MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION $240,450,000

The FY 2007 Budget Request for the Major Research Equipment and Facilities Construction (MREFC) account is $240.45 million, an increase of $49.57 million, or 26.0 percent, above the FY 2006 Current Plan of $190.88 million.

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

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change Over FY 2006 Amount	Change Over FY 2006 Percent
Major Research Equipment and Facilities Construction	$165.14	$190.88	$240.45	$49.57	26.0%

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 2005 Actual	FY 2006[1] Current Plan	FY 2007 Request	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate
Ongoing Projects								
ALMA	49.30	45.14	47.89	47.07	37.37	20.98		
EarthScope	44.80	46.40	27.40					
IceCube	48.10	46.25	28.65	22.38	11.33	0.95		
NEON			12.00	12.00	20.00	30.00	26.00	
SODV	6.08	53.09	42.88					
SPSM	16.86		9.13					
DOJ Judgment			3.00					
New Starts								
ARRV			56.00	42.00				
OOI			13.50	48.00	77.00	78.00	53.00	40.00
AdvLIGO			-	28.48	42.81	46.31	36.25	22.90
Totals	$165.14	$190.88	$240.45	$199.93	$188.51	$176.24	$115.25	$62.90

Totals may not add due to rounding.

Estimates for FY 2008 and beyond do not reflect policy decisions and are presented for planning purposes only.

[1]The FY 2006 Current Plan excludes $45.68 million carried forward from previous years. This includes an unobligated balance of $14.88 million from FY 2005 distributed pro rata among ALMA, EarthScope, IceCube and SODV; and an additional carryover of $2.17 million for EarthScope, $6.59 million for IceCube, $8.80 million for SODV, and $13.17 million for SPSM.

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. NSF's FY 2007 request for the MREFC account positions the agency to meet the future needs and opportunities of the research community.

In September 2005, NSF released "A Joint National Science Board-National Science Foundation Management report on *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*." This "Setting Priorities" report outlines in general terms the changes NSF will implement to its large facilities process over the next year, and was developed largely in response to the February 2004 National Academies' report of the same name. That report recommended an open process for selecting new projects to be funded, establishing well-defined criteria, including maximum community input, and ensuring that the results of this final prioritization should be "discussed, explained and documented". NSF concurs with these recommendations and continues to refine the MREFC process to ensure that decisions are clearly documented and explained and selection criteria clearly articulated.

In accordance with the plan outlined in NSF's Setting Priorities document, NSF continues to develop the guiding documentation for the MREFC process. NSF released its first *Facility Plan*[1] in September, 2005 and will release its second annual *Facility Plan* in March, 2006. The revised *Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction (MREFC) Account*[2] was released in November 2005, and the final management document, the *Facility Manual*[3], is expected to be released during FY 2006.

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 this Budget Request meet these criteria.

MREFC projects under consideration must undergo a multi-phase review and approval process[4]. This includes a review by the internal NSF MREFC Panel, comprised of the Deputy Director, the Assistant Directors, the Heads of the Office of Polar Programs and the Office of Cyberinfrastructure, the Chief Financial Officer, and the Deputy Director for Large Facility Projects. The MREFC Panel makes recommendations to the NSF Director with attention to criteria such as scientific merit, importance, readiness, and cost-benefit. These criteria have been modified to align with the criteria recommended by the National Academies. The Director then selects candidates to send to the National Science Board

[1] 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)

[2] The Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction (MREFC) Account, also referred to as 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)

[3] The revised Large Facilities Manual and supplemental modules will provide step-by-step guidance to NSF staff and awardees on strong 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.

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

(NSB) for consideration, which then approves, or not, projects for inclusion in future budget requests and establishes priorities in August of each year. The Director, in keeping with the NSB prioritization, selects from the group of approved projects those appropriate for inclusion in a particular budget request to OMB, and after discussion with OMB, to the Congress.

As a general framework for priority setting, NSF assigned priority to projects based on the following criteria:

> First Priority: Ongoing Projects – Projects that have received funding for implementation and where outyear funding for the full project has already been included in a Budget Request to Congress.
>
> Second Priority: NSB-Approved New Starts – New projects that have received NSB approval for inclusion in a budget request but which have not yet been included in a budget request or have not yet received funding.

NSF believes that the highest priority within the MREFC Account must be the current projects. To that end, the FY 2007 Budget requests funding for the Atacama Large Millimeter Array ($47.89 million); EarthScope ($27.40 million); the IceCube Neutrino Observatory ($28.65 million); the National Ecological Observatory Network ($12.0 million); the Scientific Ocean Drilling Vessel ($42.88 million); and the South Pole Station Modernization Project ($9.13 million). An additional $3.0 million is requested to reimburse the DOJ Judgment Fund for a settlement related to the Polar Aircraft Upgrades project.

NSF's second priority are those projects that have received NSB-approval for inclusion in a budget request but which have not yet received funding. NSF is requesting funding for two new starts in FY 2007. In priority order, these are the Alaska Region Research Vessel ($56.0 million) and the Ocean Observatories Initiative ($13.50 million). Finally, NSF is requesting funding for one new start in FY 2008: Advanced LIGO ($28.48 million in FY 2008).

At the August 2005 meeting of the NSB, NSF recommended and the NSB approved the termination of Rare Symmetry Violating Processes (RSVP) project[5]. NSF remains committed to particle physics as a premier field with unprecedented opportunities for major discoveries in the decades ahead; and NSF will work with its partners to enable U.S. scientists to fully participate in the discoveries ahead. NSF will work with the RSVP project management on an orderly phase-out of activities over the next few months. There were no MREFC funds spent on RSVP.

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, ~~$193,350,000~~*$240,450,000*, to remain available until expended. *(Science Appropriations Act, 2006.)*

[5] The NSB resolution states "Resolved, that the National Science Board concurs with the recommendation that the Rare Symmetry Violating Processes (RSVP) Project be terminated before the start of construction as a result of the significantly increased construction and operations costs identified during the final stages of planning and the negative impact on the NSF portfolio that would result from proceeding with the project under such circumstances. The National Science Board notes the significant lost scientific opportunity that will result from this project termination."

