities: The NHMFL base award currently includes approximately $240,000 per year in support of Research Experiences for Undergraduates (REU), and a wide variety of pre-college educational outreach and partnership activities with additional funding from the State of Florida. The REU program further supports the NHMFL CO-WIN program, which hosted 24 females, 2 Hispanics and 4 African-Americans among the 42 REU students in the 2004 and 2005 programs. In FY 2006 NHMFL was awarded $122,057 to continue a Research Experiences for Teachers (RET) activity in FY 2006 and 2007.

In FY 2005, educators at the Center for Integrating Research and Learning (an integral part of the NHMFL) provided in-class educational experiences for over 6600 students from 31 schools in nine counties and two states. The Center provided professional development opportunities for over 100 teachers through summer institutes, workshops, and conferences. In addition, tours of the NHMFL were provided to 970 members of the general public with 840 contact hours led by over 60 different guides. This gives rise to a total of more than 7000 students, teachers, and general public coming in contact with some facet of the NHMFL's educational programs.

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	16	189
FY 2005[d]	7,000	20	12	200

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

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

[3]Reflects teachers participating in workshops, Ambassador Program, and Research Experiences for Teachers.

[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 2003.

[d]The FY 2005 number of students receiving PhD's data is incomplete

In addition to the individuals included 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 2005, the NHMFL at FSU supported an average of 86 graduate students, 29 postdoctoral research associates, and 18 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, 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 individual users annually.

National Nanofabrication Infrastructure Network (NNIN)

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 successfully 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 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. The second annual review was held at the Austin, Texas node in February 2005. 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 FY 2007 request is $13.89 million, $130,000 above the FY 2006 Current Plan of $13.76 million. 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	Total, NSF
FY 2004		13.80	$13.80
FY 2005		13.90	$13.90
FY 2006 Current Plan		13.76	$13.76
FY 2007 Request		13.89	$13.89
FY 2008 Estimate		15.90	$15.90
FY 2009 Estimate		18.30	$18.30
FY 2010 Estimate		21.00	$21.00
FY 2011 Estimate		24.10	$24.10
FY 2012 Estimate		24.70	$24.70

NOTE: Data in FY 2004-2007 does not include $200,000 provided through the Advanced Technological Education program in the Directorate for Education and Human Resources. Estimates for FY 2008 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.

- Operations and Maintenance: 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 2008 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 March 2004-February 2005. The cumulative number of users for all 13 NNIN sites is 4,133. This includes academic users (3,560), small company users (423), and large company users (150). The number of graduate students conducting research at the facilities during the year was over 3,200, and the number of undergraduates was over 150. Over 1,700 scholarly publications resulted from users of the facilities.

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 second year of the REU program, 81 students participated. In FY 2006, 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 (NSCL)

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 U.S. 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 recently 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 three Associate Directors: one for Nuclear Science, one for Accelerator Research, and one for Operations. 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. During the NSCL upgrade, NSF convened several technical panels to review cost, schedule, technical progress, and management of the project to monitor progress and maintain oversight.

Current Project Status: An experimental program using the recently completed coupled cyclotron facility is now underway. The FY 2007 Request for the NSCL totals $17.60 million, a slight increase over the the FY 2006 Current Plan of $17.32 million for FY 2006. 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 Actual		17.50	$17.50
FY 2006 Current Plan		17.32	$17.32
FY 2007 Request		17.60	$17.60
FY 2008 Estimate		18.00	$18.00
FY 2009 Estimate		18.00	$18.00
FY 2010 Estimate		18.00	$18.00
FY 2011 Estimate		18.00	$18.00
FY 2012 Estimate		18.00	$18.00

The current Cooperative Agreement expires in FY 2006. Operations estimates for FY 2008 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 upgraded between 1996 and 2001 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. Activities include routine preventive maintenance of the two coupled NSCL cyclotrons carried out each quarter, including vacuum systems, RF power systems, beam transport systems, the helium refrigerator used to supply coolant for the superconducting cyclotrons, and miscellaneous subsystems. Approximately 25 percent of the funding is directed toward in-house research (both experimental nuclear science and accelerator research and 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 NSCL faculty has an excellent reputation for high quality instruction and innovation in the classroom. Several NSCL faculty members have received Michigan State University's prestigious Teacher Scholar Award. NSCL faculty members make effective use of technology to enhance active learning in large lecture courses commonly found at large research universities. They pioneered the CAPA (Computer-Assisted Personalized Assignment) program and developed it further into the Learning Online Network with CAPA (LON-CAPA), an open-source software system, free of licensing fees, which provides a shared pool of over 60,000 granular learning

resources within the framework of a full-featured course management system. Faculty at over 30 colleges and universities worldwide participate in the creation and sharing of problems as well as of other educational resources. In addition, online learning materials from seven major science textbook publishers are available in connection with the adoption of their printed materials, and K-12 teachers from over 20 schools use LON-CAPA for their students. NSCL faculty have also pioneered the use of multi-media "virtual university" teaching technologies and offer several courses for long-distance learners over interactive websites.

