MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION — $244,740,000

The FY 2008 Budget Request for the Major Research Equipment and Facilities Construction (MREFC) account is $244.74 million, an increase of $4.29 million, or 1.8 percent, above the FY 2007 Request of $240.45 million.

Major Research Equipment and Facilities Construction Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change Over FY 2007 Amount	Change Over FY 2007 Percent
Major Research Equipment & Facilities Construction	$233.81	$240.45	$244.74	$4.29	1.8%

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. Initial planning and design, and follow on operations and maintenance costs of the facilities are provided through the Research and Related Activities (R&RA) account.

MREFC Account Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
Ongoing Projects								
ARRV[1]		56.00	42.00	25.00	-			
ALMA[2]	48.66	64.27	102.07	74.75	42.76	21.44	3.00	-
DOJ Judgment		3.00	-					
EarthScope	49.62	27.40	-					
IceCube	56.44	28.65	22.38	11.33	0.95	-		
NEON[3]		4.00	8.00	20.00	30.00	26.00	12.00	-
OOI[4]		5.12	30.99	80.00	90.00	95.00	30.00	-
SODV	66.03	42.88	-					
SPSM[5]	13.07	9.13	6.55	-				
New Starts								
AdvLIGO[6]		-	32.75	51.43	46.30	15.21	23.73	15.50
MREFC Account Total	$233.81	$240.45	$244.74	$262.51	$210.01	$157.65	$68.73	$15.50

Totals may not add due to rounding.

[1]The recent baseline analysis for ARRV noted the potential for a cost increase of $25.0 million (included in FY 2009).

[2]ALMA is increased by $16.38 million in FY 2007 following a rebaselining completed in FY 2006. Figures for FY 2008 and beyond also reflect the new baseline.

[3]NEON is reduced in FY 2007 to partially cover ALMA's increase. NEON's revised baseline is expected in May 2007 following a Preliminary Design Review (PDR). The amount in FY 2012 reflects the reduced funding in FY 2007 and FY 2008.

[4]OOI is reduced by $8.38 million in FY 2007 to cover the remainder of ALMA's increase. OOI plans to conduct a PDR in December 2007, at which time firmer cost estimates will be available.

[5]The SPSM cost to complete was updated in August 2006. The revised work plan, schedule and estimate were reviewed in detail by an external panel in September 2006 and the estimate for FY 2008 reflects the cost to complete the remaining scope of the project in accordance with the revised schedule.

[6]The AdvLIGO estimate reflects the formal project baseline reviewed by the external panel convened by NSF in June 2006.

A modern and effective research infrastructure is critical to maintaining U.S. leadership in science and engineering (S&E). The future success of entire fields of research depends upon their access to new generations of powerful research tools. Increasingly, these tools are large and complex, and have a significant information technology component.

Among federal agencies, NSF is a primary supporter of forefront instrumentation and facilities for the academic research and education communities. In recent years, the number of funding requests for the construction of major research facilities and equipment from the S&E community has increased. Many of these requests have received outstanding reviews from research peers, program staff, management and policy officials, and the National Science Board (NSB). NSF's FY 2008 request for the MREFC account positions the agency to meet the future needs and opportunities of the research community.

In accordance with the plan outlined in "A Joint National Science Board-National Science Foundation Management report on *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation,*[1]", NSF continues to develop the guiding documentation for the MREFC process. NSF released its first *Facility Plan*[2] in September 2005 and will release its second annual *Facility Plan* in conjunction with this Budget Request. The revised *Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction (MREFC) Account*[3], also known as the *MREFC Guidelines*, were released in November 2005, and the final management document, the *Facility Manual*[4], which incorporates the *MREFC Guidelines*, is expected to be released in FY 2007. All of the projects in the MREFC account are undergoing or have undergone major cost and schedule reviews, as required by these guidelines.

- NSF contracted for two independent cost estimates for the **Alaska Region Research Vessel** (ARRV) in November 2006, which identified a $25.0 million increase. The estimates included a survey of the availability of U.S. shipyards, updates on major equipment quotes and pricing, and escalated labor costs through FY 2009. Accordingly, the ARRV funding profile includes an additional $25.0 million in FY 2009 to cover this cost increase.

- An independent baseline review for the **Atacama Large Millimeter Array** (ALMA) was completed in FY 2006 and resulted in a reduction of scope, a revised cost estimate, and a 24 month extension of the project schedule. Based on this review, the FY 2007 funding requirement increased by $16.38 million above the FY 2007 Request level. NSF will reduce NEON and OOI in FY 2007 to offset this increase.

[1]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 of the same name. (www.nsf.gov/pubs/2005/nsb0577/nsb0577.pdf)

[2] The 2005 NSF *Facility Plan* provides an overview of science and engineering research objectives and opportunities that collectively form the context for NSF's current and potential future investments through its MREFC account. (www.nsf.gov/pubs/2005/nsf05058/nsf05058.pdf)

[3] The *Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction (MREFC) Account* (the *MREFC Guidelines)*, clearly define the MREFC planning process, including the policies, and requirements by which candidate projects are identified, developed, prioritized, and selected for funding. (www.nsf.gov/bfa/docs/mrefcguidelines1206.pdf)

[4] The revised *Facility Manual* and supplemental modules will provide step-by-step guidance to NSF staff and awardees on project planning, management, and oversight of large facilities; clearly state the policies, procedures, and requirements that come into play at each stage of the facility project; and document the experience, knowledge, and best practices gained over many years in order to facilitate a process of continuous improvement.

- NSF initiates support for **National Ecological Observatory Network** (NEON) and the **Ocean Observatories Initiative** (OOI) in FY 2007. Both projects will undergo Preliminary Design Reviews (PDRs) on schedule in 2007, after which revised funding profiles will be available. Information on these reviews is provided in the relevant sections of this chapter.

In order for a project to be considered for MREFC funding, NSF requires that it represent an exceptional opportunity that enables research and education. In addition, the project should be transformative in nature in that it should have the potential to shift the paradigm in scientific understanding and/or infrastructure technology. NSF believes that all the projects included in the FY 2008 Budget Request meet these criteria.

Projects being considered for MREFC funding undergo a multi-phase review and approval process[5]. This includes a review by the internal NSF MREFC Panel, chaired by the NSF Deputy Director and comprised of the Assistant Directors, the Heads of the Office of Polar Programs (OPP), the Office of Cyberinfrastructure (OCI), the Office of International Science and Engineering (OISE), the Office of Legislative and Public Affairs (OLPA), and the Chief Financial Officer (CFO), the BFA Deputy Director for Large Facility Projects (DDLFP), and the Office of General Counsel (OGC). The MREFC Panel makes recommendations to the NSF Director with attention to criteria such as scientific merit, importance, readiness, and cost-benefit. The Director then selects candidates to send to the NSB for consideration, which then approves, or not, projects for inclusion in future budget requests. The Director, in keeping with NSB prioritization, selects from the group of approved projects those appropriate for inclusion in a particular budget request to the Office of Management and Budget (OMB), and after discussion with OMB, to the Congress.

NSF believes that the highest priority within the MREFC Account must be the current projects. To that end, the FY 2008 Budget requests funding for the Alaska Region Research Vessel ($42.0 million); the Atacama Large Millimeter Array ($102.07 million); the IceCube Neutrino Observatory ($22.38 million); the National Ecological Observatory Network ($8.0 million); the Ocean Observatories Initiative ($30.99 million); and the South Pole Station Modernization project ($6.55 million).

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 one new start in FY 2008: Advanced LIGO ($32.75 million).

Appropriation Language

For necessary expenses for the acquisition, construction, commissioning, and upgrading of major research equipment, facilities, and other such capital assets pursuant to the National Science Foundation Act of 1950, as amended, including authorized travel, $244,740,000, to remain available until expended.

[5] The process is described in greater detail in the *MREFC Guidelines.*

Major Research Equipment and Facilities Construction
FY 2008 Summary Statement
(Dollars in Millions)

	Enacted/ Request	Rescission	Carryover/ Recoveries	Transfers	Total Resources	Obligations Incurred/Est.
FY 2006 Appropriation	$193.35	-$2.47	$45.71	-	$236.59	$233.81
FY 2007 Request	240.45	-	2.78	-	243.23	243.23
FY 2008 Request	244.74	-	0.00	-	244.74	244.74
$ Change from FY 2007						$1.51
% Change from FY 2007						0.6%

Totals may not add due to rounding.

Explanation of Carryover:

Within the Major Research Equipment and Facilities Construction (MREFC) appropriation, a total of $2.78 million was carried forward into FY 2007 including $2.61 million for EarthScope. The Office of Polar Programs carried forward $138,209 for the South Pole Station Modernization project and the South Pole Safety and Health project.

FIRST PRIORITY: ONGOING PROJECTS IN FY 2008

Ongoing projects in FY 2008 include:

- the Alaska Region Research Vessel
- the Atacama Large Millimeter Array
- the IceCube Neutrino Observatory
- the National Ecological Observatory Network
- the Ocean Observatories Initiative, and
- the South Pole Station Modernization project.

Information on these projects, as well as information on EarthScope and the Scientific Ocean Drilling Vessel, both of which received their final year of construction funding in FY 2007, follows.

Alaska Region Research Vessel

Project Description: The Alaska Region Research Vessel (ARRV) is proposed to replace the 40-year old R/V *Alpha Helix*, the oldest ship in the national Academic Research Fleet. At present, science activities in this region are limited by the capabilities of the R/V *Alpha Helix*, a restrictively small ship that cannot operate in ice or in severe winter weather in the open seas. The ARRV will be built to operate year round in the challenging waters of the Chukchi, Beaufort, and Bering Seas, as well as the open Gulf of Alaska, coastal Southeast Alaska and Prince William Sound, including in seasonal ice.

As we strive to understand a variety of complex regional and global ecosystem and climate issues, the need to conduct research at the ice edge and in seasonal ice (up to 2.5 feet thick) has become increasingly urgent. The ARRV will provide greatly improved access to the region, enabling further exploration to address critical issues. With an operating year of 275-300 days, the ARRV could accommodate up to 500 scientists and students at sea annually.

This image is an artist's rendition of the ARRV, proposed to replace the R/V *Alpha Helix*, which, at 39 years is the oldest ship in the national academic research fleet.

Principal Scientific Goals: Satellite observations have shown that the perennial ice in the arctic is thinning at a rate of 9 percent per decade, which is beginning to have major regional and global consequences. Research is urgently needed on topics ranging from climate change, ocean circulation, ecosystem studies and fisheries research to natural hazards and cultural anthropology. Most of these cutting edge science projects require a technologically advanced oceanographic platform in the Alaska region to conduct field research and long-term observations.

Principal Education Goals: The ARRV will provide a sophisticated and significantly larger platform for scientists, graduate and undergraduate students to participate in complex multidisciplinary research activities and will enable the training of the next generation scientists with the latest equipment and technology. Broadband satellite connections capable of relaying data including high definition video, from tools such as remotely operated vehicles, which explore under the ice and the ocean depths, will bring research into the K-12 classroom and to the general public.

Connections to Industry: Research results facilitated by the ARRV will enhance Arctic climate variability predictions, including the opening up of Arctic global shipping trade routes as the ice continues to recede in the Arctic Ocean. Geophysical studies will optimize U.S. Arctic oil and gas exploration, while fisheries and oceanography research will promote optimal management of the richest U.S. fishery resource, which is in the Bering Sea region.

Management and Oversight: The NSF coordinator is the Program Director for Ship Acquisition and Upgrades, within the Integrative Programs Section (IPS) in the Division of Ocean Sciences in the Directorate for Geosciences (GEO), with additional staff in IPS providing project management assistance. Two section members hold the Master's Certificate in Project Management through NSF-sponsored training, and other members of the Division are in training. Internal oversight for the construction cooperative agreement will be provided by a Project Advisory Team (PAT), which includes staff from GEO, the Office of Budget, Finance, and Award Management (BFA), including the BFA DDLFP, and the OGC. The Awardee will establish a project management office and submit a project execution plan (PEP) for review by NSF. The baseline will be established following the award of the construction contract but prior to any construction funds being released. In addition, the University-National Laboratory System

(UNOLS) Fleet Improvement Committee, an external committee composed of representatives from the community that meets several times a year, will review progress and provide advice regarding scientific outfitting of the vessel.

Current Project Status: Final model tank testing and data analysis were successfully completed in 2003. Results from model testing concluded that the current design has excellent sea keeping and enhanced icebreaking capabilities. In addition, acoustic testing demonstrated that the vessel will have sufficient "quieting" characteristics to support fisheries research. Results from the design studies have been shared with the community on many occasions during development, offering opportunities for interactive exchanges to take place between potential vessel users and the naval architects. Following minor design adjustments based upon these inputs, the design phase was completed in 2004. A meeting of the Oversight Committee and agency representatives held in December 2004 reviewed and accepted the final "contract design" document. This document provides the complete list of specifications and drawings from which a shipyard could make a construction bid. NSF issued a competitive solicitation for a cooperative agreement for the construction and operation of this ship in October 2006. Proposals were due in January 2007.

The Interagency Working Group for Facilities (IWG-F) continues to endorse the ARRV as the next vessel needed to help renew the aging national academic research fleet, originally stated in the 2001 report (*Charting the Future for the National Academic Research Fleet: A long-range plan for renewal*) submitted to the National Ocean Research Leadership Council[6]. An update of this Plan will be published later this year.

Milestones for ARRV are outlined below:

FY 2006 Milestones:
- Prepared and issued a solicitation to build and operate the ARRV via a Cooperative Agreement.

FY 2007 Milestones:
- Complete an external merit review process of proposals received
- Internal management plan approved by NSF
- Bring to the NSB for approval the selection based on the merit reviewed proposals
- Negotiate a Cooperative Agreement with the selected institution
- Awardee establishes the Project Management Office, submits a PEP for review to NSF, and issues the shipyard construction bid package
- Awardee reviews ship construction bids and prepares a contract with the successful bidder
- Vessel construction is initiated

FY 2008 Milestones:
- Vessel construction continues
- Conduct monthly and in-depth quarterly reviews with NSF oversight, to include on site inspections

FY 2009 Milestones:
- Complete vessel construction and outfitting
- Undergo sea and science trials
- Finalize acceptance and delivery of vessel to operating institution
- Incorporate vessel into the UNOLS ship scheduling process

[6] This report is available online: www.geo-prose.com/projects/fleet_rpt_2.html

FY 2010 Milestones:

Begin operations on NSF and other agency funded scientific missions
NSF conducts final review of project

Funding Profile: It was recognized from the outset of R/V *Alpha Helix* operations that the ship was of marginal size and capability for the Alaskan region, and so replacement planning has been ongoing since that time. NSF funded design studies in 1980 and 1995, but neither were implemented. Following a renewed effort by the user community through UNOLS to develop forward looking science mission requirements in 1999, NSF funded the concept design, detailed design and model testing for a replacement vessel and is prepared to initiate a three-year construction phase.

Based on the results of two independent cost analyses conducted during November 2006, the funding profile has been revised upward, with $25.0 million added in FY 2009. This upward adjustment recognizes the rapid inflation in raw materials and the current and projected strong market conditions in the U.S. shipbuilding industry.