Major Research Equipment and Facilities Construction Account
Budgetary Resources Summary
(Dollars in Millions)

	Enacted/ Request	Rescission	Carryover/ Recoveries	Transfers	Total Budgetary Resources	Obligations Incurred/ Estimated
FY 2005 Actual	175.05	-1.40	37.17	-	210.82	165.14
FY 2006 Current Plan	193.35	-2.47	45.68	-	236.56	236.56
FY 2007 Request	240.45	-	-	-	240.45	240.45
$ Change from FY 2006	$47.10				$3.89	
% Change from FY 2006	24%				2%	

Explanation of Carryover

Within the Major Research Equipment and Facilities Construction (MREFC) appropriation $45.68 million was carried forward into FY 2006. OPP activities include $13.17 million for South Pole Station Modernization, $10.19 million for the IceCube Neutrino Observatory (IceCube), and $33,795 for the South Pole Safety Project. The remaining MREFC carryover includes $12.94 million for GEO's Scientific Ocean Drilling Vessel (SODV), $5.79 million for GEO's EarthScope, $3.52 million for MPS' Atacama Large Millimeter Array (ALMA) Construction, and $33,819 for MPS' Large Hadron Collider. The amounts reported above include $14.88 million carried over for the Rare Symmetry Violating Processes (RSVP) project that was distributed pro rata to the following projects: ALMA, $3.52 million; EarthScope, $3.62 million; IceCube, $3.60 million; and SODV, $4.14 million.

FIRST PRIORITY: ONGOING PROJECTS IN FY 2007

Ongoing projects in FY 2007 include:

- the Atacama Large Millimeter Array
- EarthScope
- the IceCube Neutrino Observatory
- the National Ecological Observatory Network
- the Scientific Ocean Drilling Vessel, and
- the South Pole Station Modernization project.

Information on these projects, as well as information related to the $3.0 million requested to reimburse the DOJ Judgment Fund for a settlement related to the Polar Aircraft Upgrades project, follows.

Atacama Large Millimeter Array (ALMA)

ALMA VertexRSI test antenna, one of two prototypes constructed at the site of the Very Large Array near Socorro, New Mexico.

Project Description: The global ALMA project will be an aperture-synthesis radio telescope operating in the wavelength range from 3 to 0.4 mm. It grew out of a U.S.-only project called the Millimeter Array (MMA). 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 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.

Partnerships and Connections to Industry: North America and Europe were equal partners in ALMA as originally planned. 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. 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 (in MPS). An NSF advisory group, consisting of representatives from the Office of General Counsel, the Office of Budget, Finance, and Award Management, and the Office of Legislative and Public Affairs, serves as a standing ALMA Project Advisory Team (PAT). The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. AST's external 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, whose staff includes the ALMA Director, Project Manager, and Project Engineer.

Current Project Status: Construction progress continued in FY 2005, both at the site in Chile, and within the ALMA partner countries. The most significant event for the project in FY 2005 was the signing of a production contract for North America's share of the array's antennas. NSF gave permission to AUI/NRAO to proceed with the antenna contract, after intensive testing of the ALMA 12m prototypes was completed, and with the consent of the Joint ALMA Office and the ALMA Board, the project's governing body.

The current baseline schedule for ALMA is specified in version 1 of the ALMA Project Plan, adopted by the ALMA Board in February 2003 following the signature of the ALMA Agreement. While the Project Plan has been under configuration control by the Joint ALMA Office since 2004, the current project schedule was developed prior to the start of ALMA construction activities and the entry of Japan into the project. ALMA is currently 9-12 months behind this existing baseline schedule. However, a detailed reexamination of the project construction baseline and schedule, as well as its operating costs, has been underway since the start of FY 2005, and a set of intensive peer reviews of revised baseline strategies, scrutinizing both the full international project as well as North America's detailed responsibilities, began in October 2005. After the completion of these reviews in February 2006, a new project baseline will be established.

Major project milestones attained in FY 2005 included:

Placement of North American production antenna contract
Road from base to high-altitude site 80% complete
Placement of contract for three 12m antennas in compact array
Placement of contracts for foundation and shell of high-altitude Array Operations Site (AOS) technical building

Major milestones for FY 2006 are expected to include:

Completion of all baseline reviews
Completion of ALMA site camp
Critical design reviews for three receiver bands completed
Placement of European production antenna contract
Placement of antenna transporter contract
North American front end integration and test center operational
Prototype integration testing begins at Socorro NM antenna test facility (interferometry)

Although dependent to some extent upon the adopted new project baseline, major milestones for FY 2007 are expected to include:

Completion and provisional acceptance of AOS technical building
Delivery of first North American production antenna to Chile site
Delivery of first front end to Chile site
European front end integration and test center operational

Completion of the construction project and the start of full science operations is expected to occur around the end of 2012 under the new baseline.

Funding Profile: A $26.0 million, three-year Design and Development Phase was originally planned for a U.S.-only project, the MMA. However, since 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 budget level of $5.99 million. U.S. construction of ALMA was initiated in FY 2002.

The current project schedule, which still reflects the original ALMA baseline, calls for U.S.-funded construction activities to continue through 2010, with full project completion at the end of calendar 2011 (early FY 2012), and full operation beginning in early FY 2013. The estimated cost to construct ALMA is $702.0 million, with the U.S. share of the joint array construction estimated to be $344.28 million.