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

NEES: The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)

Project Description: NEES is a national, networked simulation resource of 15 advanced, geographically distributed, shared use earthquake engineering research experimental facilities with teleobservation and teleoperation capabilities. NEES provides a national infrastructure 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. Experimental facilities include shake tables, geotechnical centrifuges, a tsunami wave basin, large-scale laboratory experimentation systems, and mobile and permanently installed field equipment. NEES facilities are 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. NEES is currently operated by the non-profit corporation NEES Consortium, Inc. (NEESinc), headquartered in Davis, California. Through an initial five-year cooperative agreement with NSF (FY 2005 – FY 2009), NEESinc operates the 15 experimental facilities; the NEES cyberinfrastructure center; coordinates education, outreach, and training; and develops national and international partnerships.

Researchers at the University of California, San Diego, in partnership with industry, use the largest outdoor shake table in the U.S. as part of NEES to test the tallest building structure ever on a shake table. This seven-story, 65-foot tall, reinforced concrete structure is being tested to investigate "promising new designs that might improve the earthquake safety of apartment and condominium buildings and other residential structures in densely populated and seismically active regions in Los Angeles and Southern California." Credit: *Professor José I Restrepo, Department of Structural Engineering, University of Californa, San Diego*

Principal Scientific Goals: NEES' broad-based national research facilities and cyberinfrastructure enables new discovery and knowledge through capabilities to now test 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 enables the design of new methodologies, 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) 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. NSF and NEESinc have recently developed partnerships to utilize the NEES infrastructure with the 3-D Full-Scale Earthquake Testing Shake Table Facility (E-Defense), built by the Japanese National Research Institute for Earth Science and Disaster Prevention (NIED) and operational in 2005. To facilitate NEES/E-Defense collaboration, in August 2005, NEESinc and NIED signed a Memorandum of Understanding, and in September 2005, NSF and the Japanese Ministry of Education, Culture, Sports, Science, and Technology signed a Memorandum Concerning Cooperation in the Area of Disaster Prevention Research. 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.

Management and Oversight: Through a NSF cooperative agreement, NEESinc operates the 15 experimental facilities 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 experimental facility has an on site director responsible for local day-to-day equipment management, operations, and interface with NEESinc, other NEES facilities, 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 operations through a cooperative agreement with NEESinc. NEES operations are reviewed through annual site visits. The NSF program manager for NEES is located in the Civil, Mechanical and Manufacturing Innovation (CMMI) Division in the Directorate for Engineering (ENG). The NSF Deputy Director for Large Facility Projects in the Office of Budget, Finance, and Award Management 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 was used to fund construction of deferred capabilities for NEES. This included four new capabilities for system integration (cyberinfrastructure), completed on September 30, 2005, and new capabilities at 13 experimental facilities, to be completed by September 30, 2006.

Through annual program solicitations and Small Grants for Exploratory Research, CMMI has funded 26 research projects to utilize the NEES facilities. In FY 2007, $15.0 million will be used to support basic research in multi-hazard engineering involving experimental and theoretical simulations at the NEES facilities, addressing important challenges in earthquake and tsunami engineering research.

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 Experimental Program to Stimulate Competitive Research through the Education and Human Resources (EHR) account.

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						17.94		$17.94	-	-	**$17.94**
FY 2006 Current Plan						20.31		$20.31	-	-	**$20.31**
FY 2007 Request						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						23.57		$23.57	-	-	**$23.57**
FY 2011 Estimate						23.57		$23.57	-	-	**$23.57**
FY 2012 Estimate						24.16		$24.16	-	-	**$24.16**
Subtotal, R&RA	$0.70		$0.00			$176.02		$176.72			
Subtotal, MREFC		$0.39		$81.37			$0.00		$81.76		
Subtotal, EHR					$1.10					$1.10	
Total, Each Stage		**$1.09**			**$82.47**		**$176.02**				**$259.58**