Requested MREFC Funds for ARRV
(Dollars in Millions)

FY 2007 Request	FY 2008 Request	FY 2009 Estimate	Total
$56.00	$42.00	$25.00	$123.00

ARRV 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 2003 & Earlier	1.61						$1.61	-	$1.61
FY 2004	0.30						$0.30	-	$0.30
FY 2005	0.30						$0.30	-	$0.30
FY 2006	0.03						$0.03	-	$0.03
FY 2007 Request				56.00			-	$56.00	$56.00
FY 2008 Request				42.00			-	$42.00	$42.00
FY 2009 Estimate				25.00			-	$25.00	$25.00
FY 2010 Estimate					7.50		$7.50	-	$7.50
FY 2011 Estimate					8.00		$8.00	-	$8.00
FY 2012 Estimate					8.50		$8.50		$8.50
FY 2013 Estimate					9.00		$9.00	-	$9.00
Subtotal, R&RA	$2.24		-		$33.00		$35.24		
Subtotal, MREFC		-		$123.00		-		$123.00	
Total, Each Stage		$2.24		$123.00		$33.00			$158.24

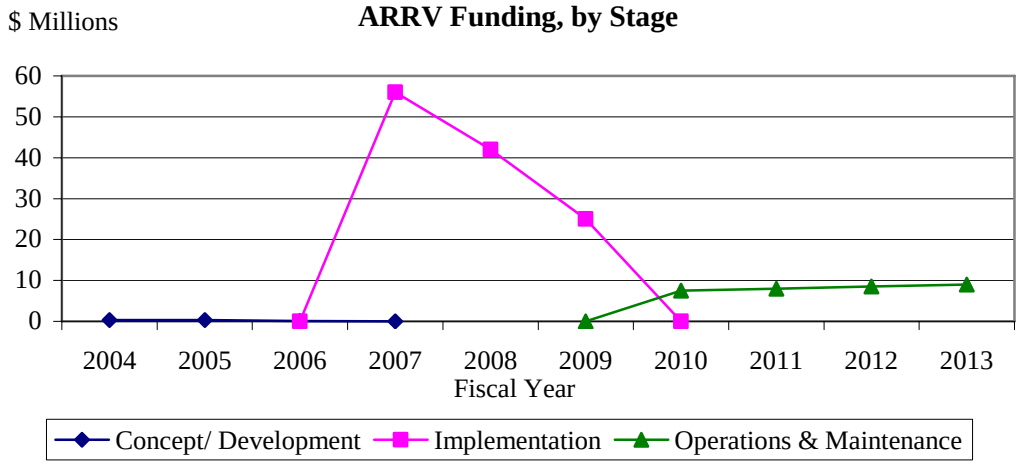
Ship operations are estimated to be approximately $7.50 million for the first full year. The expected operational service life of the ARRV is 30 years after construction is complete. Operations estimates for FY 2010 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

Information on the data in the table is provided below.

- Concept/Development: In 1999, science mission requirements were developed by the user community to provide a basis for designing a vessel to replace the R/V *Alpha Helix*. In FY 2000, Division of Ocean Sciences funds were used to develop preliminary designs for an Alaska region research vessel. In FY 2001, Congress appropriated $1.0 million to further the vessel concept design and conduct model tank testing.

- Implementation: The project will begin the construction phase in FY 2007. It is anticipated that the vessel will be constructed over a two-year period, after which it will be ready for sea trials and commissioning. It is anticipated that ARRV will then be ready to conduct science activities within 6 months to a year after construction is completed.

- Operations and Maintenance: Following commissioning, the ship will be managed by the awardee institution which will maintain and operate the vessel for NSF through a cooperative agreement. The vessel will be scheduled through the University-National Oceanographic Laboratory System (UNOLS) process, which will allow NSF and other agency funded scientists access to the vessel to conduct research and train students. The initial annual ship operation costs are estimated to be about $7.50 million.



Associated Research and Education Activities: There are successful on-going programs sponsored by NSF as well as diverse opportunities provided by state and local sources, often coordinated through the Arctic Research Consortium of the United States (ARCUS). Some examples of activities that link arctic research and education are a variety of teacher enhancement programs that provide field experience to develop scientific knowledge and integration of this knowledge into teaching practices. Another example includes active participation by K-12 students to regularly collect data on snow and lake ice in areas that are not easily accessible to researchers on a regular basis. There is also a variety of programs that bring visiting scientists and journalists to conduct research and convey this information to the general public. Last, but certainly not least, is the effort to directly include arctic communities into research programs. The ARRV will provide a stable, technically advanced platform for research and educational opportunities in the Arctic, providing a direct link to the marine environment.

Future Science Support: Along with direct operations and maintenance support for the ARRV as part of the Academic Research Fleet, NSF will support research performed using this platform through ongoing research and education programs. It is anticipated that the ARRV will greatly expand research capabilities in the region, going from a maximum of 160 ship operating days with the R/V *Alpha Helix*, up to 275-300 days with the ARRV. It is anticipated that the vastly increased capability of the ARRV, both with regard

to its ability to accommodate much larger interdisciplinary research teams and greatly enlarged geographical and seasonal ranges, will dramatically increase the number of proposals addressed to NSF for its utilization. The International Polar Year will undoubtedly stimulate new interest in expanded research in the region. Indeed, the fact that construction of the ARRV has been widely anticipated over the past several years has led to a temporary, but greatly reduced rate of submission of proposals to utilize the R/V *Alpha Helix*, because the community would vastly prefer to mount future multidisciplinary oceanographic cruises on the ARRV, with its greatly increased size, range, accommodations, habitability, and ice capability.

Atacama Large Millimeter Array (ALMA)

Project Description: The global ALMA project will be an aperture-synthesis radio telescope operating in the wavelength range from 3 to 0.4 mm. ALMA will be the world's most sensitive, highest resolution, millimeter-wavelength telescope, combining sub-arcsecond angular resolution with the sensitivity of a single antenna nearly 100 meters in diameter. The array will provide a testing ground for theories of planet formation, star birth and stellar evolution, galaxy formation and evolution, and the evolution of the universe itself. The interferometer is under construction at 5,000 meter altitude near San Pedro de Atacama in the Second Region of Chile, the ALMA host country.

Principal Scientific Goals: ALMA will function as the most capable imaging radio telescope ever built, and will bring to millimeter and submillimeter astronomy the high-resolution aperture synthesis techniques of radio astronomy. ALMA will image at 1 millimeter wavelength with the same 0.1 arcsecond resolution achieved by the Hubble Space Telescope at visible wavelengths and will form a critical complement to the leading-edge optical, infrared, ultraviolet, and x-ray astronomical instruments of the twenty-first century.

Principal Education Goals: ALMA will play a central role in the education and training of U.S. astronomy and engineering students; at least 15 percent of ALMA's approximately 1,000 yearly users are expected to be students. There is already substantial involvement by graduate students in applied physics and engineering at universities participating in the ALMA Design and Development program, providing an opportunity to broaden participation in science and engineering by members of under-represented groups.

Partnerships and Connections to Industry: North America and Europe are equal partners in the core ALMA instrument. Japan joined ALMA as a third major partner in 2004, and will deliver a number of enhancements to the baseline instrument. The North American side of the project, consisting of the U.S. and Canada, is led by Associated Universities Incorporated/National Radio Astronomy Observatory (AUI/NRAO). Funding and execution of the project in Europe is carried out through the European Southern Observatory (ESO). Funding of the project in Japan is carried out through the National Institutes of Natural Sciences of Japan and project execution is the responsibility of the National Astronomical Observatory of Japan.

From an industrial perspective, ALMA instrumentation will push gallium arsenide and indium phosphide transistor amplifier technology to high frequencies, will challenge production of high-density, high-speed integrated circuits for computational uses, and can be expected to stimulate commercial device and communication technologies development.

Management and Oversight: Programmatic management is the responsibility of the ALMA Staff Associate in the Division of Astronomical Sciences (AST) in the Directorate for Mathematical and Physical Sciences (MPS). An NSF advisory group, consisting of representatives from OGC, the Office of Budget, Finance, and Award Management (BFA), and OLPA, serves as a standing ALMA PAT. The BFA DDLFP is a member of the PAT and provides advice and assistance. AST's external Millimeter Array (MMA) Oversight Committee has been advising NSF on the project since early 1998 and comprises half of the International ALMA Management Advisory Committee. Management of the NRAO effort on ALMA is carried out under Cooperative Agreement with AUI. Oversight of the full international project is vested in the ALMA Board, whose membership includes an NSF member; coordination and management of the merged international efforts is the responsibility of the Joint ALMA Office (JAO), whose staff includes the ALMA Director, Project Manager, and Project Engineer.

Current Project Status: Construction progress continues in FY 2007, both at the site in Chile, and within the ALMA partner countries. The most significant event for the project in FY 2006 was completion of re-baselining reviews initiated due to escalation in cost of the production antennas, civil construction in Chile, and the managerial and technical complexity of an international project. These reviews resulted in a reduction of the core array from 64 to 50 antennas, a revised cost estimate (described below), and a 24 month extension of the project schedule to September 2012.

Foundation work for the Operations Support Facility (OSF) Technical Building is underway at the 9600 foot level. This building will be the nerve center of ALMA. ALMA personnel will work here, directing the operation of the Array at the 16,570 foot elevation Array Operations Site, collecting data and sending it onward to astronomers around the world. This building will be finished in 2008. *Credit: NRAO/AUI/NSF; Images compliments of Dr. Seiichi Sakamoto of the ALMA Project Office, National Astronomical Observatory of Japan*

Major project milestones attained in FY 2006 included:

- Completion of all baseline reviews and approval of a new budget and schedule by all funding agencies
- Completion of ALMA site camp
- Completion of road from base to high-altitude site
- Placement of European production antenna contract
- Placement of antenna transporter contract
- Completion of North American front end integration and commencement of test center operations
- Prototype integration testing began at Socorro NM antenna test facility (interferometry)

Major milestones for FY 2007 are expected to include:

- Completion and provisional acceptance of Array Operations Site (AOS) technical building
- Delivery of first North American production antenna to Chile
- Delivery of first front end to Chile site
- Completion of European front end integration and commencement of test center operations

Major milestones for FY 2008 are anticipated to include:

- Delivery of the second through fifth North American production antennas to Chile
- Testing of interferometry at the mid-level facility in Chile using two antennas
- Transportation of several antennas to the final, high-altitude site in Chile in preparation of commissioning in late 2008 (FY 2009)

Early science operations are expected to commence in 2010 and completion of the construction project and the start of full science operations are planned to occur around the end of 2012.

Funding Profile: A $26.0 million, three-year Design and Development Phase was originally planned for a U.S.-only project, the Millimeter Array. However, after the original three-year plan was initiated, the U.S. entered into a partnership with a European consortium to develop ALMA. Because of the expanded managerial and technical complexity of the ALMA concept, an additional year of Design and Development was supported in FY 2001, at a level of $5.99 million. U.S. construction of ALMA was initiated in FY 2002.

The cost of ALMA construction was originally set at $702.0 million, with the U.S. share of the joint array construction established at $344.28 million. The rebaselining reviews resulted in a revised cost estimate

for the U.S. share of $499.26 million, within a total construction cost of $998.0 million, and a 24 month extension through to September 2012.

The revised FY 2007 estimate of $64.27 million adopts the new baseline approved by the NSB and is $16.38 million higher than the original FY 2007 Request of $47.89 million. The additional funds are required mainly to service the $183 million antenna contract during FY 2007.

Appropriated and Requested MREFC Funds for ALMA
(Dollars in Millions)

	FY 05 & Earlier	FY06	FY07 Request	FY08 Request	FY09	FY10	FY11	FY 12	Total
ALMA R&D	31.99								$31.99
ALMA Construction	142.31	48.66	64.27	102.07	74.75	42.76	21.44	$3.00	$499.26
Total, ALMA	$174.30	$48.66	$64.27	$102.07	$74.75	$42.76	$21.44	$3.00	$531.25

ALMA Funding Profile
(Obligated Dollars and Estimates in Millions)

	Concept/ Development		Implementation[1]		Operations & Maintenance[2]		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2001& Earlier	6.50	31.99					$6.50	$31.99	**$38.49**
FY 2002				12.50			-	$12.50	**$12.50**
FY 2003				29.81			-	$29.81	**$29.81**
FY 2004				50.70			-	$50.70	**$50.70**
FY 2005				49.30	1.00		$1.00	$49.30	**$50.30**
FY 2006 Actual				48.66	1.50		$1.50	$48.66	**$50.16**
FY 2007 Request[1]				64.27	2.73		$2.73	$64.27	**$67.00**
FY 2008 Request				102.07	8.22		$8.22	$102.07	**$110.29**
FY 2009 Estimate				74.75	12.43		$12.43	$74.75	**$87.18**
FY 2010 Estimate				42.76	16.76		$16.76	$42.76	**$59.52**
FY 2011 Estimate				21.44	20.45		$20.45	$21.44	**$41.89**
FY 2012 Estimate				3.00	23.51		$23.51	$3.00	**$26.51**
FY 2013 Estimate					24.87		$24.87	-	**$24.87**
Subtotal, R&RA	$6.50		-		$111.47		$117.97		
Subtotal, MREFC		$31.99		$499.26		-		$531.25	
Total, Each Stage		**$38.49**		**$499.26**		**$111.47**			**$649.22**

[1]Implementation costs for FY 2008 and beyond are based on the funding profile developed following a rebaselining completed in FY 2006. The FY2007 Request includes an increase of $16.38 million according to that profile.

[2]Operations estimates for FY 2009 and beyond are based on current cost profiles. They will be updated following the review of a proposal for operations expected in mid-FY2007. The expected operational lifespan of this facility is at least 30 years.

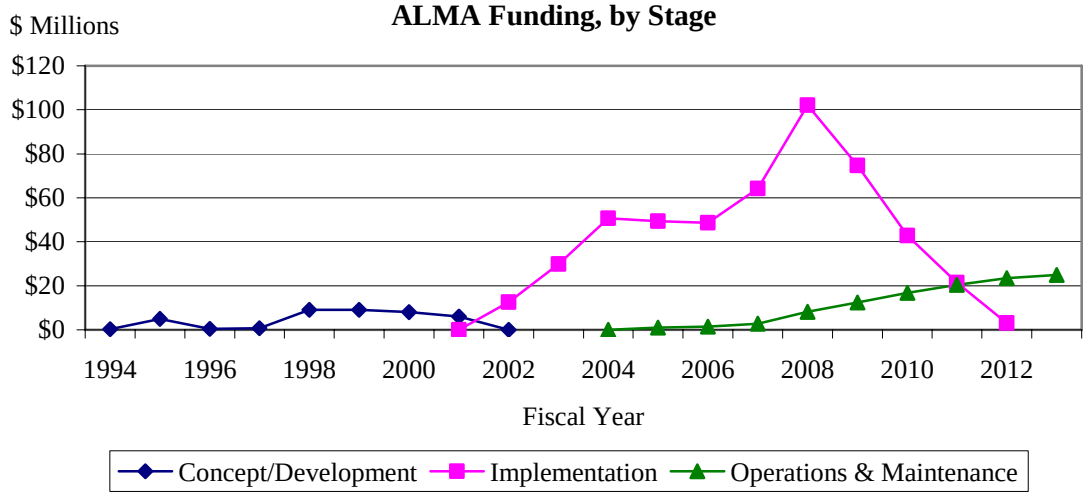
Information pertaining to the data in the table is included below.

- Concept/Development: Prior to FY 1998, NRAO utilized funds provided through the R&RA account to advance the conceptual development of the Millimeter Array, the U.S.-only antecedent to ALMA.