Appropriated and Requested MREFC Funds for ALMA

(Dollars in Millions)

	FY 03 & Earlier	FY04	FY05	FY06 Plan	FY07 Request	FY08	FY09	FY10	Total
ALMA R&D	31.99								$31.99
ALMA Construction	42.31	50.70	49.30	45.14	47.89	47.07	37.37	20.98	$340.76
Unobligated Balance from FY 2005				3.52					$3.52
Total, ALMA	$74.30	$50.70	$49.30	$48.66	$47.89	$47.07	$37.37	$20.98	$376.27

ALMA Funding Profile

(Obligated Dollars and Estimates in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2001& Earlier	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 Current Plan[1]				48.66	4.00		$4.00	$48.66	**$52.66**
FY 2007 Request				47.89	6.00		$6.00	$47.89	**$53.89**
FY 2008 Estimate				47.07	10.00		$10.00	$47.07	**$57.07**
FY 2009 Estimate				37.37	14.00		$14.00	$37.37	**$51.37**
FY 2010 Estimate				20.98	19.00		$19.00	$20.98	**$39.98**
FY 2011 Estimate					23.00		$23.00	-	**$23.00**
FY 2012 Estimate					28.00		$28.00	-	**$28.00**
FY 2013 Estimate					30.00		$30.00	-	**$30.00**
Subtotal, R&RA	$6.50		-		$135.00		$141.50		
Subtotal, MREFC		$31.99		$344.28		-		$376.27	
Total, Each Stage		**$38.49**		**$344.28**		**$135.00**			**$517.77**

NOTES: Implementation costs are based on the cost review of the original MMA and then projected to ALMA. The expected operational lifespan of this project is at least 30 years. A steady state of about $30.0 million annually is estimated for operations support beginning in about FY 2013. 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. Operations funding is provided through the National Radio Astronomy Observatory.

[1]The FY 2006 Current Plan includes $3.52 million of an unobligated balance from FY 2005.

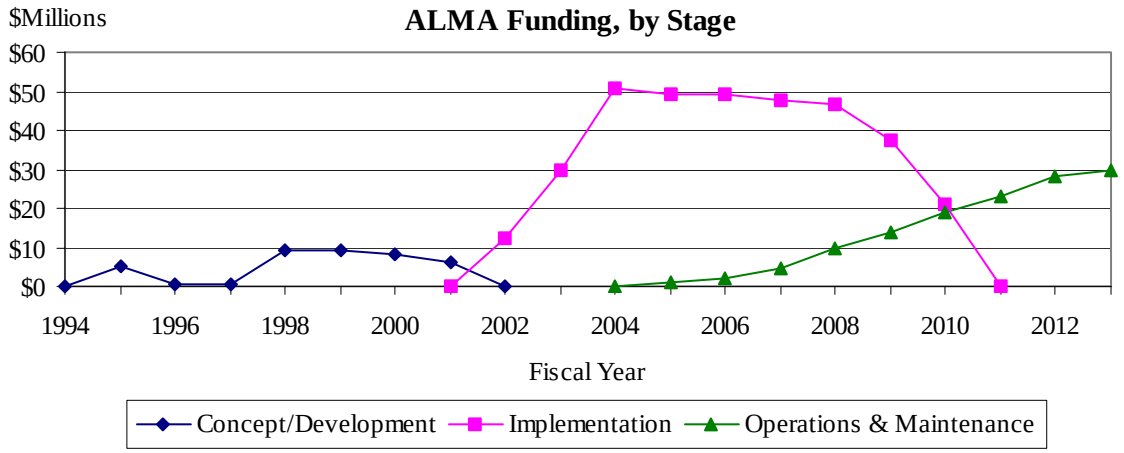
Information pertaining to the data in the table is included below.

- 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 up to 64 12-meter antennas having a total collecting area of 7,200 square meters, with 4 receiver bands extending into the submillimeter. The exact number of antennas will be determined after the completion of the baseline reviews in early 2006. The table describes the U.S. contribution to ALMA. It does not include funds resulting from Canada's participation.

- 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.



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

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.

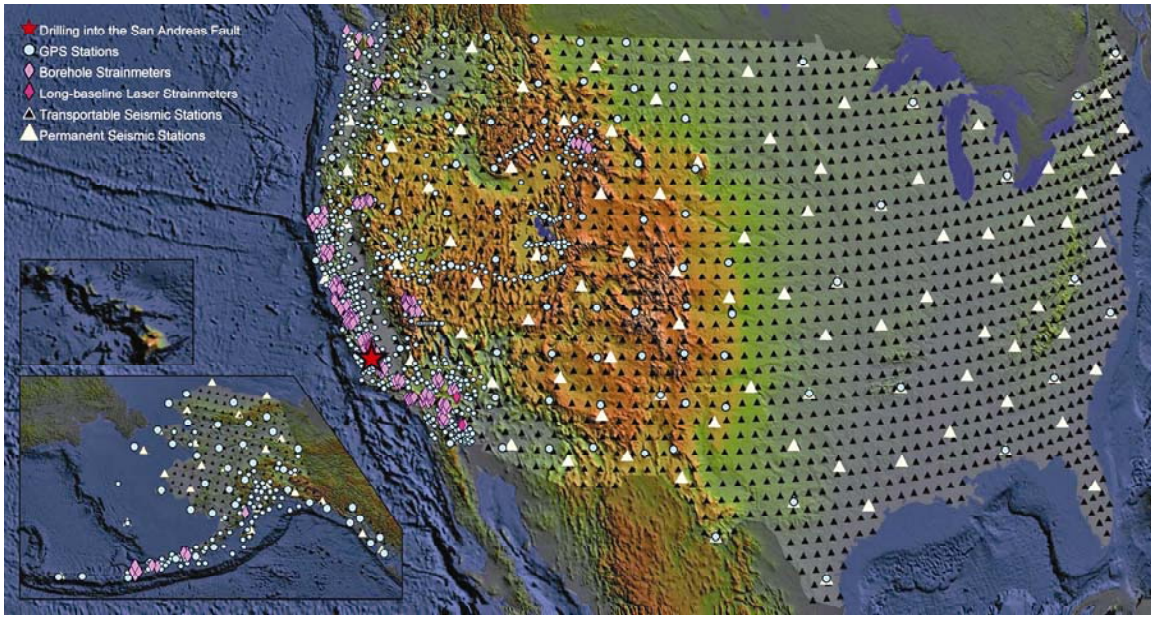
EarthScope

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.