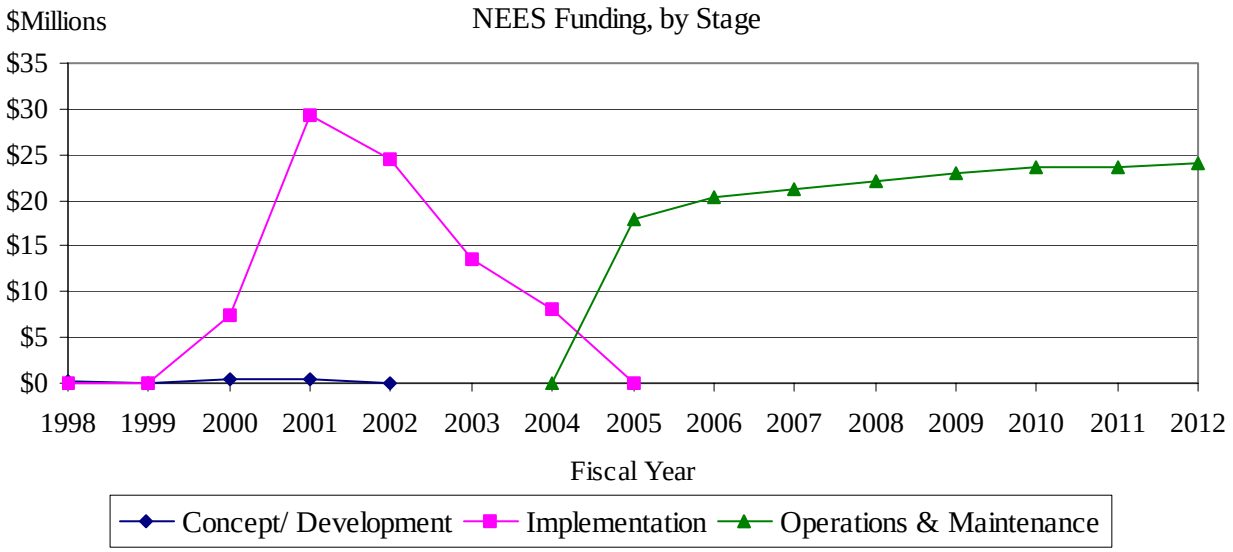
NOTE: The expected operational lifespan of this project is 10 years, from FY 2005 to FY 2014. NEES operations for FY 2005 – FY 2009 was approved by the National Science Board in May 2004 for up to $106.52 million total; approximately $21.3 million annually. Operations estimates for FY 2010 and beyond 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 funded an international workshop to foster long term working relationships for experimental earthquake engineering research and national workshops and studies 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 supported a range of equipment acquisition, as well as system integration and consortium development. To encourage the broadest participation for establishment of geographically distributed NEES experimental facilities, 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 major construction period in FY 2004, NEES entered its 10-year operational period through FY 2014. NEESinc provides the leadership, management, and coordination for operations of all the NEES shared use resources and establishes a broad and integrated partnership that includes participation of the full membership of the earthquake engineering community, both within the U.S. and abroad. NEESinc provided 2877 shared use days during its initial FY 2005 reporting period. As an internet-based resource, access to the NEES network is 24/7 to anyone with Internet capabilities. The NEES experimental facilities are utilized annually for research by the broad earthquake engineering community as well as by personnel at the host institutions of the 15 NEES facilities.



Renewal or Termination: The initial five-year NEES operations award may be renewed once for an additional five years, subject to satisfactory review of performance and availability of funds. The maximum duration of this award is ten years.

Science Support: Along with direct operations and maintenance support for NEES, NSF provides support for research conducted at NEES experimental facilities 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 utilize the NEES experimental facilities, 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 $15.0 million in FY 2007.

Other Facilities

Other Facilities support, $15.26 million in FY 2007, includes continued support for the continued phase-out of program and contract activities for the Ocean Drilling Program. Other items within this category include facilities for physics and materials research.

POLAR FACILITIES AND LOGISTICS

Antarctic Facilities and Logistics

Project Description: Antarctic Facilities and Operations provides 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, 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. The U.S. Antarctic Program also provides environmental stewardship and maintains U.S. presence in Antarctica in accord with U.S. policy.

The Earth Station behind Palmer Station provides a communication link via the 5 meter diameter antenna that sees a satellite orbiting the equator, allowing people to make phone calls and use the Internet, as well as providing the remote station with telemedicine capability.