Funds were spent on planning workshops, array design and optimization, developing project construction and operations costs, and on site searches and surveys. The planning, design and development supported through the MREFC account achieved the goals set for: (i) a refined and audited cost estimate with project milestones, (ii) the selection of a site, (iii) the development of an international partnership with defined shared costs, and (iv) the procurement of prototype antennas.

- Implementation: Implementation funds support an array of fifty 12-meter antennas having a total collecting area of 5,600 square meters, with four receiver bands extending into the submillimeter. The table describes the U.S. contribution to the rebaselined ALMA project. It does not include funds resulting from Canada's participation of $20 million (FY 2000).

- Operations and Maintenance: Operations and maintenance funds begin to phase in as initial site construction is completed and antennas begin to be delivered. Funds will be used to manage and support site and instrument maintenance, array operations in Chile, early and eventually full science operations, and in support of ALMA observations by the U.S. science community. Full ALMA science operations are anticipated to begin in FY 2013.



Associated Research and Education Activities: Extensive public and student ALMA outreach programs will be implemented in North America, Europe, and Chile as ALMA approaches operational status. A visitors' center will be constructed at the 2,800 meter-altitude Operations Support Facility gateway to the ALMA site near San Pedro de Atacama in northern Chile. The project also supports a fund for the Antofagasta (II) Region of Chile that is used for economic, scientific, technical, social and cultural development, particularly within the nearby towns of San Pedro de Atacama and Toconao.

Future Science Support: Peer-review telescope allocation committees provide merit-based telescope time but no financial support. NSF does not provide awards targeted specifically for use of ALMA. Most U.S. users will be supported through NSF or NASA grants to pursue research programs that require use of ALMA.

EarthScope

Project Description: The EarthScope Facility is a distributed, multi-purpose geophysical instrument array that will make major advances in our knowledge and understanding of the structure and dynamics of the North American continent. EarthScope instrumentation is expected to inhabit nearly every county within the U.S. over the life span of the program.

One of the components of EarthScope is a project to drill an angled hole through a seismically active portion of the San Andreas Fault Zone, creating a San Andreas Fault Observatory at Depth (SAFOD). SAFOD is drilling through the fault to a depth of 3.2 km, obtaining samples and making geophysical measurements within and adjacent to the fault zone, and installing instruments to continuously monitor variations in rock deformation and other parameters during the earthquake cycle. *Credit: www.EarthScope.org*

Principal Scientific Goals: Enhanced understanding of the structure and evolution of the North American continent, including earthquakes and seismic hazards, magmatic systems and volcanic hazards, lithospheric dynamics, regional tectonics, continental structure and evolution, fluids in the crust, and associated educational aspects.

Principal Education Goals: To engage science and non-science students in geosciences discovery through the use of technology in real time or retrospectively with the aim of integrating research and education.

Partnerships and Connections to Industry: The U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the International Continental Scientific Drilling Programme are funding partners, with USGS and NASA expected as operating partners. Project partners may also include state and local governments, geological and engineering firms, and Canadian and Mexican agencies. Over 3,000 earth scientists and students are expected to use the facility annually. Geotechnical and engineering firms directly use data and models, which are enabled by EarthScope. Instrumentation firms are collaborating on development for state-of-the-art seismic systems, down-hole instrumentation, and high-precision GPS antenna designs.

Management and Oversight: The EarthScope Program Director, located in the Earth Sciences (EAR) Division in GEO, provides NSF oversight. The EAR Deep Earth Processes Section Head and a PAT including the BFA DDLFP and staff from GEO, OGC, and the Office of Budget, Finance and Award Management (BFA), provide other internal oversight. Following the recommendations of the Large Facilities Management and Oversight guideline documents, external oversight is provided through periodic reviews, including facility construction project baseline reviews and *ad hoc* technical, science, and education and outreach committee meetings, as well as site visits.

Current Project Status: Downhole measurements and experiments were conducted at the San Andreas Fault Observatory at Depth (SAFOD) site during 2006. A sensor string was installed during July 2006 to record data through the winter. Analysis of sidewall cores collected in the deepest part of the hole provides tantalizing evidence of what appears to be talc being formed within the San Andreas fault. Overall, GPS and seismic station equipment acquisition and installation are slightly behind schedule. The Plate Boundary Observatory (PBO) has installed more than 500 permanent geodetic stations, 16 borehole strainmeter stations, and three long-baseline strainmeters. The USArray has installed more than 300 Transportable Array stations, and installations continue on schedule. Other highlights include the combined use of PBO geodetic and strain data and USArray seismic data in analyses of "slow

earthquakes" in the Cascadia subduction system. The EarthScope project has been represented at several dozen professional meetings and conferences through an exhibit booth, presentations, and scientific sessions. Scientific results utilizing data collected by the EarthScope facility have already been presented at national meetings and in professional publications.

FY 2006 Milestones:
- San Andreas Fault site characterization studies carried out
- Installation of 530 equivalent permanent GPS and 54 equivalent borehole strain systems
- Complete installation of 3 long baseline strainmeters
- Equipment for 100 portable GS sites available
- Complete installation of 39 equivalent ANSS stations
- Installation of 281 equivalent Transportable Array stations
- Equipment for 1,200 Flexible Array sites available
- NSF conducts annual review of project status

FY 2007 Milestones:
- Use site characterization and monitoring data to choose four coring intervals at depth in San Andreas Fault Observatory
- Main hole Phase 3 drilling begins at SAFOD
- Installation of 728 equivalent permanent GPS and 85 equivalent borehole strain systems
- Complete first footprint of USArray (400 Transportable Array stations)
- Equipment for 1,680 Flexible Array sites available
- NSF conducts annual review of project status

FY 2008 Milestones:
- Redeployment of USArray/Transportable Array begins
- Main hole Phase 3 drilling and related activities completed at SAFOD
- Install monitoring instrumentation in main hole of SAFOD
- SAFOD data archiving and sample distribution completed
- Complete installation of 875 equivalent permanent GPS and 103 equivalent borehole strain systems
- Complete installation of 4 long baseline strainmeters
- Equipment for 2,400 Flexible Array sites available
- NSF conducts annual review of project status

FY 2009 – FY 2013 Milestones:
- Redeployment of USArray on a continual basis
- Analysis of San Andreas Fault cores, cuttings and logs completed. Continue monitoring at depth
- Ongoing operation and maintenance of the PBO
- NSF conducts biennial reviews of project status

Funding Profile: Conceptual planning for the EarthScope project was developed over the past decade. NSF funded planning, design, and development since FY 1998 through the R&RA account and began funding the implementation of a five-year period of acquisition, construction, and commissioning in FY 2003 through the MREFC account. The total project cost for EarthScope facility implementation is $197.44 million.

Appropriated and Requested MREFC Funds for EarthScope
(Dollars in Millions)

FY 2003	FY 2004	FY 2005	FY 2006	FY 2007 Request	Total
$29.81	$43.24	$46.97	$50.02	$27.40	$197.44

EarthScope 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 2002 & Earlier	6.00						$6.00	-	**$6.00**
FY 2003	3.36			29.81	0.40		$3.76	$29.81	**$33.57**
FY 2004				43.24	1.70		$1.70	$43.24	**$44.94**
FY 2005				44.80	4.69		$4.69	$44.80	**$49.49**
FY 2006				49.62	6.72		$6.72	$49.62	**$56.34**
FY 2007 Request				29.97	11.61		$11.61	$29.97	**$41.58**
FY 2008 Request					21.61		$21.61	-	**$21.61**
FY 2009 Estimate					24.00		$24.00	-	**$24.00**
FY 2010 Request					24.76		$24.76	-	**$24.76**
FY 2011 Estimate					25.82		$25.82	-	**$25.82**
FY 2012 Estimate					26.47		$26.47		
FY 2013 Estimate					27.00		$27.00	-	**$27.00**
Subtotal, R&RA	$9.36		-		$174.78		$184.14		
Subtotal, MREFC		-		$197.44		-		$197.44	
Total, Each Stage		**$9.36**		**$197.44**		**$174.78**			**$381.58**

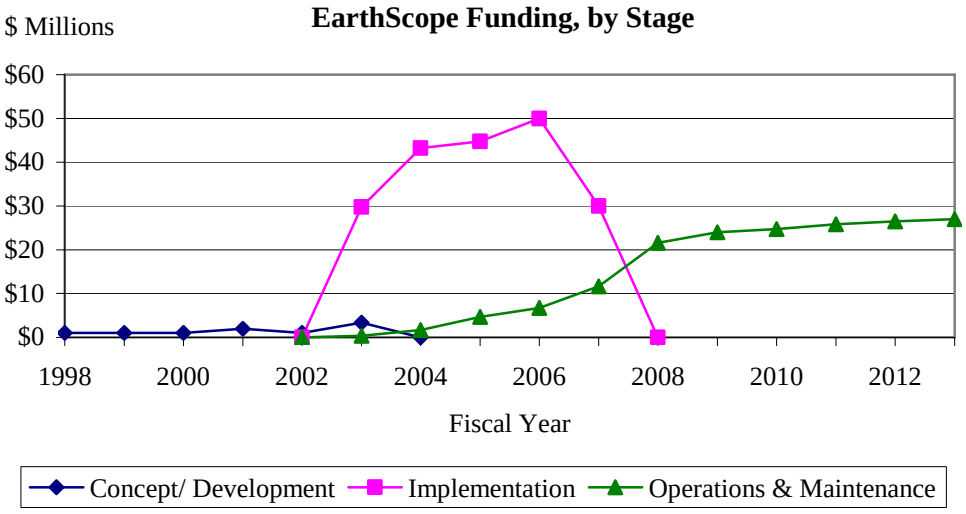
NOTE: The expected operational lifespan of this project is 15 years after construction is complete in FY 2008. Operations estimates for FY 2007 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

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

- Concept/Development: FY 1998-2000 funds were used to support workshops, instrument development, and installation technique development appropriate to EarthScope from existing programs within EAR. Dedicated funding was established for FY 2001-2003 supporting pre-EarthScope activities that facilitated construction and installation. This funding supported meetings, workshops, instrumentation prototype development, installation technique development, and site selection activities.

- Implementation: The project is putting in place three components of the distributed EarthScope system: (1) the USArray - portable seismometers for deployment across North America; (2) the San Andreas Fault Observatory at Depth - to monitor fault conditions; and (3) the Plate Boundary Observatory – an array of GPS monitors and borehole strain systems to monitor crustal deformation.

- Operations and Maintenance: Operations and maintenance began to phase-in during the first year of construction. When EarthScope is completed it will be managed, operated and maintained by consortia including participation from host institutions, affiliate organizations, and the user community.

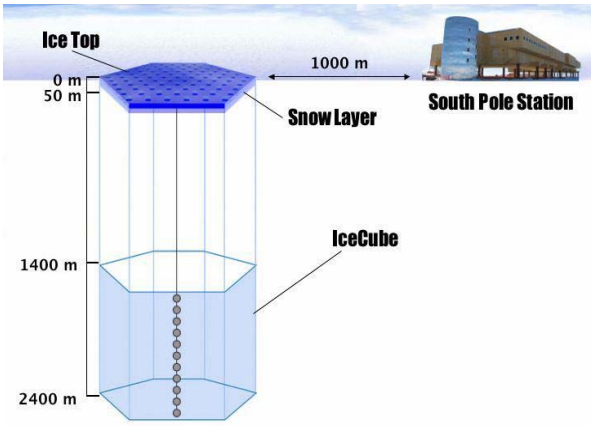


Future Science Support: Along with direct operations and maintenance support for the EarthScope Facility, NSF will support research performed utilizing the facility through ongoing research and education programs. The annual support for such activities is estimated to be about $15 million once the facility reaches full operations.

Recent Research Highlight

► **Tracking slow earthquakes:** In September 2005 and again in November 2006, the initiation and duration of a "slow earthquake", a newly recognized phenomenon, was tracked across the Puget Sound/Olympic Peninsula region of Washington using EarthScope geodetic, strain, and seismic data. "Slow earthquakes" release the energy of a moderate earthquake (approximately magnitude 6.5) across a region over several weeks, rather than in a single, rapid earthquake. These events occur below the locked source region of large subduction zone earthquakes, adding stress and bringing the large fault closer to failure. "Slow Earthquakes" in Cascadia appear to occur every 14.5 months (± 1 month), initiating beneath the Puget Sound and terminating beneath Vancouver Island. EarthScope instruments will continue to collect data in Cascadia and elsewhere along the plate boundary to be used to better understand the nucleation and duration of all types of earthquakes.

IceCube Neutrino Observatory



IceCube will occupy a volume of one cubic kilometer. One of the 80 strings of optical modules is depicted here (number and size not to scale). IceTop located at the surface, comprises an array of sensors to detect air showers. It will be used to calibrate IceCube and to conduct research on high-energy cosmic rays. *Credit: NSF*

Project Description: IceCube will be the world's first high-energy neutrino observatory and will be located deep within the icecap under the South Pole in Antarctica. It represents a new window on the universe, providing unique data on the engines that power active galactic nuclei, the origin of high energy cosmic rays, the nature of gamma ray bursters, the activities surrounding supermassive black holes, and other violent and energetic astrophysical processes. IceCube construction is being carried out by the IceCube Collaboration, led by the University of Wisconsin (UW). Approximately one cubic kilometer of ice is being instrumented with photomultiplier (PM) tubes to detect neutrino-induced, charged reaction products produced when a high energy neutrino interacts in the ice within or near the cubic kilometer fiducial volume. An array of Digital Optical Modules (DOMs), each containing a PM and associated electronics, will be distributed uniformly from 1.5 km to 2.5 km beneath the surface of the South Pole ice cap, a depth where the ice is highly transparent and bubble-free. When completed, IceCube will record the energy and arrival direction of high-energy neutrinos ranging in energy from 100 GeV (10^{11} electron Volts [eV]) to 10 PeV (10^{16} eV). The principal tasks in the IceCube project are: production of the needed DOMs and associated electronics and cables; production of an enhanced hot water drill and a DOM deployment system capable of drilling holes for and deploying DOM strings in the ice at the Pole; refurbishment and outfitting of the designated IceCube Laboratory at the South Pole; the actual drilling of the deep-ice holes, deployment of the needed DOMs, and their commissioning and verification; installation of a surface array of air shower detectors ('IceTop') to both calibrate and eliminate background events from the IceCube DOM array; construction of data acquisition, handling, archiving, and analysis systems; and associated personnel and logistics support.

Principal Scientific Goals: Measurement of the number, direction, timing, and energy spectrum of high-energy neutrinos will provide unique new insights regarding the dynamics of active galactic nuclei, the acceleration mechanisms and locations of the sources of high energy cosmic rays, the properties and dynamics of gamma ray bursters, and the types of processes that take place near the event horizon of supermassive black holes at the centers of galaxies. Many of these phenomena take place at cosmological distances in regions shielded by matter and shrouded by radiation. Since neutrinos carry no charge and interact very weakly with matter, easily passing through the entire earth, they are unique messenger particles for understanding the astrophysics of such extreme phenomena and are capable of bringing us information about previously undiscovered cosmic objects, ones that are invisible to existing observatories that record electromagnetic signals or charged particles. IceCube data on sources will also complement data from existing astrophysical observatories in the optical, x-ray, and gamma ray regions of the electromagnetic spectrum, providing new tests of theories of the dynamics underlying these objects.