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 will be enabled by EarthScope. Instrumentation firms will collaborate on development for state-of-the-art seismic systems, down-hole instrumentation, and high-precision GPS antenna designs.



The complete EarthScope footprint. 1600 of the transportable sites (moving west to east) and all 2400 campaign stations will continue to be deployed after the conclusion of the MREFC project. Locations of the 2400 campaign stations will be determined through the annual proposal review process; many of these sites likely will change annually. *Credit: EarthScope*

Management and Oversight: The EarthScope Program Director, located in the Earth Sciences (EAR) Division in the Directorate for Geosciences (GEO), provides NSF oversight. The Deep Earth Processes

Section Head (EAR) and a Project Advisory Team including the NSF Deputy Director for Large Facility Projects and staff from GEO, the Office of the General Counsel and the Office of Budget, Finance and Award Management, 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: Phase 2 drilling at the San Andreas Fault Observatory at Depth (SAFOD) site concluded successfully on August 9, 2005. The drill crossed the main trace of the San Andreas Fault at a depth of about 3,831 meters (12,570 feet) on August 3, 2005. Geophysical logging and other active data collection concluded successfully in November, 2005. A sensor string was installed during November, 2005, to record data through the winter. In December, 2005, scientists from around the world met at the temporary core repository (USGS, Menlo Park) to examine the core from the Phase 2 drilling and to request samples for scientific investigations. Overall, GPS and seismic station equipment acquisition and installation are slightly behind schedule. The Plate Boundary Observatory (PBO) has installed 239 permanent geodetic stations, 10 borehole strainmeter stations, and one long-baseline. The USArray has installed 88 Transportable Array stations, and installations continue on schedule. Other FY 2005 highlights include the use of USArray seismic data in analyses of the Sumatra-Andaman earthquake (one of the largest earthquakes ever recorded) and a very successful National Meeting. The EarthScope project has been represented at over a 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.

The EarthScope Facility Project Execution Plan has been reviewed and updated. The initial milestones are listed below. These milestones are reviewed quarterly and the project underwent a very successful baseline review on September 20–22, 2005. Thus, these milestones are being revised to reflect changes in instrument delivery schedule and other recommendations made by the review panel.

FY 2005 Milestones:

Main hole Phase 2 drilling completed at SAFOD;
Down-hole monitoring instrumentation installed;
Installation of 300 equivalent permanent GPS, 30 equivalent borehole strain, and 3 equivalent long baseline strainmeter systems;
Equipment for 50 portable GS sites available;
Installation of 29 equivalent ANSS and 80 equivalent Transportable Array stations;
Equipment for 720 Flexible Array sites available; and
NSF conducted annual review of project status.

FY 2006 Milestones:

San Andreas Fault site characterization studies carried out;
Installation of 540 equivalent permanent GPS and 100 equivalent borehole strain systems;
Complete installation of 5 long baseline strainmeters;
Equipment for 100 portable GS sites available;
Complete installation of 39 equivalent ANSS stations;
Installation of 220 equivalent Transportable Array stations;
Equipment for 1,200 Flexible Array sites available; and
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 780 equivalent permanent GPS and 162 equivalent borehole strain systems;
Complete first footprint of USArray (400 Transportable Array stations);
Equipment for 1,680 Flexible Array sites available; and
NSF conducts annual review of project status.

FY 2008 Milestones:

Redeployment of USArray begins;
Main hole Phase 3 drilling completed at SAFOD;
Install permanent monitoring instrumentation in four core intervals and main hole of SAFOD;
Complete installation of 875 equivalent permanent GPS and 175 equivalent borehole strain systems;
Equipment for 2,400 Flexible Array sites available; and
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; and
NSF conducts biennial reviews of project status.

Funding Profile: Conceptual planning for the EarthScope project 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 Plan	FY 2007 Request	Total
EarthScope	$29.81	$43.24	$46.97	$46.40	$27.40	$193.82
Unobligated Balance from FY 2005				$3.62		
Total, EarthScope	$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 1998	1.00						$1.00	-	**$1.00**
FY 1999	1.00						$1.00	-	**$1.00**
FY 2000	1.00						$1.00	-	**$1.00**
FY 2001	2.00						$2.00	-	**$2.00**
FY 2002	1.00						$1.00	-	**$1.00**
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 Current Plan				52.19	6.72		$6.72	$52.19	**$58.91**
FY 2007 Request				27.40	11.61		$11.61	$27.40	**$39.01**
FY 2008 Estimate					23.41		$23.41	-	**$23.41**
FY 2009 Estimate					30.00		$30.00	-	**$30.00**
FY 2010 Request					31.00		$31.00	-	**$31.00**
FY 2011 Estimate					32.00		$32.00	-	**$32.00**
FY 2012 Estimate					32.00		$32.00	-	**$32.00**
Subtotal, R&RA	$9.36		-		$173.53		$182.89		
Subtotal, MREFC		-		$197.44		-		$197.44	
Total, Each Stage		**$9.36**		**$197.44**		**$173.53**			**$380.33**