Principal Education Goals: By maintaining and operating the three U.S. stations in Antarctica, Antarctic Facilities and Operations supports 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 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 Division of 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 oversight and direction of South Pole Station Modernization, an activity funded out of the Major Research Equipment and Facilities Construction (MREFC) account since FY 1998. The new station will provide the infrastructure required for imaginative new research only possible at the South Pole.

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 is discussed in the MREFC chapter.

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		147.04	$147.04
FY 2005		155.73	$155.73
FY 2006 Current Plan		199.96	$199.96
FY 2007 Request		218.09	$218.09
FY 2008 Estimate		224.60	$224.60
FY 2009 Estimate		231.30	$231.30
FY 2010 Estimate		238.20	$238.20
FY 2011 Estimate		245.30	$245.30

NOTE: Estimates for FY 2008 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 estimates 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. The contractor is selected through a competitive bidding process. Rotary- and fixed-wing aircraft used in support of research are provided through additional competitively awarded contracts. 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 has exercised its option to extend the performance period through 2010.

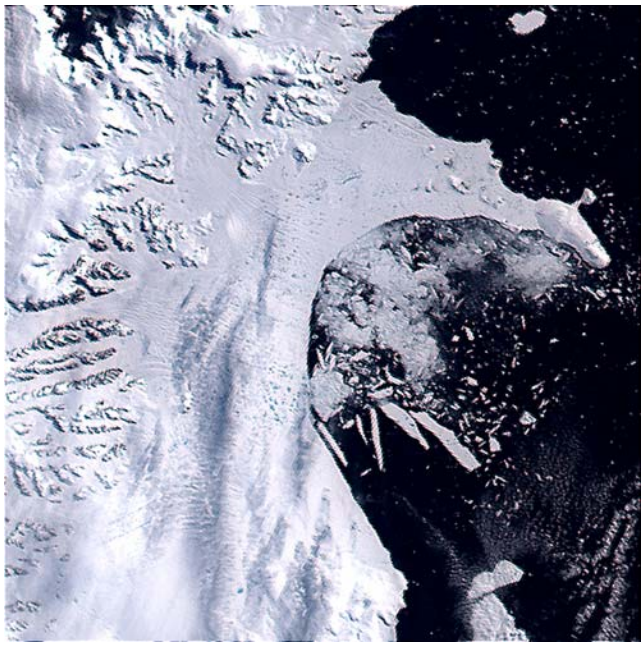
Associated Research and Education Activities: The Antarctic infrastructure makes science in Antarctica possible - ranging from astrophysics to microbiology and climatology - and also provides infrastructure supporting education and outreach activities. The U.S. Antarctic Program infrastructure and scientific activity also maintains a U.S. presence in Antarctica in accordance with U.S. policy. Research is funded through NSF's Antarctic Research Grants Program and through other federal agencies funding research in Antarctica. A major focus of research and education activity in FY 2007 and FY 2008 in the polar regions will be the International Polar Year (IPY).

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 responds 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. The current contract with VECO USA to provide research support and logistics services for NSF-sponsored activities in the Arctic was recompeted and awarded in January 2005. The contract has an initial term of four years and three one-year extensions excercised on the basis of performance. Additional major support 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; and development of a network of strategically placed U.S. Long-Term Ecological Research Observatories linked to similar efforts in Europe and Canada.

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 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 resupply of McMurdo Station; fuel purchased from the Defense Logistics Agency; and use of Department of Defense satellites for communications.



One of a series of satellite images of the Antarctic Penninsula that recorded the catastrophic break-up of a massive portion of the Larsen B ice shelf – an area larger than Rhode Island – in 2002. *Credit: USAP*

NSF is requesting $112.42 million for Polar Logistics, an increase of $10.56 million from the FY 2006 Current Plan of $101.86 million. Arctic Research Support and Logistics increases to $44.90 million, and will provide infrastructure critical to supporting IPY as well as 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 increases from $66.66 million in FY 2006 to $67.52 million in FY 2007.

Polar Icebreakers

With the FY 2006 Budget Request, NSF assumed the responsibility, from the U.S. Coast Guard, for funding the costs of icebreakers that support scientific research in polar regions. The FY 2007 Request for support of this activity is $57.0 million.

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS

National Astronomy and Ionosphere Center (NAIC)

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 and serves over 250 users annually. 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.

The Gregorian Dome housing the telescope's feed optics and detectors is suspended 450 feet above the main reflector of the Arecibo radio telescope. With its diameter of 305 m (1000 feet), the main reflecting dish covers almost twenty acres and makes Arecibo the largest telescope on the planet.

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 NRAO, Penn State and other universities, and the Angel Ramos Foundation of Puerto Rico (a private organization).