Principal Education Goals: IceCube provides a vehicle for helping to achieve national and NSF education and outreach goals based on the conduct of visionary science in the South Pole environment. Specific outcomes will include: the education and training of next-generation leaders in astrophysics, including undergraduate students, graduate students, and postdoctoral research associates; K-12 teacher

scientific/professional development, including development of new inquiry-based learning materials; increased diversity in science through partnerships with minority institutions; and enhanced public understanding of science through broadcast media and museum exhibits. (One is currently under construction.) Some of these outcomes will result from separate R&RA grants to universities and other organizations for work associated with IceCube, selected following standard NSF merit review.

Partnerships and Connections to Industry: The IceCube Collaboration consists of 12 U.S. institutions and institutions in three other countries: Belgium, Germany, and Sweden. NSF's foreign parners are contributing approximately $32 million to the project, as well as a pro rata share of IceCube Maintenance and Operations based on the number of PhD level researchers. The Department of Energy, through its Lawrence Berkeley National Laboratory, is also participating.

Management and Oversight: The strong project management structure at UW, which includes international participation, provided the framework for the Start-up Project funded in FY 2002 and FY 2003, and the initiation of full construction with FY 2004 funding. UW has in place an external Scientific Advisory Committee, an external Project Advisory Panel, and a high-level Board of Directors (including the Chancellor) providing awardee-level oversight of the project. IceCube, internal to the project, is managed by a Project Director and a Project Manager. NSF, internally, has appointed a Project Coordinator to manage and oversee the NSF award. NSF carried out a comprehensive external baseline review of the entire project (including cost, schedule, technical, and management) in February 2004. There was a follow-up external cost review in Fall 2004, and comprehensive annual external reviews are planned for each subsequent spring following the annual deployment season. Such annual reviews were held in May of 2005 and 2006. Besides annual progress reviews and other specialized reviews (e.g., a safety review), the project provides written monthly progress reports and quarterly reports. NSF conducts site visits, weekly teleconferences with the project managers, and weekly internal NSF project oversight and management meetings. Oversight responsibility for IceCube construction is the responsibility of the OPP; support for operations, research, education, and outreach will be shared by OPP and MPS as well as other organizations and international partners.

Current Project Status: The project is proceeding according to plans and is on budget. Of the planned 70 DOM strings that will comprise IceCube, nine were deployed during the FY 2005 and 2006 drilling and deployment seasons at the South Pole, with an additional 12 strings planned for FY 2007. The Enhanced Hot Water Drill used to melt the 2.5 km water columns, into which the strings of DOMs are deployed, continues to perform well, with fuel efficiency better than planned and with a penetration rate that meets specifications. Of the DOMs deployed thus far, 99 percent are now working at or better than design specifications, consistent with original reliability requirements for the project. The data acquisition system (DAQ) and all related electronics have been transferred from the temporary counting house to the permanent IceCube Laboratory (ICL). All surface cables have also been moved and reconnected to the ICL, and DOM string commissioning activities are again being carried out. Installation of the IceTop surface array is proceeding according to schedule, with elements deployed on the surface at each of 26 string locations. DOM production and cold-testing facilities in the U.S. and Europe continue to work with high efficiency, producing reliable DOMs that continue to meet or exceed requirements. Key to the success of IceCube is the important logistics support chain required to transport all material and personnel to the South Pole, and this, too, continues to perform at a very high level.

Major milestones for IceCube are below:

FY 2007 Milestones (as of the submission date, the project is on schedule to meet projected goals):

Complete ICL to conditional occupancy, and transition surface electronics, DAQ, and data handling systems from temporary counting house to ICL;

Produce and test DOMs, IceTop modules, cables, and associated electronics production to provide for 2007/2008 drilling and deployment season;
Drill, deploy, test, and commission 12 additional DOM strings and corresponding electronics and DAQ elements; this will make a total of 21 strings deployed, or 30 percent of the planned array;
Deploy 20 additional IceTop modules, including electronics and associated DAQ elements.
Complete full functionality of DAQ; and
Start limited operations for science.

Projected outyear milestones (FY 2008-2011) are based on current project planning and represent a general outline of anticipated activities. These activities are also dependent on weather conditions and the Antarctic logistics schedule.

FY 2008-11 Milestones:
Completion, commissioning, and final acceptance of ICL;
Continue DOM and IceTop module production and testing through full amount planned;
Continue to drill, deploy, test, and commission DOM strings (up to 14 strings per season) and the corresponding IceTop modules (two for each DOM string), including installing and testing of the associated DAQ elements;
Complete installation and commissioning of strings; and
Ramp up to full operations of IceCube in FY 2011.

Funding Profile: Startup activities were funded with FY 2002-03 appropriations, and construction was initiated with FY 2004 appropriations. The current project cost is $274.12 million, $2.97 million more than the original estimate, but NSF's contribution remains constant at $242.07 million. The change is due to an increase in the value of the contributions made by foreign partners (now $32.05 million).

Appropriated and Requested MREFC Funds for IceCube
(Dollars in Millions)

FY 2004 & Earlier	FY 2005	FY 2006	FY 2007 Request	FY 2008 Request	FY 2009	FY 2010	Total
$81.29	$47.62	$49.85	$28.65	$22.38	$11.33	$0.95	$242.07

The funding profile table below reflects actual obligations for past years and anticipated obligations for future years. The differences between these two tables are due to funds appropriated in FY 2002 and FY 2003 but not spent until later years. In addition to the $3.60 million shown in the table above, $6.59 million has been carried over from prior year appropriations into FY 2006. Neither table includes contributions from foreign partners.

IceCube 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	0.50						$0.50	-	**$0.50**
FY 2002				10.12			-	$10.12	**$10.12**
FY 2003				25.75			-	$25.75	**$25.75**
FY 2004				38.36			-	$38.36	**$38.36**
FY 2005				48.10			-	$48.10	**$48.10**
FY 2006 Actual				56.44			-	$56.44	**$56.44**
FY 2007 Request				28.65	0.50		$0.50	$28.65	**$29.15**
FY 2008 Request				22.38	3.00		$3.00	$22.38	**$25.38**
FY 2009 Estimate				11.33	4.00		$4.00	$11.33	**$15.33**
FY 2010 Estimate				0.94	4.50		$4.50	$0.94	**$5.44**
FY 2011 Estimate					5.00		$5.00	-	**$5.00**
FY 2012 Estimate					5.13		$5.13		
FY 2013 Estimate					5.25		$5.25	-	**$5.25**
Subtotal, R&RA	$0.50		-		$27.38		$27.88		
Subtotal, MREFC		-		$242.07		-		$242.07	
Total, Each Stage		**$0.50**		**$242.07**		**$27.38**			**$269.95**

NOTE: The expected operational lifespan of this project is 25 years. Operations and Maintenance in support of scientific research will likely begin in FY 2007. Corresponding support for conduct of research also must be provided. International partners will provide a significant share of the operations and maintenance costs. Out-year budgets for O&M (FY2009-2013) are estimates only; actual budgets will be determined following a period of early limited operation (FY2007-2008), after which a comprehensive review and evaluation will take place. Host Laboratory responsibilities are covered by Antarctic Infrastructure and Logistics.

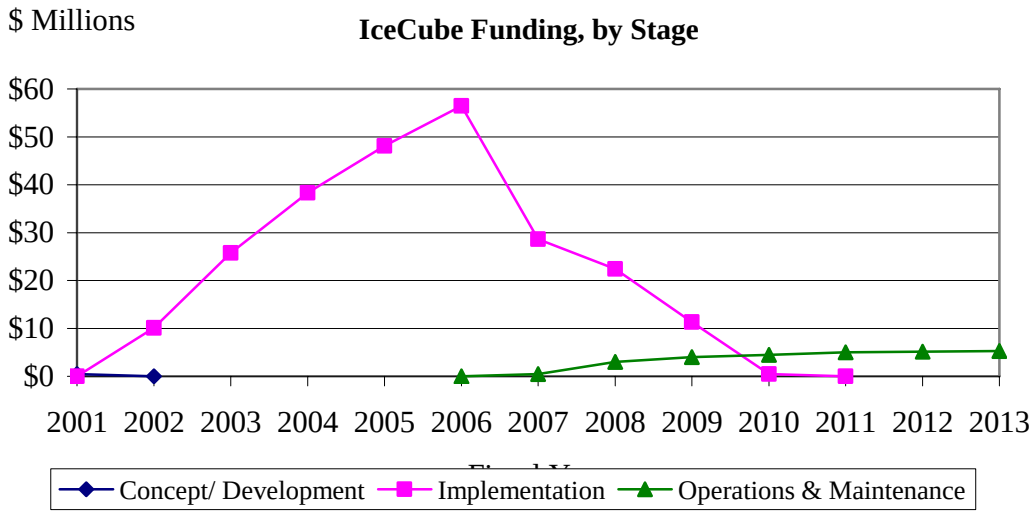
Information pertaining to the data in the table is provided below.

- Concept/Development: $500,000 was provided in FY 2001 through the R&RA account to support drill conceptual development and design; research and development (R&D) on advanced data acquisition and analysis techniques; and development of interface electronics and associated software for digital detector electronics readout. IceCube builds on the work of the Antarctic Muon and Neutrino Detector (AMANDA), which demonstrated proof-of-principle. Those investments focused on state-of-the art drill and electronics development and acquisition.

- Implementation: The current project cost is $274.12 million, $2.97 million more than the original estimate. The change is due to an increase in the value of the contributions made by foreign partners (now $32.05 million). NSF's cost remains at $242.07 million.

  Construction is planned to extend into FY 2011, although funding will end in FY 2010. A comprehensive baseline review of IceCube was conducted in February 2004, providing a solid project baseline scope, cost, and schedule. Holes will be drilled and DOM strings deployed each austral summer season (November through mid-February). This began with the successful deployment of the first IceCube string in the FY 2005 austral summer season (2004/2005) and, in FY 2006, the first test of the production capability of the drilling and deployment system. The latter test validated the current drilling and deployment plan for project outyears to deploy 14 strings/season. Subject to weather-induced complications of logistics support, the full complement of DOMs should be in place by the end of FY 2011.

- Operations and Maintenance: Full operation of the IceCube Neutrino Observatory is planned to commence in FY 2011 following completion of drilling and DOM deployment in that year. Operations in support of scientific research may begin in FY 2007, ramping up in subsequent years to full science operations in FY 2011. These costs will be shared by the collaborating institutions, domestic and foreign. The cost of the data analysis that will be carried out by the collaborating U.S. and foreign IceCube institutions, is estimated to be approximately $4.0 million and is outside of support for operations and maintenance (e.g., the data acquisition and data handling systems, data quality monitoring, information technology (IT) upgrades). The general operations of South Pole Station, reported in a separate section, also contribute to supporting IceCube. Costs included for IceCube here include only those that are project-specific and incremental to general South Pole Station operations. The expected operational lifespan of this project is 25 years beginning FY 2011.



Associated Research and Education Activities: Besides the training of next-generation astrophysicists, IceCube will encourage the creation of new links to K-12 teachers for the purpose of scientific/professional development of secondary school teachers, reaching into the classroom with new inquiry-based IceCube learning materials, as well as using the unique South Pole environment to convey the excitement of astrophysics, and science generally, to K-12 students. Extra measures will be undertaken to interest underrepresented groups in science. The plan includes partnership with two largely minority institutions (Clark-Atlanta University, Atlanta, GA, and Southern University, Baton Rouge, LA). Public outreach will be carried out through broadcast media and museum exhibits based on the IceCube science and the South Pole environment. Funding for education and outreach activities will come from the R&RA account. Annual education and outreach budgets are estimated at $400,000.

Future Science Support: NSF will support activities at U.S. institutions working on more refined and specific data analyses, data interpretation (theory support), and instrumentation upgrades, through ongoing research and education programs. The annual support for such activities is currently estimated at approximately $4.0 million once the facility reaches full operations.

National Ecological Observatory Network (NEON)

Project Description: NEON will be a continental scale research platform consisting of geographically distributed infrastructure for ecological research that is networked via state-of-the-art communications technology. Cutting-edge sensor networks, instrumentation, experimental infrastructure, natural history archive facilities, and remote sensing will be linked via the internet to computational, analytical, and modeling capabilities to comprise NEON.

Principal Scientific Goals: NEON will advance ecological research by enabling studies of the biosphere at regional to continental scales, quantifying the forces regulating these systems, and predicting the consequences of climate and land use change on the biosphere. Through remote sensing, in-situ observation, experimentation, synthesis, and modeling, the National Ecological Observatory Network will enable transformative scientific approaches needed to quantify and understand the complex biosphere processes and interactions that operate across local to continental scales.

As a "shared-use" research platform to advance fundamental understanding of the biosphere NEON will facilitate interdisciplinary research on the complex interactions between the biological, physical and human drivers of ecological change. NEON will be used to make comprehensive, regional to continental-scale observations on ecological systems and thus will represent a virtual laboratory for research to obtain a predictive understanding of the biosphere.

Principal Education Goals: The knowledge base NEON will create, its real time and continuous integrated data, simulation and observation capabilities, and its networked communication will be an asset for formal and informal education and training. NEON will foster the NSF goal of integrating research and education by creating a research-intensive and collaborative learning environment. A NEON gateway will provide resources to support informal public education and provide opportunities for citizens to actively participate in scientific investigations. Data from standard measurements made using NEON will be publicly available.

Partnerships and Connections to Industry: Federal agencies such as the U.S. Geological Survey (USGS), the Environmental Protection Agency (EPA), and the Department of Energy (DOE) participated in the NEON Advisory Board and planning committees. A NEON Federal Agency Coordinating Committee meets on a regular basis[7]. Discussions are underway with the U.S. Department of Agriculture (USDA), National Park Service (NPS), USGS, and DOE on formal agreements. NEON will be the only observation network that will be able to provide the *in situ* biospheric component called for in the U.S. Group on Earth Observations Ten-year Strategic Plan. International perspectives are provided through the Global Lakes Ecological Observatory Network (GLEON) with Australia, New Zealand, Taiwan, China, South Korea, U.K., Finland, Sweden, Israel, and Canada. GLEON is a cyberinfrastructure and sensor prototype for NEON that focuses on lake metabolism. Private foundations, e.g., the Heinz Center, Nature Serve, and U.S. Landtrust, are participating in the NEON design and research and development. NEON-generated information will be useful to natural resource industries, such as forestry and fisheries. Resource managers and decision makers will participate in NEON through partnerships; use of its facilities, data, and forecasts; and education, training, and outreach opportunities. NEON's scientific and networking demands require technological innovations that involve partnerships with industry for infrastructure development, deployment, and operation.

Management and Oversight: The Division of Biological Infrastructure (DBI) within the Directorate for Biological Sciences (BIO) provides oversight for the development, construction, and implementation of

[7] A full list of the members of these committees can be provided on request.

NEON. The NEON program officer, in consultation with a BIO-NEON committee, which includes the BFA DDLFP, formulates the program planning of NEON, i.e., drafting, release, and review of program solicitations, etc. The BIO Advisory Committee provides external advice to BIO about specific program planning aspects of NEON.

The NEON program officer is a member of the NSF Environmental Observing Networks Task Force and serves on the PATs for other large facility projects, such as the Network for Earthquake Engineering Simulation (NEES), OOI, and Global Environment for Network Investigations (GENI). Coordination with other federal agencies occurs through the NEON Federal Agency Coordinating Committee. In addition, NEON is represented on the Architecture and Data Management task force of the U.S. Group on Earth Observations, the U.S. component of Global Earth Observation System of Systems (GEOSS), an activity of the National Science and Technology Council, Committee on Environment and Natural Resources.