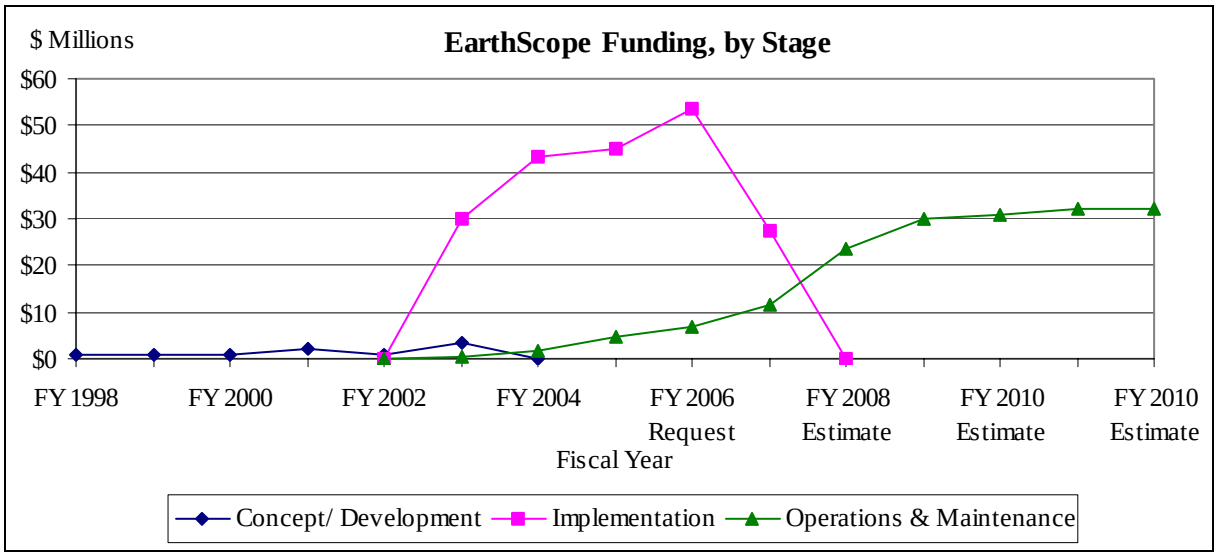
NOTE: Operations and maintenance support is anticipated to increase after FY 2008. The expected operational lifespan of this project is 15 years after construction is complete in FY 2008. Operations estimates for FY 2007 and beyond are developed strictly for planning purposes and are based on current 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.

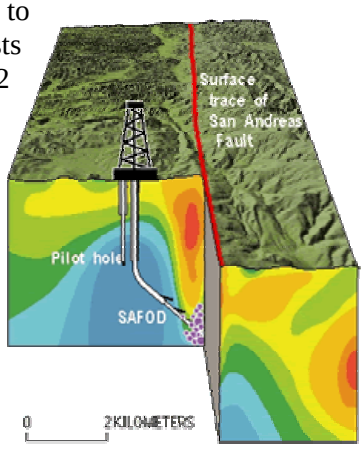
- Operations and Maintenance: Operations and maintenance began to phase-in during the first year of construction. When EarthScope is completed it will be managed, operated and maintained by consortia including participation from host institutions, affiliate organizations, and the user community.



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

► **Keeping an Eye on the San Andreas Fault:** Last August, while drilling to create the new San Andreas Fault Observatory at Depth (SAFOD), scientists tapped into the active zone of the San Andreas Fault at a depth of about 2 miles. The drill hole, near Parkfield, California, starts on the Pacific tectonic plate, west of the San Andreas Fault, goes through the active earthquake zone, and ends in the North American Plate, east of the fault. The SAFOD drill hole, part of the broader NSF-supported EarthScope project, will house instruments to collect data at intervals from the surface to the depth where earthquakes form. Fluid pressure, temperature, and geophysical data collected around the clock will be used to observe the physical and chemical changes that take place as earthquakes occur.



Location of the SAFOD drill hole relative to the San Andreas Fault.

IceCube Neutrino Observatory

Pictured in the UW-Madison Physical Sciences Laboratory before being vacuum-sealed, each IceCube DOM is very much like a small computer. A total of 4,200 DOMs, designed to sample high-energy neutrino particles from deep space, are being deployed in 70 deep holes in the Antarctic ice.

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 Station 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 Consortium, 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; installation of a surface array of air shower detectors to both calibrate and eliminate background events from the IceCube DOM array; construction of a data acquisition and analysis system; and associated personnel and logistics support.

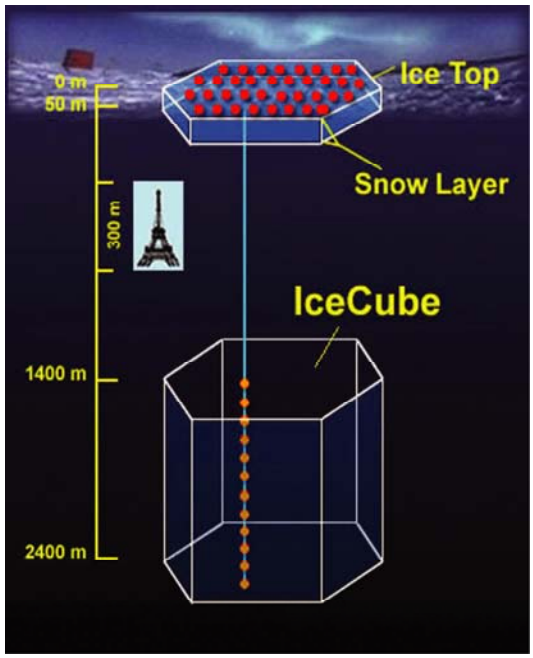
Principal Scientific Goals: IceCube will be the world's first observatory capable of studying the universe with high-energy neutrinos. Measurement of the number, direction, timing, and energy spectrum of such neutrinos will provide unique new insights regarding the dynamics of active galactic nuclei, 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 underlying dynamics of 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 exciting South Pole environment. These goals include broadening the scientific workforce base in the U.S. and creating a technologically facile workforce with strong ties to fundamental research that is the core of a strong economy. 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 the standard NSF merit review process.

Partnerships and Connections to Industry: The IceCube Collaboration consists of 12 U.S. institutions and institutions in three other countries: Belgium, Germany, and Sweden. 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 oversight of the project. IceCube is externally managed by a Project Director and a Project Manager. Internally, NSF has appointed a Project Coordinator to manage and oversee the NSF award. A comprehensive external baseline review of the entire project (including cost, schedule, technical, and management) was carried out 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. The first such annual review was held in May 2005. Besides annual progress reviews and other specialized reviews, 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 OPP; support for operations, research, education, and outreach will be shared by OPP and MPS as well as other organizations and international partners.