Management and Oversight: 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. The proposal from Cornell was deemed to be superior and was approved for funding by the NSB at its March 2005 meeting. A new cooperative agreement is now in effect. The FY 2007 Request for NAIC totals $12.16 million, level with the FY 2006 Current Plan.

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[1]
FY 2001	1.10	9.00	$10.10
FY 2002		11.00	$11.00
FY 2003		12.63	$12.63
FY 2004		12.32	$12.32
FY 2005 Actual		12.42	$12.42
FY 2006 Current Plan		12.16	$12.16
FY 2007 Request		12.16	$12.16
FY 2008 Estimate		12.16	$12.16
FY 2009 Estimate		12.16	$12.16
FY 2010 Estimate		12.16	$12.16
FY 2011 Estimate		12.16	$12.16
FY 2012 Estimate		12.16	$12.16

NOTE: Total budget includes funding from both MPS/AST and GEO/ATM. In FY 2007, $10.46 million is provided from AST and $1.70 million from ATM. Operations budgets for FY 2008 and beyond are placeholders only. Budgets will be established based on the outcome of a review of AST facilities portfolio in 2005-2006.

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 usable bandwidth.

- Operations and Maintenance: Funding for management, operations and maintenance primarily maintains and utilizes existing facilities and develops new instrumentation in support of research by the national astronomical community. 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). The planetary radar program was funded by NASA until FY 2005 and is now incorporated in the base NAIC budget.

Renewal or Termination: On October 1, 2005, a new 54-month cooperative agreement with Cornell University went into effect.

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 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.

Science Support: In addition to the funds listed above, approximately $70,000 per year is provided for the REU activities from the Program for Education and Special Programs in the Division of Astronomical Sciences (in MPS) and the Division of Atmospheric Sciences (in GEO). 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 NAIC. Many users are supported through NSF or NASA grants which pursue scientific programs that require use of NAIC.

National Center for Atmospheric Research (NCAR)

Project Description: National Center for Atmospheric Research 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 45 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 69 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, DOD, 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 Contracts and Complex Agreements (DCCA), 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 2," in FY 2006 NCAR is embarking on a plan to implement 5 strategic goals and priorities that collectively have a wide range in scientific scope. Examples include explaining how the Earth system functions and accurately predict how it is likely to evolve and provide robust, accessible, and well-integrated information services and tools for research, analysis, and education. By connecting the strategic goals, plans, and accomplishments, the NCAR annual report (http://www.nar.ucar.edu/) provides an summary of the full life-cycle of the research, facilities, and educational activities that have taken place in FY 2005.

In addition, NCAR has managed the acquisition of the Major Research Equipment and Facilities Construction (MREFC) project High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER). A highly modified and FAA certified Gulfstream G-V aircraft, HIAPER begins full scientific operations research at in the first quarter of calendar year 2006. HIAPER will be operated and maintain by NCAR. Operation of HIAPER is estimated at approximately $5.0 million annually.

NCAR 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 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	4.73	75.95	$80.68
FY 2006 Current Plan	4.85	78.51	$83.36
FY 2007 Request	4.97	81.88	$86.85
FY 2008 Estimate	4.30	83.00	$87.30
FY 2009 Estimate	4.44	85.00	$89.44
FY 2010 Estimate	4.58	87.00	$91.58
FY 2011 Estimate	4.55	89.00	$93.55
FY 2012 Estimate	4.69	91.00	$95.69

NOTE: MPS contributions for statistics and modeling are included. Operations estimates for FY 2008 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 is being performed; funding levels beyond FY 2006 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. In FY 2005, there were 637 guided tour groups involving 12,727 visitors on scheduled tours of which 8,623 were in the K-12 group, 241 were college or graduate students, and approximately 60,000 adults from the general public. The significant increase in visitors is directly attributable to the major upgrade in the Mesa Laboratory informal science displays. 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. In addition, NCAR's education and outreach (EO) program maintains a website Windows to the Universe (www.windows.ucar.edu/, a bi-lingual English/Spanish website) and other EO websites which have K-12 as their primary audience. These sites touch many students with over 10,386,330 user sessions, involving 83,415,577 pages served.

Direct Impact of NCAR's Participation in Education Activities

Year	K-12	Undergrad	Graduate	Teachers
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
FY 2005	13,723[c]	*92*	*135*	1,510

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.