Current Project Status: In FY 2006, a research community Consortium (NEON Inc.), which provides a link between NEON planning and construction, was established. The NEON Integrated Science and Education Plan and Networking and Informatics plans were merit reviewed. The preliminary Project Execution Plan (PEP), and Project Development Plan (PDP) were submitted for review. Research and development on environmental sensors, networks, and cyber tools that advanced the development of NEON as a network of nationally deployed infrastructure was supported through the R&RA account. R&RA funds were also provided to the Consortium of Regional Ecological Observatories to evaluate deployment criteria and locations across the continental U.S., Alaska, Hawaii, and Puerto Rico and to form the collaborations, partnerships, and organizations needed for NEON infrastructure deployment.

A Conceptual Design Review was held in November 2006. The review panel concluded that "NEON has made impressive progress in engaging the ecological community, in defining representative NEON domains across the continent, and in creating a vision for a continental-scale environmental biology capability. NEON has defined site-independent domain systems of fixed and movable sensors, with associated remote and mobile sensing, biotic data gathering and cyberinfrastructure. An integrated science plan illustrates how this system may be used to address NEON science questions. NEON has defined a governance process for the construction and operations phases. First cost estimates and preliminary schedules have been developed." The review panel also recommended that, led by the new Chief Executive Officer, NEON should prepare for a Preliminary Design Review (PDR) (planned for May 2007) and outlined the steps needed to achieve this goal.

Persistent sensing, sentinel measurements, remote sensing campaigns, satellite images, and legacy data will be connected and enabled via cyberinfrastructure into a national research platform. *Credit: Nicolle Rager-Fuller,NSF*

In FY 2006, R&RA funding was provided to NEON for the Cyberinfrastructure for Environmental Observatories: Prototype Systems to Address Cross-Cutting Needs competition to stimulate interdisciplinary collaborations that result in the development and deployment of viable prototype cyberinfrastructure for environmental observatories. The resulting awards expanded NEON research and development to include a cyberinfrastructure research program to address interoperability with other networks and observing systems.

During FY 2007, R&RA funds will be used to complete the final PEP for NEON, address specific site deployment, support NEON office activities, and begin work on Environmental Impact Assessments and/or Environmental Impact Statements (EIA/EIS). R&RA funds will also continue to support ongoing R&D projects such as environmental sensors and networks, cyberinfrastructure for environmental observatories, and enabling technologies for ecological forecasting. Following successful reviews as specified in NSF's Guidelines for Planning and Managing the MREFC Account, FY 2007 MREFC funds will be used for the construction and evaluation of the integrated NEON fundamental sensor infrastructure and cyberinfrastructure backbone, focusing on the NEON Fundamental Instrument Unit (FIU) Sensor Array Integration, the Cyberinfrastructure Network Integration, and Software Development to create an end to end observation system.

In FY 2008, NEON R&RA funds will be used to complete site deployment assessments and selection, EA/EIS studies (as appropriate); NEON project office costs prior to initiation of construction (if construction is delayed in FY 2007 or until late in FY 2008), and ongoing R&D projects on environmental sensors and networks, cyberinfrastructure for environmental observatories, and enabling technologies for ecological forecasting. MREFC funds are requested for the NEON Construction Office, Project Management Control System, and to begin mass construction of the NEON Fundamental Instrumentation Unit and embedded cyberinfrastructure and network level cyberinfrastructure.

Major milestones for NEON are listed below.

FY 2006 Milestones:

- NEON Inc. established
- NEON Science Plan and Requirements merit review completed
- Baseline Networking and Informatics Plan and an external design review completed
- NEON Conceptual Design, Preliminary PEP, and PDP completed
- Management review of the NEON Design Consortium and Project Office completed
- R&D of cyberinfrastructure to address interoperability with other environmental networks and observing systems funded

FY 2007 Milestones:

- NEON Conceptual Design Review (CDR) conducted in November 2006
- NEON infrastructure deployment plan to be finalized
- Final PEP to be completed
- NEON Preliminary Design Review (PDR) to be conducted in May 2007
- EIA/EIS will begin
- NEON fundamental technology unit (BioMesoNet, sensor micronets, and enabling cyberinfrastructure) will be assembled and integrated
- NEON Construction Project Office will start-up
- R&D projects on environmental sensors and sensor networks, cyberinfrastructure, and enabling technologies for ecological forecasting and social science collaboration continue

FY 2008 Milestones:

- Finalize national infrastructure deployment locations

Complete EIA/EIS, if appropriate,
Fully integrate and validate NEON fundamental technology unit (BioMesoNet, sensor micronets, and enabling cyberinfrastructure) and cyberinfrastructure
Initiate deployment of BioMesoNet and basic towers
Bring Project Management Control Software System to a fully operational status
Complete R&D projects on environmental sensors and sensor networks, cyberinfrastructure, and enabling technologies for ecological forecasting and social science collaboration

FY 2009 – FY 2013 Milestones:
Continue construction of NEON research, networking, informatics, and education, training, and outreach infrastructure
Support operations and research activities as NEON components are commissioned and come on-line

Funding Profile: The NEON baseline is under revision based on the continential design recommended in the NRC report. The revised baseline will be reviewed as part of the PDR scheduled for May 2007. The figures shown here reflect the FY 2007 Request. The revised baseline is expected to include higher funding levels in FY 2009 and in the out years. After this thorough cost review, a revised budget for NEON infrastructure and maintenance and operations will be provided.

Requested MREFC Funds for NEON
(Dollars in Millions)

FY 2007 Request	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	Total
$4.00	$8.00	$20.00	$30.00	$26.00	$12.00	$100.00

NEON Funding Profile
(Obligated Dollars and Estimates in Millions)

	Concept/ Development		Implementation[1]		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2004 & Earlier	5.83						$5.83	-	**$5.83**
FY 2005	5.98						$5.98	-	**$5.98**
FY 2006 Actual	6.04						$6.04	-	**$6.04**
FY 2007 Request	11.94			4.00			$11.94	$4.00	**$15.94**
FY 2008 Estimate	15.94			8.00			$15.94	$8.00	**$23.94**
FY 2009 Estimate	8.00			20.00	8.80		$16.80	$20.00	**$36.80**
FY 2010 Estimate	6.00			30.00	14.80		$20.80	$30.00	**$50.80**
FY 2011 Estimate	4.00			26.00	28.00		$32.00	$26.00	**$58.00**
FY 2012 Estimate	2.00			12.00	28.70		$30.70	$12.00	**$42.70**
FY 2013 Estimate	-				28.70		$28.70	-	**$28.70**
Subtotal, R&RA	$65.73		-		$109.00		$174.73		
Subtotal, MREFC		-		$100.00		-		$100.00	
Total, Each Stage		**$65.73**		**$100.00**		**$109.00**			**$274.73**

NOTE: The expected operational lifespan of this project is 30 years after construction is complete. Implementation funding levels will be updated when the Preliminary Design Review is complete (see information below). Annual operations and maintenance estimates for FY 2009 and beyond are presented strictly for planning purposes. They will be updated as new information becomes available.

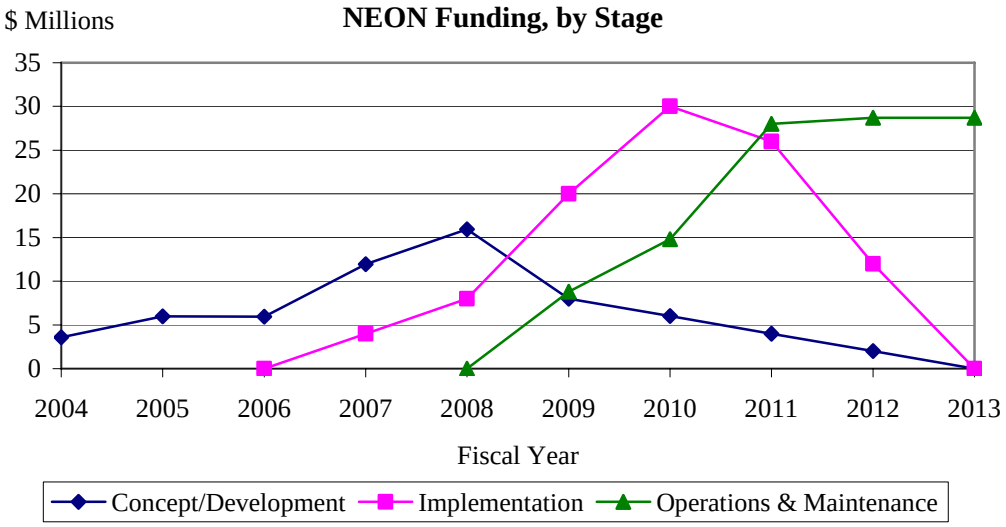
Information pertaining to the data in the table is provided below.

NOTE: The NEON baseline is under revision based on the continental design recommended in the NRC report. The revised baseline will be reviewed as part of the PDR review scheduled for May 2007. The figures shown here reflect the FY 2007 Request. The revised baseline is expected to include higher funding levels in FY 2009 and in the outyears.

- Concept/Development: In FY 2003, the National Research Council's study on NEON recommended that the infrastructural elements needed to address the six greatest ecological research challenges be simultaneously deployed across the U.S. and that a central NEON governance structure be established. A redefinition of an earlier scope, schedule, and cost for NEON was required in light of these recommendations. In FY 2004 and FY 2005, an award was made for a NEON Design Consortium and Project Office to redefine NEON (science and education plan and reference design) and to develop the preliminary PEP for simultaneous national deployment. In FY 2006, the NEON Science Plan and Requirements, the Networking and Informatics Plan, preliminary PEP, PDP, and Construction Costs were completed. Support will be continued for ongoing R&D projects on enabling technologies.

- Implementation: Construction costs for NEON research, networking, and education infrastructure will be vetted at the PDR in May 2007. After a thorough cost review, a revised budget for NEON infrastructure and operations and maintenance will be provided. NEON will include the standardized technology deployed across the U.S. and connected via cyberinfrastructure into a national research platform. In FY 2007, MREFC funds will be used to begin to establish the NEON Construction Office and assemble and evaluate the NEON fundamental technology unit (BioMesoNet, sensor micronets, and enabling cyberinfrastructure) that will be deployed. In FY 2008, MREFC funds will be used to complete staffing and infrastructure for the NEON construction office and begin materials acquisition for large scale deployment of the NEON FIU and cyberinfrastructure.

- Operations and Maintenance: Initial operations support will begin in FY 2009 as the CI backbone components of NEON (networking and informatics infrastructure) are commissioned and brought on-line.



Future Science Support: Since NSF supports 63 percent of the fundamental environmental biology research performed at U.S. academic institutions, advances in the field of ecology, and the infrastructure to enable those advances, depend largely on support from NSF. Current research infrastructure is inadequate to enable studies to address the complex phenomena driving ecological change in real time and at the appropriate scales. As a continent-wide research instrument, NEON will be. Along with direct operations and maintenance support for NEON, NSF will support research performed using the NEON platform through a special competition and through ongoing research and education programs. Based on prior experience with other new activities, BIO expects that within 3-5 years proposal submission to regular programs to use NEON will have grown sufficiently to negate the need for a special competition and resources dedicated to the competition will be transferred to core programs.

NEON will support a large and diverse group of organizations and individuals; foremost are the scientists, educators, and engineers who will utilize NEON infrastructure in their research and educational programs. NEON will provide enhanced research opportunities for existing field-based research networks, using natural history collections, and the cyberinfrastructure communities that are facilitating network-level ecological science. As a cyberinfrastructure enabled network, NEON will be accessible to academic and research institutions, state and federal research and management organizations, minority serving institutions, community colleges, K-12 school systems, the general public, natural resource and conservation organizations, and other public and private organizations. Thousands of researchers will be able to use NEON, tens of thousands of children may participate in NEON activities through its educational programs, and the NEON data, information and research products will be fully accessible via the Internet.

Associated Research and Education Activities: During the design and planning stage, NEON strategic R&D has focused on reducing project risk by funding scientists and engineers to pursue research in the areas of cyberinfrastructure (e.g. prototyping for environmental observatories, embedded, scalability), sensor prototyping (aquatic genosensor, animal tracking, harsh environments), dynamically drive data analysis, end-to-end cyberinfrastructure design of the NEON fundamental instrument unit, and software development for field and data hand held devices. In addition to training graduate students, these research projects included undergraduate participation through funding from the Research Experiences for Undergraduates Program. Outreach conducted by these individual projects includes K-12 students, teachers, and the public. As an example, during engineering week over 600 K-12 students, from elementary school to senior high school students around Missouri, along with their teachers, visited an engineering lab focused on developing animal video sensing. Workshops were conducted in the areas of social science, modeling, and animal sensing. These workshops focused on evolving technologies, technical and development issues, fostering collaborations, enhancing interoperability among observing systems, and communication. Active outreach to and involvement by minority serving institutions was initiated through the establishment of a NEON mentorship program by the Science and Engineering Alliance. The program involves Historically Black Colleges (HBCUs), Hispanic Serving Institutions (HSIs) and Tribal Colleges and Universities (TCUs).

Ocean Observatories Initiative (OOI)

Project Description: This project will construct an integrated observatory network that will provide the oceanographic research and education communities with continuous, interactive access to the ocean. The OOI will have three elements: 1) a global-scale array of relocatable deep-sea buoys, 2) a regional-scaled cabled network consisting of interconnected sites on the seafloor spanning several geological and oceanographic features and processes, and 3) an expanded network of coastal observatories, developed through new construction or enhancements to existing facilities. The primary infrastructure for all components of the OOI consists of an array of seafloor junction boxes connected to cables running along the seafloor to individual instruments or instrument clusters. Depending upon proximity to the coast and other engineering requirements, the junction box is either terminated by a long dedicated fiber-optic cable to shore, or by a shorter cable to a surface buoy that is capable of two-way communications with a shore station. A cutting edge, user-enabling cyberinfrastructure will link the three components of the OOI and facilitate experimentation using assets from the entire OOI network. The observatory infrastructure of the OOI will be operated as a shared-use facility with open community access to data.