IceCube will occupy a volume of one cubic kilometer. Here we depict one of the strings of optical modules (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/University of Wisconsin and Darwin Rianto, University of Wisconsin.*

Current Project Status: The primary IceCube project tasks carried out to date are: (1) completion, testing, and shipment to the South Pole of the Enhanced Hot Water Drill (EHWD) system for drilling the required deep-ice holes into which the strings of DOMs will be placed; (2) completion and commissioning of the three planned DOM production and low temperature (-80^{o}C) testing facilities in the U.S., Germany, and Sweden; (3) production, testing, shipment to the Pole, and subsequent re-testing of the DOMs and cables needed for deployment of DOM strings in the 2004/2005 and 2005/2006 austral summer seasons (November to mid-February); (4) design, construction, and installation of the initial data acquisition system at the Pole; (5) completion of plans for commissioning and verification of the initial DOM strings; (6) placement at the Pole of the building that will serve as the IceCube

permanent counting house in the 2005/2006 season; (7) during the 2004/2005 season, successful drilling of the first deep hole at the Pole and the deployment of the first IceCube string (60 DOMs), which is now connected to the data acquisition system, fully operational, and functioning well, as well as successful deployment and operation at the Pole of eight surface cosmic ray air shower detector modules (2 DOMs/module); and (8) during the 2005/2006 season, the first test of the production capability of the EHWD and DOM deployment systems, with plans for deployment of up to ten additional strings (as of this writing (January 15, 2006) four additional detector strings have been installed).

Major milestones for IceCube are below:

FY 2004 and FY 2005 Milestones:
- Completed production of digital optical modules and data acquisition and handling system (DAQ)
- Delivered EHWD system and DOM deployment system to the South Pole
- Delivered initial DOM strings, IceTop modules, and initial elements of the DAQ to South Pole
- Assembled the EHWD and DOM deployment systems
- Established drill camp and move new counting house building into place
- Drilled, deployed, and tested initial DOM strings and corresponding IceTop modules

FY 2006 Milestones:
- Ramp up to near-full DOM production at all facilities and IceTop module production
- Drill, deploy and test up to 10 additional DOM strings and corresponding IceTop modules, including installing and testing the associated DAQ elements

Projected outyear milestones (FY 2007-2010) 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 2007-10 Milestones:
- Complete and commission new counting house at the Pole
- Continue DOM and IceTop module production
- Continue to drill, deploy, test, and commission DOM strings (up to 18 strings per season) and the corresponding IceTop modules (two for each DOM string), including installing and testing of the associated DAQ elements
- Begin initial operations of IceCube with strings available in FY 2007
- Complete installation and commissioning

FY 2011 Milestones:
- Commence full operations of IceCube for science

Funding Profile: Startup activities were funded with FY 2002-03 appropriations. Construction was initiated with FY 2004 appropriations. The total project cost for IceCube is $271.77 million. Of this amount, $242.07 million will be from the U.S. and $29.70 million will come from foreign contributions.

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

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007 Request	FY 2008	FY 2009	FY 2010	Total
IceCube	$15.00	$24.54	$41.75	$47.62	$46.25	$28.65	$22.38	$11.33	$0.95	$238.47
Unobligated Balance from FY 2005					$3.60					$3.60
Total	$15.00	$24.54	$41.75	$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 and will be obligated in FY 2006 and later years.

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 Current Plan				49.85			-	$49.85	**$49.85**
FY 2007 Request				35.71	0.50		$0.50	$35.71	**$36.21**
FY 2008 Estimate				22.38	1.75		$1.75	$22.38	**$24.13**
FY 2009 Estimate				11.33	2.25		$2.25	$11.33	**$13.58**
FY 2010 Estimate				0.47	3.75		$3.75	$0.47	**$4.22**
FY 2011 Estimate					4.00		$4.00	-	**$4.00**
FY 2012 Estimate					4.00		$4.00	-	**$4.00**
Subtotal, R&RA	$0.50		-		$16.25		$16.75		
Subtotal, MREFC		-		$242.07		-		$242.07	
Total, Each Stage		**$0.50**		**$242.07**		**$16.25**			**$258.82**

NOTE: The expected operational lifespan of this project is 25 years after construction is complete in FY 2010. Operations support is planned to begin in FY 2007. Corresponding support for conduct of research also must be provided. Current planning calls for international partners to provide a share of the costs. The estimates shown above are for operations and maintenance and have been developed for planning purposes. Efforts are underway to further develop these cost estimates; they will be updated as new information becomes available.

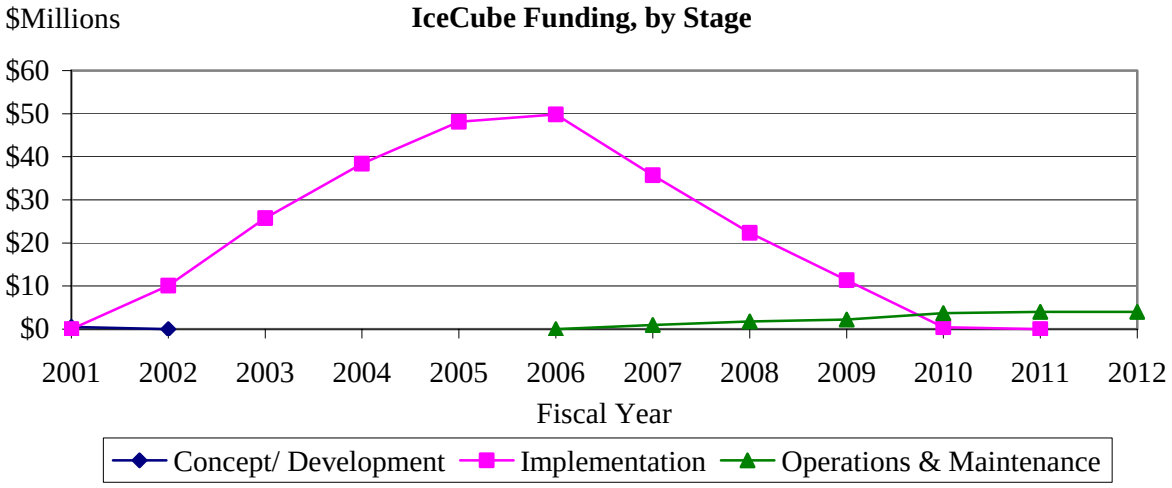
Information pertaining to the data in the table is provided below.