[c] Includes public visits to Mesa Lab throughout year and special events: Super Science Saturday and 2 Wild Bear Science Saturdays, Earth Day: (4,100 attendance)

Science Support: NSF-supported researchers with grants totaling approximately $25 million per year used the aircraft and observational facilities operated by NCAR in FY 2005. This support comes from programs within the Atmospheric Sciences Division (in GEO) 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.

National Optical Astronomy Observatories (NOAO) and the National Solar Observatory (NSO)

Project Description: NOAO 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 is the gateway for the U.S. astronomical community to 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. In addition, NSO provides routine synoptic solar data used by many researchers and other agencies. 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 and serve over 1,000 users annually.

Principal Scientific Goals: NOAO and NSO support basic research in astronomy and solar physics by providing access to modern ground-based astronomical telescopes and instrumentation to the nation's astronomers and solar physicists, 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: (1) 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; (2) the Teacher Leaders in Research-Based Science Education (TLRBSE), a summer workshop for middle and high school teachers; and (3) Astronomy from the Ground Up, a program for professional development of informal science educators from small- and moderate-size science centers nationwide.

Partnerships and Connections to Industry: Thirty-two U.S. member institutions and seven international affiliate members comprise the Member Institutions of the Association of Universities for Research in Astronomy (AURA), Inc., the management organization for NOAO and NSO. 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.

An aerial image of the Cerro Tololo Interamerican Observatory in Chile, taken after the dome of the Blanco 4-meter telescope was silvered early in 2001. *Credit: NOAO/AURA*

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 that are submitted to NSF. 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, 3.5 years into the current cooperative agreement. The FY 2007 Request for base operations for NOAO and NSO totals $34.55 million, level with the FY 2006 Current Plan. Two community instrumentation programs are also administered by NOAO; these are increasing by $3.14 million, bringing the NOAO/NSO total to $40.05 million, up from the FY 2006 Current Plan of $36.91 million. The Telescope System Instrumentation Program (TSIP), totaling $4.0 million in the FY 2007 Request, an increase of $2.0 million over the FY 2006 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. The Adaptive Optics Development Program (AODP) totals $1.50 million in the FY 2007 Request, increasing $1.14 million over its FY 2006 Current Plan level.

NSO is nearing the completion of the design and development phase for the Advanced Technology Solar Telescope, which entered the 'readiness' phase for MREFC funding in late FY 2005. NOAO is also actively participating in the development of 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 National Research Council's Astronomy and Astrophysics Survey Committee.

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

NOAO and NSO Funding Profile
(Dollars in Millions)

	TSIP	AODP	NOAO and NSO Base Operations and Maintenance	Total, NSF
FY 2001			31.20	$31.20
FY 2002	4.00		32.82	$36.82
FY 2003	4.00	3.00	32.64	$39.64
FY 2004	4.00	3.00	34.35	$41.35
FY 2005	2.00	1.20	34.74	$37.94
FY 2006 Current Plan	2.00	0.36	34.55	$36.91
FY 2007 Request	4.00	1.50	34.55	$40.05
FY 2008 Estimate	4.00	1.50	34.55	$40.05
FY 2009 Estimate	4.00	1.50	34.55	$40.05
FY 2010 Estimate	4.00	1.50	34.55	$40.05
FY 2011 Estimate	4.00	1.50	34.55	$40.05
FY 2012 Estimate	4.00	1.50	34.55	$40.05

NOTE: The current cooperative agreement expires in FY 2007. Funding for FY 2008 and beyond are placeholders only. Budgets will be established based on the outcome of a review of AST facilities portfolio in 2005-2006.

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

- Implementation: 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 and the dedication of the Southern Astrophysical Research (SOAR) 4.1 m telescope in April 2004. SOAR commissioning is nearing completion and limited scientific observing has begun.

- 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 at the end of FY 2007. A management review will be carried out this year, 3.5 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 2008 and beyond will be determined based on the outcome of a review of AST facilities portfolio in 2005-2006.

Associated Research and Educational Activities: Teacher training includes participation of more than 160 teachers in Project ASTRO, which directly impacts nearly 6000 students in the Tucson area; intensive (multi-week) training of about 25 teachers per year through Teacher Learning through Research Based Science Education; and Research Experiences 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 Research Experiences for Undergraduate (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 EHR, 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 (NRAO)

Project Description: NRAO 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. NRAO is also the North American executing organization for the international ALMA project. 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, and annually serve over 1,500 users worldwide.

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, as well as the design, construction, test and implementation of innovative scientific instruments and telescopes for radio astronomy and of software tools for 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.