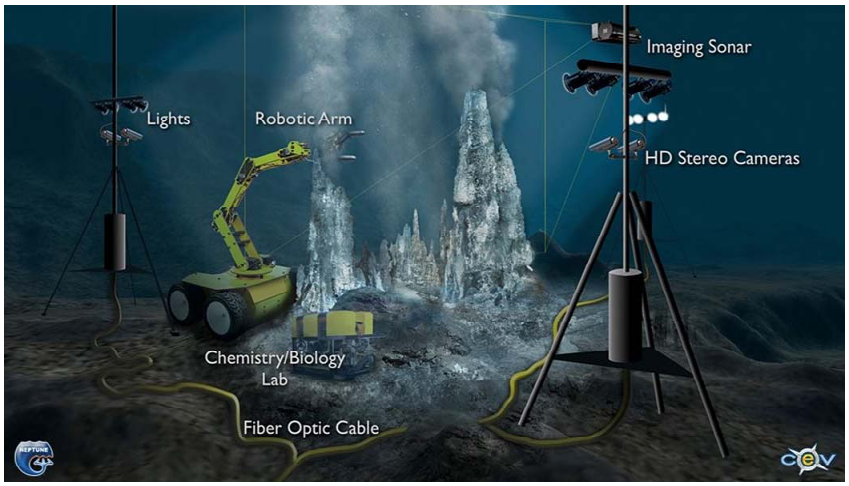
Principal Scientific Goals: Scientific problems requiring OOI infrastructure are broad in scope and encompass nearly every area of ocean science. Once established, seafloor observatories will provide earth, atmospheric, and ocean scientists with unique opportunities to study multiple, interrelated processes over timescales ranging from seconds to decades; to conduct comparative studies of regional processes and spatial characteristics; and to map whole-earth and basin scale structures. OOI facilities will meet the following goals: continuous observations at frequencies from seconds to decades; spatial scales of measurement from millimeters to kilometers; high power and bandwidth capabilities as well as two-way data transmission for interactive experimentation; an ability to operate during storms and in harsh conditions; an ability to easily connect sensors, instruments, and imaging systems; profiling systems for cycling instruments up and down the water column, either autonomously or on command; docking stations enabling autonomous underwater vehicles to download data and recharge batteries; ability to assimilate data into models and make three-dimensional forecasts of the oceanic environment; means for making data available in real time to researchers, schools, and the public over the Internet; and low cost relative to the cost of building and maintaining ships and manned submersible systems.

Principal Education Goals: Scientific discoveries arising from the OOI will provide new opportunities for ocean education and outreach through the capabilities for real-time data transmission and, particularly, real-time display of visual images from the seafloor. Educational links will be made with the Division of Ocean Sciences (OCE) Centers for Ocean Science Education Excellence (COSEE). In addition, with the planned establishment of the National Integrated Ocean Observing System (IOOS), there will be an unprecedented need for oceanographers skilled in the use and manipulation of large, oceanographic, time-series datasets. The facilities comprising the OOI will provide the ideal platforms to train this new generation of oceanographers.

Partnerships and Connections to Industry: Some of the component technologies that are part of the OOI are currently in use or in development as part of the telecommunication and exploration industries. These groups were involved in drafting the OOI Conceptual Network Design (CND) as well as in the review of OOI planning. Industry will also be important participants in the construction and implementation phase of the OOI as well as in the future development of sensors critical to the evolution of the OOI network.

Management and Oversight: The project is managed and overseen by a program manager in OCE (in GEO). The program manager receives advice and oversight support from an NSF PAT that includes representatives from GEO, BIO, ENG; BFA; OISE; OGC; and OLPA. The BFA DDLFP is a member of the PAT and provides advice and assistance. The management structure proposed for the construction phase of the OOI is based on a structure that has been successfully used by the Ocean Drilling Program.

In this structure, management, coordination, and oversight of the OOI will be the responsibility of the OOI Project Director operating from the Ocean Observatory Project Office established through a cooperative agreement with NSF in 2004. This Project Director will be accountable to an external advisory structure consisting of executive, scientific, and technical advisory committees. Advisory committee membership will be drawn from individuals with expertise in ocean observing science and engineering. Requests for Proposals have been released by the Project Office to establish Implementing Organizations (IOs) that will provide the detailed management and oversight for implementation of the three OOI elements as well as the project's cyberinfrastructure. These IOs will report directly to the Project Office. The OOI will be coordinated with the IOOS that will support operational mission objectives of agencies such as the National Oceanic and Atmospheric Administration (NOAA), the U.S. Navy, the National Aeronautics and Space Administration (NASA), and the U.S. Coast Guard.



Conceptual representation of a future seafloor laboratory on the Regional Cabled Observatory network. *Credit: the NEPTUNE Project* www.neptune.washington.edu

Current Project Status: Numerous community workshops have been held and reports written since 2000. These activities helped define the scientific rationale, determine the technical feasibility, and develop initial implementation plans for the OOI. These include two NRC reports as well as two community reports for each of the three OOI components. These planning activities were followed by a large, multi-disciplinary workshop held in January 2004 to develop an initial science plan for the OOI across coastal, regional, and global scales. The Ocean Observatory Project Office has been established and tasked to continue refinement of the OOI network design with advice from the research community; to develop a consensus vision for the OOI organizational structure, governance, and operating plans; to identify and engage all constituencies of the ocean science research community in consensus-building activities; and to operate an interactive web site for communicating with the ocean science community in regard to OOI activities and planning. In 2005, detailed conceptual proposals for ocean science research experiments were solicited through the Project Office. These proposals were peer reviewed and used to develop the OOI CND and to identify specific experimental instrumentation needs of the user community. From these proposals, detailed cost estimates for infrastructure to be constructed though the OOI have been developed. The initial CND arising from this exercise was reviewed and discussed by approximately 300 members of the ocean science community at the March 2006 OOI Design and Implementation workshop. Input from this activity was incorporated into the network design that was reviewed at the OOI Conceptual Design Review (August 14-17th 2006) as well as by the "Blue Ribbon" panel (July 2006), which reviewed whether the science that will be enabled by the OOI network is of highest priority for the ocean science research community. Recommendations from these reviews were incorporated into the final CND plan that will be reviewed at the Preliminary Design Review (PDR) in December of 2007. Using R&RA funds, the Ocean Technology and Interdisciplinary Coordination Program has continued to provide support for proposals whose goals are to ensure that infrastructure needed to enable OOI experimentation is available for the implementation phase of the OOI.

The construction schedule for this project is still under review and therefore the milestones listed below will likely be revised as the project's schedule is finalized.

FY 2006 Milestones:
- Internal Management Plan reviewed by Facilities Panel
- Completion of Project Development Plan
- OOI Conceptual Design Review

FY 2007 Milestones:
- Selection of Implementing Organizations
- OOI Preliminary Design Review and Construction Proposal Review
- Development of Programmatic Environmental Assessment
- Initial RCO cable route surveys
- Release of RFP for deployment of the RCO

FY 2008 Milestones:
- Shore station construction for the RCO
- Award of RFP for deployment of the RCO
- Finalize RCO cable route surveys
- Initial implementation of OOI cyberinfrastructure
- EA/EIS permitting process for the RCO cable route and coastal array

FY 2009 Milestones:
- Initiate first phase of the global array
- Initiate first phase of the coastal array
- Continue deployment of the Regional Cabled Network
- Initial installation and inspection of cable backbone section
- Initial installation of science nodes and instrumentation on backbone section
- Build 1.0 of the OOI cyberinfrastructure
- Initial implementation of the OOI Education and Public Awareness Plan

FY 2010 Milestones:
- Continue first phase of the global array
- Continue first phase of the coastal array
- Continue deployment of the Regional Cabled Network
- Final installation and inspection of cable backbone section
- Final installation of science nodes and instrumentation on backbone section
- Build 2.0 of the OOI cyberinfrastructure
- Continued implementation of the OOI Education and Public Awareness Plan

FY 2011 Milestones:
- Second phase of the global array
- Second phase of the coastal array
- Commissioning and testing of the RCO
- Build 3.0 of the OOI cyberinfrastructure
- Finalize implementation of the OOI Education and Public Awareness Plan

FY 2012 Milestones:
- Complete second phase of the global array
- Complete second phase of the coastal array

Commissioning and testing of the global and coastal arrays
Commissioning of the OOI cyberinfrastructure

Funding Profile: NSF expects to spend approximately $61 million in concept and development activities through FY 2007. The total construction cost for OOI is $331.11 million beginning in FY 2007. These cost estimates have increased since the program was first proposed in response to increased deployment costs due to rising fuel costs and vessel operation costs (averaging 13% per year for recent years) and increases in the costs estimated for OOI cyberinfrastructure. Management, operations and maintenance will be funded through the R&RA account.

Requested MREFC Funds for OOI
(Dollars in Millions)

FY 2007 Request	FY 2008 Request	FY 2009	FY 2010	FY 2011	FY 2012	Total
$5.12	$30.99	$80.00	$90.00	$95.00	$30.00	$331.11

OOI 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 2004 & Earlier	35.72						$35.72	-	$35.72
FY 2005	3.20						$3.20	-	$3.20
FY 2006	4.15						$4.15	-	$4.15
FY 2007 Request	8.30			5.12			$8.30	$5.12	$13.42
FY 2008 Request	9.00			30.99	6.10		$15.10	$30.99	$46.09
FY 2009 Estimate				80.00	10.20		$10.20	$80.00	$90.20
FY 2010 Estimate				90.00	15.20		$15.20	$90.00	$105.20
FY 2011 Estimate				95.00	29.30		$29.30	$95.00	$124.30
FY 2012 Estimate				30.00	46.40		$46.40	$30.00	$76.40
FY 2013 Estimate					50.00		$50.00	-	$50.00
FY 2014 Estimate					53.00		$53.00	-	$53.00
Subtotal, R&RA	$60.37		-		$210.20		$270.57		
Subtotal, MREFC		-		$331.11		-		$331.11	
Total, Each Stage		$60.37		$331.11		$210.20			$601.68

NOTE: A steady state of about $50.0 million in operations support is expected to occur in or about FY 2013. The expected operational lifespan of this project is 30 years, beginning in FY 2011. Operations 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.

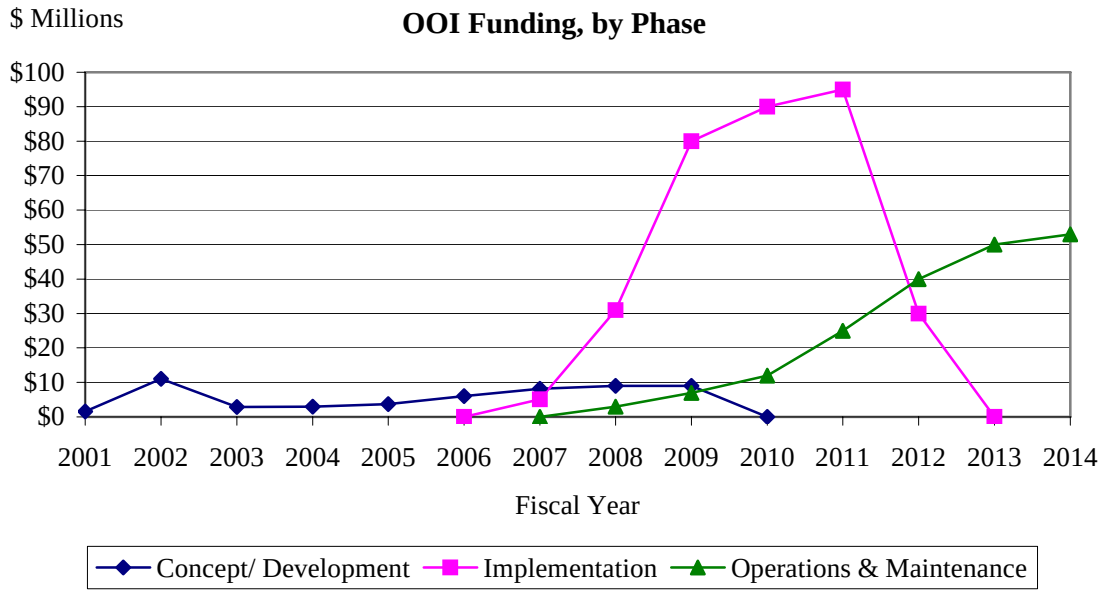
Information pertaining to the data in the table is provided below.

- Concept/Development: NSF provides nearly $45 million in R&RA funding through FY 2006, and an additional $17.30 million in FY 2007 and FY 2008, to support development activities to ensure that technologies needed for OOI implementation are ready by the Construction Phase. These funds also support workshops to identify the observatory infrastructure needed to address the high priority science requiring time-series measurements as well as development efforts to advance observing technologies. Specific design characteristics and platform requirements were developed through

conceptual design reviews and best practices consultations with industry and academic experts. In addition, $11.60 million was awarded to the Monterey Bay Aquarium Research Institute to establish an advanced cabled observatory in Monterey Bay. This observatory will advance scientific goals as well as create a systems and instrumentation testbed for potential future cabled ocean observing systems. R&RA funds are also being used to support the Ocean Observatories Project Office, advisory committees, and the implementing organizations. Finally, an office has been established to coordinate and lead development activities for the OOI.

- Implementation: Funds requested for this phase will construct a regional cabled observatory network spanning several geological and oceanographic features and processes; several relocatable deep-sea buoys to investigate global-scale processes; and new construction or enhancements to existing facilities leading to an expanded network of coastal observatories.

- Operations and Maintenance: Access to OOI Infrastructure will be determined by peer review and all data will be openly accessible. OOI Infrastructure will be maintained and operated by the Ocean Observatories Project Office. Future development of more complex sensor packages for the OOI infrastructure will be funded using R&RA funds within OCE. Observing platforms of the OOI will accommodate instrumentation from other agencies, international partners, as well as new instruments that are developed.



Associated Research and Education Activities: Research activities utilizing OOI infrastructure will be selected through the standard OCE, peer-review proposal process to ensure that experiments are of the highest caliber and that they are closely linked to programmatic priorities within the Division of Ocean Sciences. Collaboration with other environmental research programs such as the Integrated Ocean Drilling Program and the National Ecological Observing Network will encourage the implementation of a broad range of interdisciplinary experiments never before possible. These experiments will be catalysts for development of new fields of environmental study and will enhance education activities across a broad range of disciplines. Education and outreach activities will be enhanced through support of educators with expertise in utilizing large data systems to support education as well as in developing the tools targeted to meet the needs of identified audiences.

Future Science Support: Along with direct operations and maintenance support for the OOI, NSF will support research performed using this infrastructure through ongoing research and education programs. The annual support for such activities is estimated to be about $50.0 million, once the network is fully implemented.

Scientific Ocean Drilling Vessel (SODV)

Project Description: This project is to support the contracting, conversion, outfitting and acceptance trials of a deep-sea drilling vessel for long-term use in a new international scientific ocean drilling program. Commercial drillships are not routinely configured or equipped to meet the requirements of scientific research. The proposed Scientific Ocean Drilling Vessel (SODV) will be prepared for year-around operations and will be capable of operating in all ice-free ocean environments. The vessel will accommodate approximately 50 scientific and technical staff. The converted drillship will provide the U.S. facility contribution to the Integrated Ocean Drilling Program (IODP), which began in October 2003. The IODP is co-led by NSF and the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan. European and Asian nations are also participating in the program.

Principal Scientific Goals: The IODP will recover sediment and crustal rock from the seafloor using scientific ocean drilling techniques, and emplace observatories in drillholes to study the deep biosphere, the flow of fluids in sediments and the crust, the processes and effects of environmental change, and solid earth cycles and geodynamics. MEXT will provide a heavy drillship for deep drilling objectives of the programs. NSF will provide a light drillship and science support services for high-resolution studies of environmental and climate change, observatory and biosphere objectives.

Principal Education Goals: To engage students and the public in geoscience discovery through distance learning initiatives, classroom modules on IODP research initiatives and outreach displays for museums and educational/teaching institutions will be developed through research awards.

NSF Management and Oversight: The project is managed and overseen by a project manager in the Division of Ocean Sciences in GEO. The project manager receives advice and oversight support from a NSF PAT, which consists of representatives from GEO, OPP, BFA, and OGC. The BFA DDLFP is a member of the PAT and provides advice and assistance. A SODV Independent Oversight Committee (SIOC) has been established to provide technical, financial and scheduling recommendations and advice for the SODV project to top- level management. Also, a Program Advisory Committee (PAC) composed of members of the science and drilling communities, will provide an ongoing assessment of design plans for the on-board science and drilling capabilities and will ensure that the final plans reflect the needs of the scientific communities.