- Concept/Development: $500,000 was provided in FY 2001 through the R&RA account to support drill conceptual development and design, 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 total project cost of the IceCube construction project is currently estimated at $271.77 million. Of this amount $242.07 million will be from NSF, and $29.70 million from foreign partners. Construction is planned to extend through FY 2010. A comprehensive baseline review of the IceCube project was conducted in February 2004 to provide a solid project baseline scope, cost, and schedule. The plan is to drill holes and deploy strings of DOMs in 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. With good EHWD drill performance, and barring weather-induced complications of logistics support, the full complement of DOMs should be in place by about the end of FY 2010.

- Operations and Maintenance: Full operation of the IceCube Neutrino Observatory is planned to commence in FY 2011 following completion of drilling and DOM deployment and full detector commissioning planned for FY 2010. Initial operations will 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. Of the amounts shown in the table for operations, approximately half are for data analysis that will be carried out by the collaborating U.S. and foreign IceCube institutions, the other half are for direct operations and maintenance support (IceCube-specific logistics, system engineering, operation and maintenance of the data acquisition and data handling systems, data quality monitoring, IT upgrades, and calibrations). 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 operations. The expected operational lifespan of this project is 25 years beginning in FY 2011.

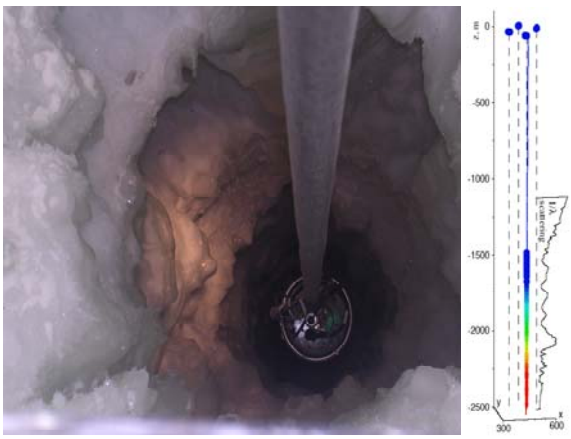


Future Science Support: NSF will support activities at U.S. institutions working on more refined and specific data analyses, data interpretation (theory support), and instrumentation upgrades, through ongoing research and education programs. The annual support for such activities is estimated at $3.0 million once the facility reaches full operations.

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 (E&O) activities will come from the R&RA account. Annual E&O budgets are estimated at $400,000.

Recent Research Highlight

IceCube, a New Kind of 'Telescope' at the South Pole: A sub-surface observatory that tracks elusive cosmic messengers called neutrinos is now under construction beneath the South Pole. When completed, the IceCube detector array will comprise as many as 80 separate "strings," each containing 60 sensors, that descend vertically more than a mile deep into ancient ice that has been compressed so hard that it is clear as glass. In January 2005, the first string was lowered into a narrow shaft produced by a novel hot-water "drill." When tested, the string met or exceeded its design requirements, and began taking data.



Strings of instruments such as this one will detect the arrival and trajectory of neutrinos, producing data of the sort seen in the diagram on the right. The size of the circle is proportional to the strength of the signal, and the color (from blue to red) indicates relative times of the "hits" recorded by the string's sensors. *Credit: University of Wisconsin*

IceCube, so called because it will eventually extend to a square kilometer of sensors buried between 1,450 and 2,450m below the surface, will observe the arrival of high-energy neutrinos (subatomic particles generated in violent astronomical events in our galaxy or others, such as stellar explosions), record their characteristics, and determine their point of origin in space within 1/2 of a degree.

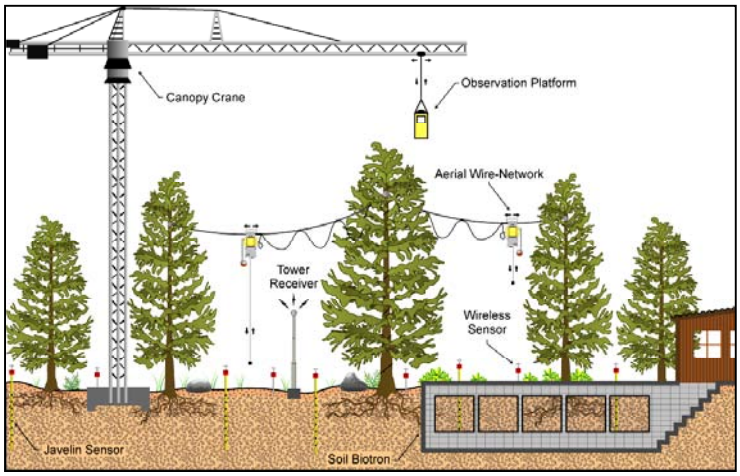
National Ecological Observatory Network (NEON)

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, remote sensing, will be linked via the internet to computational, analytical and modeling capabilities to comprise NEON.

Principal Scientific Goals: NEON will transform ecological research by enabling studies of the biosphere at regional to continental scales, quantifying the strong and weak 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 new 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 conduct comprehensive, regional to continental-scale experiments 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 cutting-edge 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.



Planning for the National Ecological Observatory Network includes visual rough drafts of sensors and research infrastructure deployed across a forest ecosystem, from the forest canopy to the soil community.

Partnerships and Connections to Industry: Federal agencies such as USGS, EPA and DOE are on the NEON Advisory Board and planning committees. A NEON Federal Agency Coordinating Committee meets on a regular basis[6]. Discussions are underway with the U.S. Department of Agriculture (USDA), USGS and DOE on formal agreements. NEON will be the only observation network that will be able to provide the insitu biospheric component called for in the US Group on Earth Observations Ten-year Strategic Plan. International perspectives are provided through the NEON Advisory Board, which is comprised of Environment Canada and CONABIO, Mexico, and the NEON planning committees, one of

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

which includes a member of Argentine National Research Council. Private foundations, e.g., the Heinz Center, Nature Serve, and US Landtrust, participate on the NEON design consortium. 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 will require technological innovations that will foster partnerships with industry for infrastructure development, deployment, and operation.