The Very Large Array, pictured here, consists of 27 radio antennas in a Y-shaped configuration on the Plains of San Agustin fifty miles west of Socorro, New Mexico. Each antenna is 25 meters (82 feet) in diameter. The data from the antennas is combined electronically to give the resolution of an antenna 36km (22 miles) across, with the sensitivity of a dish 130 meters (422 feet) in diameter.

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 submitted to NSF. NSF conducts periodic reviews of AUI management using external committees. Ongoing oversight and evaluation is by an assigned NSF program director in the Division of Astronomical Sciences (in 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 the end of FY 2009 by action of the National Science Board in December 2005. The VLA is undergoing an upgrade of its electronics and communications systems to significantly enhance its capabilities. The upgrade, referred to as Phase I of the Expanded Very Large Array (EVLA), is being carried out with NRAO funding. 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 2007 Request for NRAO totals $50.74 million, level with the FY 2006 Current Plan. The FY 2007 request includes an increase of $2.0 million for early ALMA operations for a total of $6.0 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	6.34	40.69	$47.03
FY 2006 Current Plan	5.00	45.74	$50.74
FY 2007 Request	5.00	45.74	$50.74
FY 2008 Estimate	4.32	46.42	$50.74
FY 2009 Estimate	4.32	46.42	$50.74
FY 2010 Estimate	4.32	46.42	$50.74
FY 2011 Estimate	4.32	46.42	$50.74
FY 2012 Estimate	4.32	46.42	$50.74

The current cooperative agreement expires in FY 2009. Operations budgets for FY 2008 and beyond are placeholders only. Budgets will be established based on the outcome of a review of AST facilities portfolio in 2005-2006.

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 New Mexico that will enhance the capabilities of the current VLA. This upgrade is referred to as Phase I of 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: While ALMA construction is funded through the MREFC account, as elements of the facility take form, operations and maintenance must begin. The funding profile for the ALMA

activity includes early operations funding beginning in FY 2005 at $1.0 million and increasing to $6.0 million in FY 2007. These amounts are included in the NRAO O&M figures above.

Renewal or Termination: The present cooperative agreement was extended to the end of FY 2009 with approval by the NSB in December 2005.

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 Research Experiences for Undergraduates (REU) program.

Science Support: In addition to the funding listed above, approximately $500,000 per year is provided in total from the Directorate for Education and Human Resources 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.

Recent Research Highlights

Image Courtesy of the American Physical Society

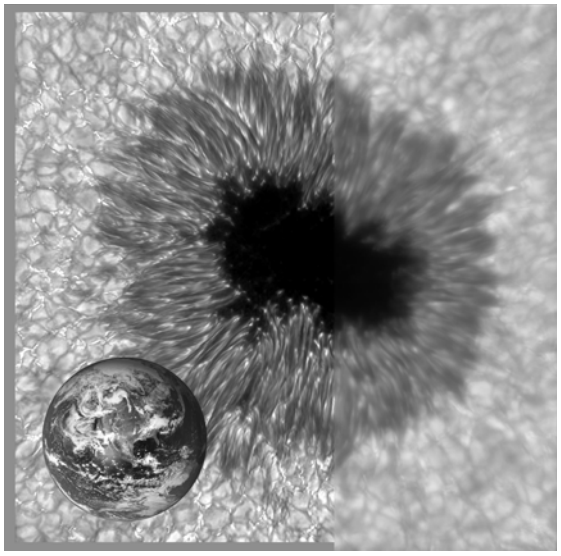
► **Catch a Wave from Space:** A new NSF-supported project called Einstein@Home permits members of the general public to participate in cutting-edge space research on their personal computers. The project reaches out through the Internet and harnesses those computers by the thousands to search through data from the Laser Interferometer Gravitational wave Observatory (LIGO) in the United States, and from the GEO 600 gravitational wave observatory in Germany. The goal is to find gravitational wave signals coming from extremely dense, rapidly rotating objects such as quark stars or neutron stars. If some of these compact stars are not perfectly spherical—which scientists believe is a distinct possibility—then the objects should emit characteristic gravitational waves that LIGO and GEO 600 may begin to detect in coming months. Einstein@home is a close collaboration between gravitational physicist Bruce Allen of the LIGO Scientific Collaboration group at the University of Wisconsin, Milwaukee, and the computer scientists who developed the software for a somewhat similar NASA program called SETI@home. LIGO, an NSF flagship project, is a crucial component of the U.S. participation in the World Year of Physics, a worldwide effort in education and outreach, based on Einstein's revolutionary discoveries in 1905. (MPS/PHY)