Current Project Status: In September 2003, NSF awarded a contract to Joint Oceanographic Institutions, Inc. (JOI) for IODP drilling operations, which includes the planning and implementation of the SODV project. JOI issued an RFP to acquire, upgrade, and operate a commercial vessel for scientific ocean drilling. The contract was awarded to Overseas Drilling Limited in December 2005. The SODV Project received $14.88 million in FY 2005, with $57.23 million appropriated in FY 2006. Engineering design and science lab development activities are currently underway. The project schedule is outlined below:

FY 2006 Milestones:
- Vessel Decision and Drilling Contractor Awarded
- Initiated Engineering Design Phase, including Science Lab Development

FY 2007 Milestones:
- Initiate Long Lead Item Equipment Procurement
- Complete Engineering Design Phase
- Issue Drilling Contractor Solicitation for Conversion Shipyard
- Shipyard Contract Award
- Initiate Shipyard Conversion of Drillship
- Complete Equipment/Structural Removals

Develop Production Engineering Package
Complete Habitability and Science improvements
Outfit Scientific Laboratories
Vessel Acceptance Trials
Vessel Commissioning and Acceptance –Terminate SODV MREFC project
Vessel Scientific Operations Begin

Funding Profile: Planning through FY 2005 cost approximately $4.7 million, funded through the R&RA account. In FY 2005, $14.88 million was appropriated to begin the project; approximately $6.08 million of this amount was awarded to JOI to initiate contract activity, planning and design. Approximately $109.0 million of MREFC funds will be required from FY 2005 through FY 2007 for conversion/equipping/testing of the drillship.

Appropriated and Requested MREFC Funds for SODV

(Dollars in Millions)

FY 2005	FY 2006	FY 2007 Request	Total
14.88	$57.23	$42.88	$115.00

NOTE: Totals may not add due to rounding.

SODV Funding Profile

(Obligated Dollars and Estimates in Millions)

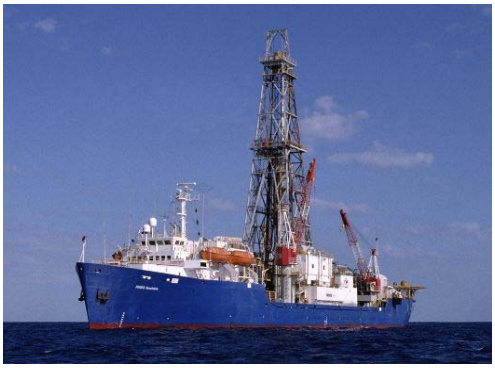
	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2004 & Earlier	4.20						$4.20	-	$4.20
FY 2005	0.50			6.08			$0.50	$6.08	$6.58
FY 2006				66.03			-	$66.03	$66.03
FY 2007 Request				42.88	21.30		$21.30	$42.88	$64.18
FY 2008 Request					33.36		$33.36	-	$33.36
FY 2009 Estimate					35.03		$35.03	-	$35.03
FY 2010 Estimate					36.78		$36.78	-	$36.78
FY 2011 Estimate					38.62		$38.62	-	$38.62
FY 2012 Estimate					40.55		$40.55		
FY 2013 Estimate					42.58		$42.58	-	$42.58
Subtotal, R&RA	$4.70		-		$248.21		$252.91		
Subtotal, MREFC		-		$115.00		-		$115.00	
Total, Each Stage		$4.70		$115.00		$248.21			$367.91

NOTE: Totals may not add due to rounding.
A steady state of about $33 million in operations support is expected to occur beginning in FY 2008 as the SODV vessel begins full operations, but these estimates are developed based on current cost profiles and will be updated as new information becomes available. The expected operational lifespan of this project is 15 years, beginning in FY 2007. The ship conversion activity is currently out for bid. The budget estimates shown may be modified based on actual shipyard bids received for the conversion work.

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

- Concept/Development: Activities supported by the R&RA account included coordination and planning efforts necessary for SODV planning with Japanese partners and the scientific user

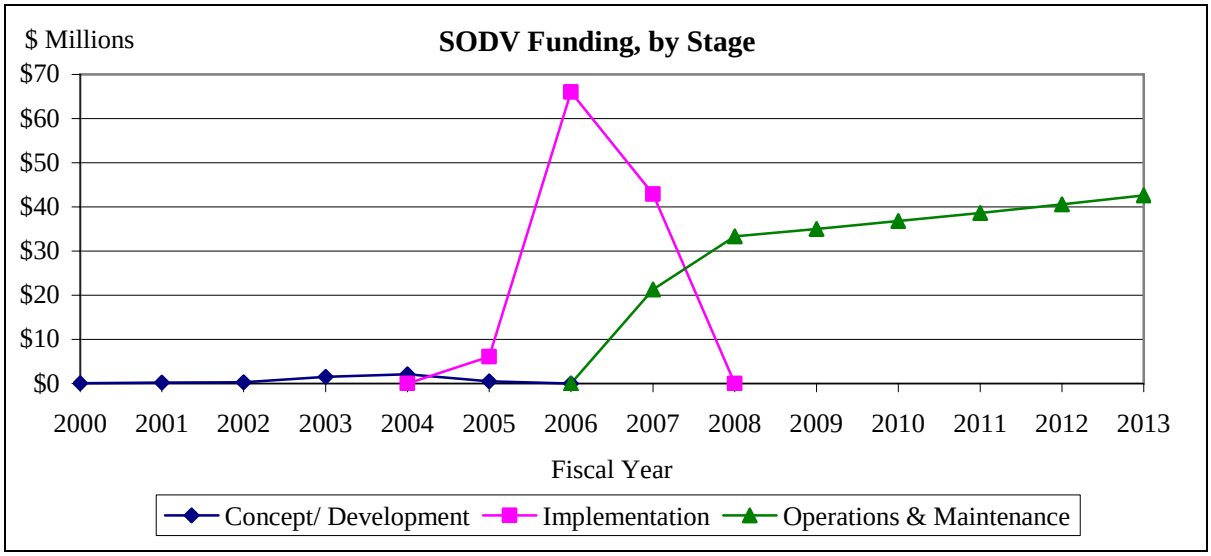
community; development of the SODV Project Execution Plan by the contractor; scoping of the environmental requirements, and permitting issues for the SODV drilling vessel.



Pictured above is the *JOIDES Resolution*, the current drillship of the ODP. NSF will modify this or a similar ship to provide the IODP with light drillship capability. *Credit: JOI*

- Implementation: The MREFC funds in FY 2005-2007 are required for the engineering design and vessel conversion, including construction of laboratory and other scientific spaces, equipping of laboratories with instrumentation, computers and support equipment, upgrade of the accommodations spaces, and modifications to the drilling equipment of the contracted vessel. Funding is also required for vessel lease during modification and for sea-trial operations in FY 2007.

- Operations and Maintenance: Following conversion, the drillship will be managed, operated and maintained by JOI (and subcontractors) with funding from the R&RA account, for use in the Integrated Ocean Drilling Program. Operations cost estimates are based on NSF experience in management of the IODP precursor, the Ocean Drilling Program, and the contract with the SODV operator. Specific missions will be reviewed and prioritized by a science advisory committee composed of representatives from IODP member nations. Significant coordination and integration of planning, procedures, and operations are occurring with Japanese operators of their drillship in the IODP.



Associated Research and Educational Activities: Since this vessel will serve the IODP, the activities associated with research and education are described in the Facilities chapter.

Future Science Support: Along with direct operations and maintenance support for IODP, 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 $30 million.

South Pole Station Modernization (SPSM)

Project Description: South Pole Station Modernization (SPSM) provides a new station to replace the current U.S. station at the South Pole, built 30 years ago and inadequate in terms of capacity, efficiency, and safety. The new station is an elevated complex with two connected buildings, supporting 150 people in the summer and 50 people in the winter.

Principal Scientific and Education Goals: The completed South Pole Station will provide a platform for the conduct of science at the South Pole and fulfills NSF's mandate to maintain a continuous U.S. presence at the South Pole in accordance with U.S. policy. NSF will also support education associated with the research projects at the South Pole.

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: OPP has the overall oversight responsibility for SPSM, including development of the basic requirements, design, procurement, and construction. OPP has contracted for procurement and construction management for all phases of the project, including design reviews of all drawings and specifications; conformance of the designs and procurements with established standardization criteria; assistance in establishing functional interfaces; transition from the existing to the new facilities; and systems integration. Naval Facilities Engineering Command, Pacific Division (PACDIV) selects, monitors, and manages architectural and engineering firms for design, post-construction services, and construction inspection for the project. The project status, including cost expenditures and cost projections, is monitored closely by the OPP Facilities Engineer and other OPP staff, and on a periodic basis by the project's PAT. The BFA DDLFP regularly briefs the CFO and the NSF Director on project status.

Early 2006 photograph of South Pole Station as it completes the renovation process.

Current Project Status: The original estimate for SPSM was $127.90 million. In 2001, the NSB approved a change in project scope, increasing station capacity from 110 people to 150 people, as well as a project schedule extension caused almost entirely by weather-imposed logistics delays, increasing the cost estimate to $133.44 million. The FY 2007 budget requested $9.13 million to continue the project and noted the possibility that final completion might require additional funding. Following a full external review of the remaining scope of the project, conducted by a team of experts, OPP has prepared a revised SPSM project cost and schedule that takes into account several risk factors of concern to the review panel, such as competition for skilled construction workers with reconstruction activities in Iraq and post-Katrina Louisina and Alabama; weather uncertainties; and scientific projects competing for limited logistics capabilities. These and other risk factors were also incorporated into associated contingency funds and add $6.55 million to the project cost, bringing the total to $149.30 million. The revised schedule calls for the project to be completed in 2010. This delay does not impact full use of planned station facilities and is unlikely to cause significant cost increases.

These are the current milestones.

Activity	Procurement	Transport to Antarctica	Airlift to South Pole	Start Construction	Conditional Acceptance
Vertical Circular Tower	FY98	FY99	FY99/00	FY00	FY02
Quarters/Galley	FY98	FY99	FY00/FY01	FY01	FY03
Sewer Outfall	FY98	FY99	FY00	FY01	FY02
Fuel Storage (100K gallons)	FY98	FY98	FY99	FY99	FY99
Medical/Science	FY99	FY00	FY01/02	FY02	FY04
Communications/Administration	FY99	FY01	FY02/03	FY03	FY06
Dark Sector Lab	FY98	FY99	FY99/00	FY00	FY06
Water Well	FY00	FY01	FY01/02	FY02	FY07
Remote RF Building	FY99	FY00	FY01	FY01	FY01
Emergency Power/Quarters	FY99	FY01	FY02/03	FY03	FY05
Liquid nitrogen and helium facility	FY02	FY03	FY04	FY04	FY07
Quarters/Multipurpose	FY99	FY02	FY04	FY05	FY06
Electronic Systems and Communications	FY00/03	FY01/04	FY01/05	FY01	FY06
Warehousing, SEH and Waste Management	FY99	FY02/03	FY04/05/06	FY07	FY10
Station Equipment	FY02/03	FY03/04	FY04/05	N/A	FY10

Funding Profile: Based on an updated project cost and schedule review completed after the 2005/2006 operating season, the estimated total cost to complete SPSM is $149.30 million.

Appropriated and Requested MREFC Funds for SPSM

(Dollars in Millions)

	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 2007 Request	FY 2008 Request	Total
SPSM Appropriations	70.00	39.00	5.40	13.47	-	5.96	1.29	-	-	9.13	6.55	150.80
Reprogramming				-1.00	-0.50	-0.24			0.23			-1.51
	$70.00	$39.00	$5.40	$12.47	-$0.50	$5.73	$1.29	-	$0.23	$9.13	$6.55	$149.30

NSF reprogrammed $1.0 million in FY 2001 to the Polar Support Aircraft Upgrades, $500,000 in FY 2002 to the South Pole Safety and Environment project, and $235,000 in FY 2003 to HIAPER and LHC to cover final costs due to a recission in that year. The FY 2004 appropriation for SPSM represents payback for the reprogrammings in FY 2001 and FY 2003. SPSM received $120,000 of available funds in FY 2006 from the Polar Aircraft Support Upgrades upon completion of that project, and $110,000 from other MREFC projects.

Advance funding provided in the project's early years made possible advance bulk buys of materials, which is ultimately more cost-efficient. However, this project's overall outlay is relatively slow due to unusual logistics associated with construction in Antarctica and the shortened Antarctic season. As a result, the project has carried over fairly significant amounts each year since FY 1998, resulting in obligations that are significantly lower than appropriated amounts.

The following funding profile chart includes actual obligations for past years and anticipated obligations for future years. SPSM obligations total $133.48 million through FY 2006.

South Pole Station Modernization 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 1997 & Earlier	16.40						$16.40	-	$16.40
FY 1998				24.93			-	$24.93	$24.93
FY 1999				4.28			-	$4.28	$4.28
FY 2000				15.49			-	$15.49	$15.49
FY 2001				10.14			-	$10.14	$10.14
FY 2002				15.03			-	$15.03	$15.03
FY 2003				12.65			-	$12.65	$12.65
FY 2004				21.02			-	$21.02	$21.02
FY 2005				16.86			-	$16.86	$16.86
FY 2006 Actual[1]				13.07			-	$13.07	$13.07
FY 2007 Request				9.27	15.00		$15.00	$9.27	$24.27
FY 2008 Request				6.55	15.38		$15.38	$6.55	$21.93
FY 2009 Estimate					15.76		$15.76	-	$15.76
FY 2010 Estimate					16.14		$16.14	-	$16.14
FY 2011 Estimate					16.53		$16.53	-	$16.53
FY 2012 Estimate					16.94		$16.94	-	$16.94
FY 2013 Estimate							-	-	-
Subtotal, R&RA	$16.40		-		$95.74		$112.14		
Subtotal, MREFC		-		$149.30		-		$149.30	
Total, Each Stage		$16.40		$149.30		$95.74			$261.44

NOTE: A steady state of operational support is anticipated at about $15 million by FY 2008, slightly higher than the current operational costs. The expected lifespan of the modernized station is 25 years, through FY 2031. Operations 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.

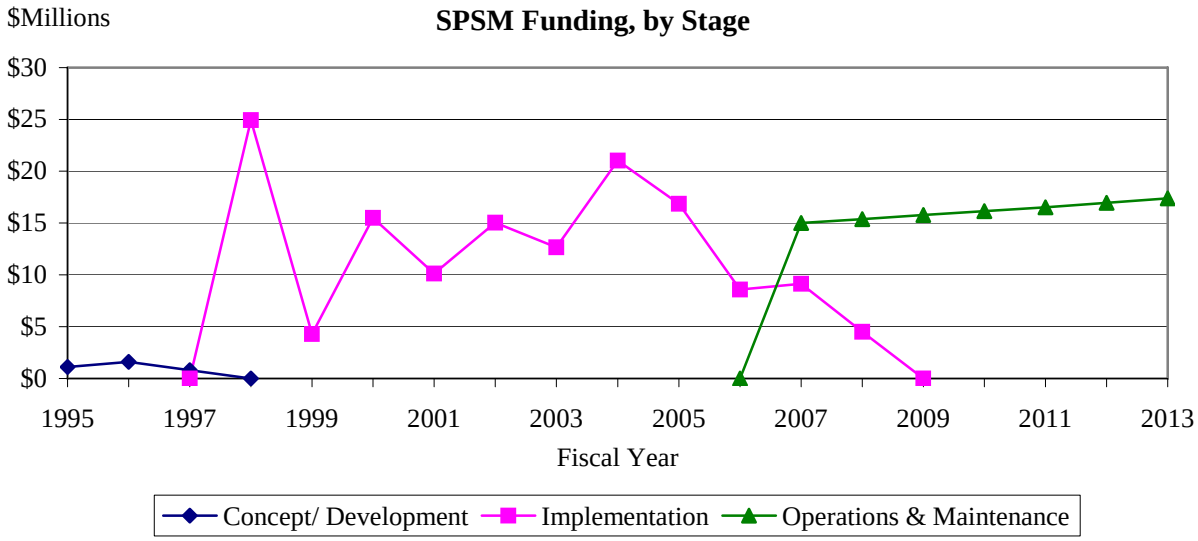
[1]FY 2007 implementation costs include carryover from FY 2006 into FY 2007.