► **HIAPER Puts Atmospheric Research Above and Beyond**
NSF has provided a long-awaited way to take earth, environmental and atmospheric research to new heights. Last fall, a custom-designed aircraft called HIAPER (High-performance Instrument Airborne Platform for Environmental Research) was launched for its first operations to test onboard systems in a true research environment. The $81.50 million twin-engine airplane, outfitted with a unique suite of special instruments and sampling devices, can fly at the rarely studied boundary between the lower atmosphere and the stratosphere. Able to fly for thousands of miles while carrying a 5,600-pound payload of sophisticated research equipment, HIAPER is the most advanced aircraft research platform in the United States. (GEO/ATM)

Credit: Gemini Observatory

► **Detailed Views of the Large Magellanic Cloud** This cloudy tempest, known as the N44 superbubble complex, is dominated by a vast bubble about 325 by 250 light-years across. A cluster of massive stars inside the cavern has cleared away gas to form a distinctive mouth-shaped hollow shell. While astronomers do not agree on exactly how this bubble has evolved for up to the past 10 million years, they do know that the central cluster of massive stars is responsible

for the cloud's unusual appearance. It is likely that the explosive death of one or more of the cluster's most massive and short-lived stars played a key role in the formation of the large bubble. The image provides one of the most detailed views ever obtained of this relatively large region in the Large Magellanic Cloud, a satellite galaxy to the Milky Way. (MPS/AST)



Credit: Friedrich Woegner, Kiepenheuer-Institut fur Sonnenphysik and Chris Berst, Mark Dosma, NSO/AURA/NSF

► **High Resolution Images of the Sun** Advanced adaptive-optics technologies now available at the National Solar Observatory's Dunn Solar Telescope at Sunspot, NM, are revealing striking details on the surface of the Sun. Such ultra-high resolution images should greatly improve our understanding the causes of solar flares, the explosive eruptions that eject high-energy particles into space and cause "solar storms" in the vicinity of Earth. Because these storms can adversely affect communications, electrical transmission lines, earth-orbiting satellites, and the safety of astronauts, better forecasting is critical. This sunspot image, spanning an area more than three times wider than Earth, is built from a series of 80 individual images, each 1/100th of a second long. taken over a period of 3 seconds. The right-hand side is an uncorrected view, while the left-hand side shows the effect of adaptive optics Superimposed on these images and on the same scale is an image of the Earth. (MPS/AST)

► **MoNA: Involving Undergraduates in Detector Construction:** Undergraduates at nine different colleges and universities – including several undergraduate-only institutions – are carrying out the bulk of the construction and testing on the Modular Neutron Array (MoNA): a new detector designed to observe high energy neutrons produced by experiments at the National Superconducting Cyclotron Laboratory at Michigan State University.

Credit: NSCL, University of Michigan

The detector itself will be seven times more efficient at single neutron detection than the laboratory's existing detectors, and will therefore represent a significant advance in the NSCL's ability to investigate the properties of exotic, neutron-rich nuclei. The participation of the undergraduates means that MoNA will also have tremendous educational and training benefits. The students will learn the basic principles of scintillator and photomultiplier tube operation, extraction of position information from fast electronic timing techniques, and detector calibration procedures. They will learn about the various kinds of nuclear physics experiments that will make use

of this multi-detector array. And they will ultimately have the opportunity to participate in the assembly of the complete array at the NSCL, then see their work as part of a larger collaboration producing cutting-edge science in nuclear physics experiments. (MPS/PHY)

► **Learning from the Tsunami** Soon after the December 2004 Asian earthquake and tsunami, more than 15 NSF-supported reconnaissance teams mobilized to collect data on its impact and effect on roads, buildings and communities. New technologies made it possible to collect, organize, and preserve perishable field data not able to be captured following previous tsunamis. Scientists and engineers can now analyze the data stored in the NSF-supported archive to design strategies to lessen damage and loss of life from future disasters. This archive will allow researchers to easily re-examine and re-analyze the data using the latest technologies, which may lead to innovative discoveries.

Damage from the Great Sumatran Earthquake and Tsunami along India's coastline. *Credit: Professor Toshitaka Katada, Gunma University, Japan*

The Network for Earthquake Engineering Simulation (NEES) consortium is also developing a tsunami data repository. The consortium manages the cyberinfrastructure for NEES, linking earthquake researchers across the U.S. with leading-edge computing resources and research facilities. The cyberinfrastructure allows earthquake researchers to use NEES' world-class facilities to conduct collaborative research on ways to minimize the risks of future earthquakes and tsunamis. (ENG/CMMI)