Information on the data in the table is provided below.

- Concept/Development: Design, development, planning, and closely related activities in support of this project included preparation of more than 40 engineering studies and reports. The documents ranged widely in subject matter including subjects such as snowdrift minimization modeling, detailed analysis of power and heating requirements, preparation of a draft Environmental Impact Statement, energy conservation measures, efficiency and maintainability of diesel generators, fuel storage support system evaluation, design code criteria matrix, concept for signal/communication systems, gray-water system evaluation, minimization of ventilation requirements, control of diesel engine exhaust emissions, and jacking plan and concept.

- Implementation: Funding supports construction of an elevated station complex with two connected buildings, supporting 150 science and support personnel in the austral summer, and 50 science and support personnel in the winter. Costs include materials, labor, logistics for transportation of all material and personnel to the South Pole, construction support, inspection, and equipment, as well as demolition and disposal of the existing station.

- Operations and Maintenance: This support represents the continued presence of a U.S. station at South Pole rather than new funds. Operational costs of the modernized station are expected to be higher than operational costs of the current station, with some lower costs due to efficiencies gained, and some higher costs due to increased station size and increases in Science Support and Information Systems. A steady state of operational support is anticipated at $15.0 million by FY 2008. The expected lifetime of the modernized station is 25 years, through FY 2031. These estimates are currently being reviewed to improve accuracy, taking into account estimated station population and cargo loads.



Future Science Support: Along with direct operations and maintenance support for South Pole Station, NSF will support science and engineering research through ongoing research and education programs. The annual support for such activities is currently estimated to be approximately $9.5 million.

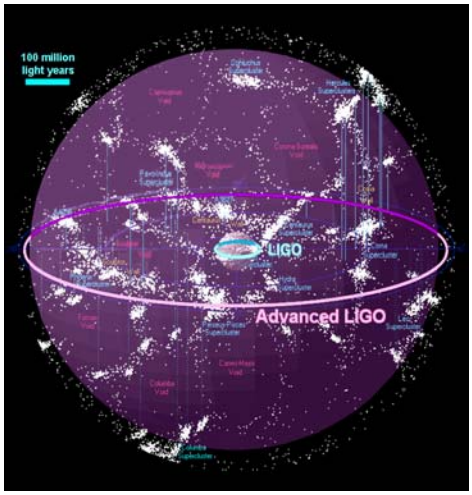
SECOND PRIORITY: NEW STARTS IN 2008

NSF's second priory 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 one new start in FY 2008: Advanced LIGO.

Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO)

Project Description: Advanced LIGO is the upgrade of the Laser Interferometer Gravitational Wave Observatory (LIGO) that will allow LIGO to approach the ground-based limit of gravitational wave detection. LIGO consists of the world's most sophisticated optical interferometers, operating at two sites (Hanford, WA and Livingston, LA) separated by 3,000 km[8]. Each interferometer has two 4-km arms at 90 degrees to one another. In addition, the interferometer at Hanford contains a 2-km interferometer within the same vacuum enclosure used for the 4-km interferometer. These interferometers are designed to measure the changes in the lengths of the arms resulting from the wave-like distortions of space-time caused by the passage of gravitational waves. The changes in arm length that can be detected by the present Phase I LIGO are a thousand times smaller than the diameter of a proton over the 4-km arm length. AdvLIGO is expected to be at least ten times more sensitive. The frequency range for which LIGO and AdvLIGO are designed will be sensitive to many of the most interesting cataclysmic cosmic phenomena believed to occur in the universe. Furthermore, because LIGO and AdvLIGO will push the sensitivity of gravitational wave detection orders of magnitude beyond existing frontiers, the potential for making discoveries of completely new phenomena is significant. LIGO is in the process of achieving its objectives as planned and may detect the first gravitational waves. AdvLIGO will greatly increase the facility's sensitivity to ensure the detection of gravitational waves and to launch the new field of gravitational-wave astronomy.

The LIGO project was planned in two phases from the beginning. Phase I would produce a gravitational wave detector that would be as sensitive as possible with the technology available in the early 1990s on a platform that could be upgraded to the ultimate sensitivity as the critical technologies were further developed. The goal of Phase I was to obtain a year's worth of accumulated data at the design sensitivity for Phase I (expressed as a dimensionless strain $h \sim 10^{-21}$, the ratio of the change in arm length to the length of the arm). The LIGO Laboratory expects to have those data in 2006-2007. The second phase, or AdvLIGO project, will upgrade LIGO to enable attainment of the ultimate sensitivity of an Earth-based gravitational wave observatory, limited only by the irreducible effects of fluctuations in the Earth's gravitational field. From the outset, the overall LIGO strategy was to produce a broadband gravitational wave detector with an unprecedented astronomical reach and then to upgrade the initial facility to achieve the most sensitive gravitational wave detector possible on Earth.



The MREFC Project Advanced LIGO will improve the sensitivity of LIGO by more than a factor of 10, which will expand the volume of space LIGO will be able to "see" by more than 1,000. Each small dot in the figure represents a galaxy. Credit: R. Powell,www.anzwers.org/free/universe/nearsc.html

The LIGO program has strongly stimulated interest in gravitational-wave research around the world, producing

[8] A full description of LIGO is included in the Facilities section of this document.

vigorous programs in other countries that provide strong competition as well as highly beneficial collaborations. LIGO has pioneered the field of gravitational-wave measurement, and a timely upgrade is necessary to reap the fruits of this bold initiative. International partners are contributing significant human and financial resources.

Principal Scientific Goals: Einstein's theory of general relativity predicts that cataclysmic processes involving extremely 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. Furthermore, the universe is believed to be filled with gravitational waves from a host of cataclysmic cosmic phenomena; however, scientists have never directly detected a gravitational wave nor measured its waveform.

The principal scientific goals of the LIGO – AdvLIGO project are to detect gravitational waves on Earth for the first time and to develop this capability into gravitational wave astronomy – a new window on the universe – 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, a stochastic background from the early universe, and a host of more exotic or unanticipated processes.

Principal Education Goals: LIGO has been a significant source of highly trained Ph.D. graduates for the country's workforce. In addition, LIGO has a diverse set of educational activities at its different sites, activities that involve a large number of undergraduates and outreach activities for the public. In 2004 NSF entered into a cooperative agreement with Caltech and Southern University/Baton Rouge to build the LIGO Science Education Center at the Livingston, LA site. Construction on the Center began in early FY 2006, and the Center was dedicated in early FY 2007.

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

Management and Oversight: LIGO is sponsored by NSF and managed by Caltech under a cooperative agreement. Under the current agreement, NSF oversight is coordinated internally by a dedicated LIGO Program Director in the Division of Physics (PHY) within MPS, who also participates in the Physics Division PAT. NSF conducts annual scientific and technical reviews involving external reviewers and participates in meetings of the LIGO Scientific Collaboration (LSC) as well as making site visits to the Hanford, WA and Livingston, LA interferometers. During the AdvLIGO construction phase, NSF will continue the activities described above and exercise more intensive oversight through more frequent reporting requirements, step up interaction with the project personnel, and schedule reviews and site visits at least twice yearly and more frequently if the need arises. The NSF LIGO Program Director will work closely with the Project Leader for the AdvLIGO Project at the Massachusetts Institute of Technology (MIT). Project management techniques used in the successful completion of the initial LIGO construction will be employed to benefit management of the AdvLIGO construction.

Current Status of Phase I: 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. Five science runs have been performed or are in progress: 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, with a sensitivity within a factor of 2 of the design

goal, from February 22, 2005 to March 23, 2005. The addition of the Hydraulic External Pre-Isolation (HEPI) system to the Livingston interferometer to eliminate interference from anthropogenic noise sources was completely successful, as indicated in the improvement of the Livingston duty factor 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. The improvements achieved in the intervals between all science runs have been remarkable. S-5, currently operating at a sensitivity about 40 percent better than the design goal, began on November 4, 2005, and has a planned duration of eighteen months. The coincident duty factor – the percentage of time during which all three facilities are operating simultaneously – has generally risen over the history of the science runs, and it is currently 57% for S-5.

Current Status of AdvLIGO: The LIGO Laboratory submitted a proposal for AdvLIGO in early 2003. The proposal was reviewed in June 2003 and the project was considered to be ready for construction. A baseline review in June 2006 judged that the project was ready for a construction start in FY 2008. The AdvLIGO project will upgrade the laser, suspension, seismic isolation, and optical subsystems. Advanced detector R&D has proceeded to the point where technology needed for the upgrade is well in hand. In particular the development of the laser subsystem has achieved performance levels essentially at the final specifications, and part of the AdvLIGO seismic isolation system is already in operation at the Livingston site, where it has successfully eliminated excess vibration from various sources. The LIGO Laboratory will have spent $40.74 million of R&RA funds on advanced R&D for AdvLIGO in the period from FY 2000 – 2008.

Major milestones for Advanced LIGO include:

FY 2006-2007 Milestones:
- Finalize concept design and development of instrumentation

FY 2008 Milestones
- Place orders for long lead time items such as test mass optics
- Continue design of remaining instrumentation

FY 2009-2011 Milestones:
- Acquire components needed to begin installation in FY 2011-2012
- Prepare sites for installation

FY 2011-2012 Milestones:
- Shutdown Livingston interferometer (early FY 2011)
- Begin installation at Livingston (mid FY 2011)
- Shutdown Hanford interferometers (late FY 2011)
- Begin installation at Hanford (early FY 2012)

FY 2013-2014 Milestones:
- Begin final computer assembly and installation begins (mid FY 2013)
- Accept Livingston upgrade (early FY 2014)
- Accept Hanford upgrades (early to late FY 2014)

FY 2015 Milestones:
- Complete final computer assembly and installation
- Livingston and Hanford interferometers simultaneously operational
- Begin commissioning

Funding Profile:

Requested MREFC Funds for AdvLIGO
(Dollars in Millions)

FY 2008 Request	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
$32.75	$51.43	$46.30	$15.21	$23.73	$15.50	$19.78	$0.42	$205.12

AdvLIGO 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 2004 & Earlier	15.60						$15.60		$15.60
FY 2005	9.20						$9.20		$9.20
FY 2006 Actual	9.70						$9.70		$9.70
FY 2007 Request	6.24						$6.24	-	$6.24
FY 2008 Request				32.75	28.20		$28.20	$32.75	$60.95
FY 2009 Estimate				51.43	27.60		$27.60	$51.43	$79.03
FY 2010 Estimate				46.30	27.80		$27.80	$46.30	$74.10
FY 2011 Estimate				15.21	29.20		$29.20	$15.21	$44.41
FY 2012 Estimate				23.73	32.20		$32.20	$23.73	$55.93
FY 2013 Estimate				15.50	36.00		$36.00	$15.50	$51.50
FY 2014 Estimate				19.78	42.90		$42.90	$19.78	$62.68
FY 2015 Estimate				0.42	47.90		$47.90	$0.42	$48.32
Subtotal, R&RA	$40.74		-		$271.80		$312.54		
Subtotal, MREFC		-		$205.12		-		$205.12	
Total, Each Stage		$40.74		$205.12		$271.80			$517.66

Note: Operations and Maintenance are for LIGO operations during AdvLIGO construction. Estimates for FY 2009 and beyond were developed strictly for planning purposes. A recent cost and schedule baseline review may result in modifications. R&RA funds for the period FY 2004 & Earlier through FY 2007 were in LIGO operations.

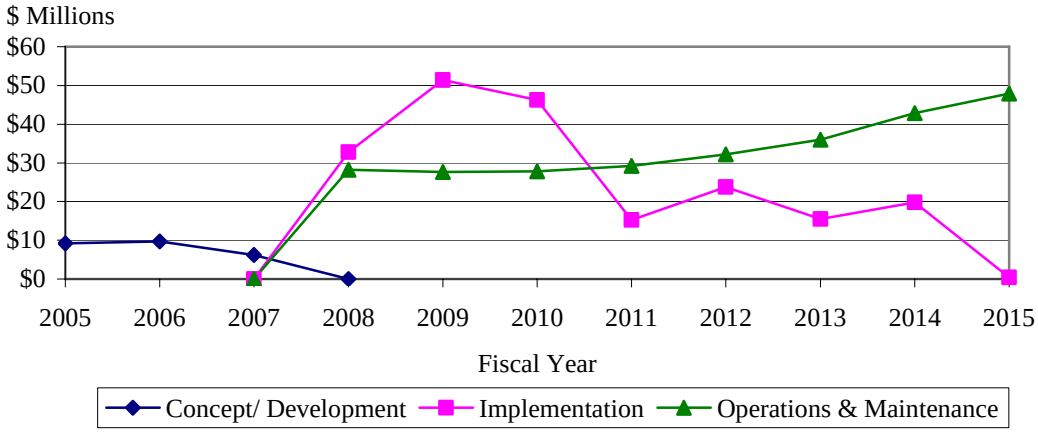
Detailed information pertaining to the data in the table is included below.

- Concept/Development: In the period of FY 2000 to FY 2008, $40.74 million will have been spent by the LIGO Laboratory for advanced R&D for concept development of AdvLIGO. Additional development work during the construction period will be directed to design development.

- Implementation: Funding during the MREFC phase of the project will provide for construction of the new instrumentation, including the laser, suspension, seismic isolation, and optical subsystems.

- Operations and Maintenance: R&RA funds will be used to maintain LIGO's existing experimental facilities and infrastructure during the construction, to continue the analysis of the data obtained during the operation of the original LIGO and LIGO's education and outreach activities, and to ramp up AdvLIGO's operations as construction reaches completion. Note that the operations and maintenance figures for AdvLIGO in FY 2008 through FY 2012 are the same as those shown for operations and maintenance of original LIGO in the Facilities section.

AdvLIGO Funding Profile



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 at each site 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 includes information on research opportunities for schools and a set of standards-based classroom activities, lessons, and projects related to LIGO science. In early FY 2007, the LIGO Science Education Center at the Livingston, LA site was dedicated and filled with Exploratorium exhibits. The Center will be the focal point for augmenting teacher education at Southern University and other student-teacher activities state-wide through the Louisiana Systematic Initiative Program. Outreach coordinators have been hired at each site to augment the existing activities. Continuing this year is Einstein@Home, a World Year of Physics project led by a collaborating scientist from the University of Wisconsin that allows almost anyone in the world with a computer to participate in LIGO data analysis.

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

In 1997, LIGO founded the LSC to organize the major international groups doing research in support of LIGO. The LSC now has over 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 instrument improvements at the LIGO facilities.