Management and Oversight: The Division of Biological Infrastructure within the Directorate for Biological Sciences manages NEON. The NEON program officer, in consultation with a BIO-NEON committee, which includes the Deputy Director for Large Facility Projects, formulates the programmatic development of NEON, i.e., drafting, release and review of program solicitations, etc. The BIO Advisory Committee provides external advice to BIO about specific programmatic elements.

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) and the Ocean Observatories Initiative (OOI). 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 US 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 2005, the NEON Design Consortium and Project Office refined the NEON science requirements, developed the scientific facilities and infrastructure reference design, completed the preliminary baseline definition for networking and informatics, formulated the infrastructure requirements for education, training, and outreach, and designed the governance and management structures for NEON as recommended in the 2004 NRC report, "NEON: Addressing the Nation's Environmental Challenges."

Three workshops were conducted to define the cross-cutting needs, challenges, and opportunities in sensors and cyberinfrastructure. The workshops addressed emerging issues of interoperability among evolving observing systems, leveraging emerging technologies and research frontiers, fostering collaboration, and stimulating robust technology development. R&RA supported R&D on environmental sensors, networks, and cyber tools that will advance the development of NEON as a network of nationally deployed infrastructure.

In FY 2006, a research community Consortium (NEON Inc.), which provides a link between NEON planning and construction, was established as a legal entity. The NEON Integrated Science and Education Plan and Networking and Informatics plans were completed. The preliminary project execution plan and design, cost, and management reviews will be conducted. R&RA funds continue to be provided to the Consortium of Regional Ecological Observatories to evaluate deployment criteria and locations across the continental US, Alaska, Hawaii, and Puerto Rico and to form the collaborations, partnerships, and organizations needed for NEON infrastructure deployment.

In FY 2006, NEON funding will be provided 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 will expand NEON research

and development to include a cyberinfrastructure research program to address interoperability with other networks and observing systems.

In FY 2007, an award will be made to complete the final Project Execution Plan for NEON, finalize deployment, and conduct (as appropriate) EIA/EIS. MREFC funds are requested for the construction and evaluation of the NEON fundamental technology unit. During FY 2007, the NEON research and development program will emphasize environmental sensors and networks to address interoperability and enabling technologies for ecological forecasting.

Major milestones for NEON are listed below.

FY 2005 Milestones:
- NEON Design Consortium and Project Office established
- NEON Advisory Board and Design Consortium subcommittees appointed
- NEON science requirements, facilities and infrastructure reference design refined, and the governance and management structures for NEON developed
- Research and development projects on environmental sensors, networks, and cyber tools that will advance the development of NEON as a network of nationally deployed infrastructure funded

FY 2006 Milestones:
- NEON Inc. established
- Review of NEON Science Plan and Requirements completed
- Baseline Networking and Informatics Plan and an external design review completed
- NEON Conceptual Design, Preliminary Project Execution Plan, and Project Development Plan completed
- NEON research infrastructure baseline design review and external cost review conducted
- Management review of the NEON Design Consortium and Project Office
- Research and development of cyberinfrastructure to address interoperability with other environmental networks and observing systems funded

FY 2007 Milestones:
- Final Project Execution Plan
- Baseline NEON Infrastructure design, cost, and management reviews
- NEON fundamental technology unit (BioMesoNet, sensor micronets, and enabling cyberinfrastructure) assembled and field-tested
- NEON infrastructure deployment plan finalized
- Environmental Impact Assessment and/or Environmental Impact Statements (EIA/EIS), if appropriate, will be conducted
- Additional research and development on environmental sensors and sensor networks and enabling technologies for ecological forecasting

FY 2008 – FY 2011 Milestones:
- Construction of NEON research, networking, informatics, and education, training and outreach infrastructure begins
- Research and development activities on environmental sensors, networks, cyber tools for NEON, and interoperability with other networks and observing systems continues

Funding Profile: NSF expects to spend approximately $18 million in concept and development activities through FY 2006. The current construction costs for NEON are being revised based on deploying NEON simultaneously as a national research platform (NRC 2004). Total construction costs for NEON will be

determined from the project execution plan developed for research, networking, and education infrastructure due June 1, 2006. Management, operations, and maintenance will be funded through the R&RA Account. After a 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	Total
$12.00	$12.00	$20.00	$30.00	$26.00	$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 2001 & Earlier	0.31						$0.31	-	**$0.31**
FY 2002	1.00						$1.00	-	**$1.00**
FY 2003	0.92						$0.92	-	**$0.92**
FY 2004	3.60						$3.60	-	**$3.60**
FY 2005	5.98						$5.98	-	**$5.98**
FY 2006 Current Plan	5.94						$5.94	-	**$5.94**
FY 2007 Request	11.94			12.00			$11.94	$12.00	**$23.94**
FY 2008 Estimate	10.00			12.00	4.80		$14.80	$12.00	**$26.80**
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				28.70		$30.70	-	**$30.70**
Subtotal, R&RA	$59.69		-		$85.10		$144.79		
Subtotal, MREFC		-		$100.00		-		$100.00	
Total, Each Stage		**$59.69**		**$100.00**		**$85.10**			**$244.79**

NOTE: The expected operational lifespan of this project is 30 years after construction is complete. Implementation funding levels will be updated based on the cost review of the Project Execution Plans (PEP) for research infrastructure, networking and informatics, and education, outreach, and training. Annual operations and maintenance estimates for FY 2008 and beyond are presented strictly for planning purposes and are calculated as 28 percent of the pre-PEP, estimated MREFC costs summed to that year. They will be updated when the implementation costs are updated and reviewed.

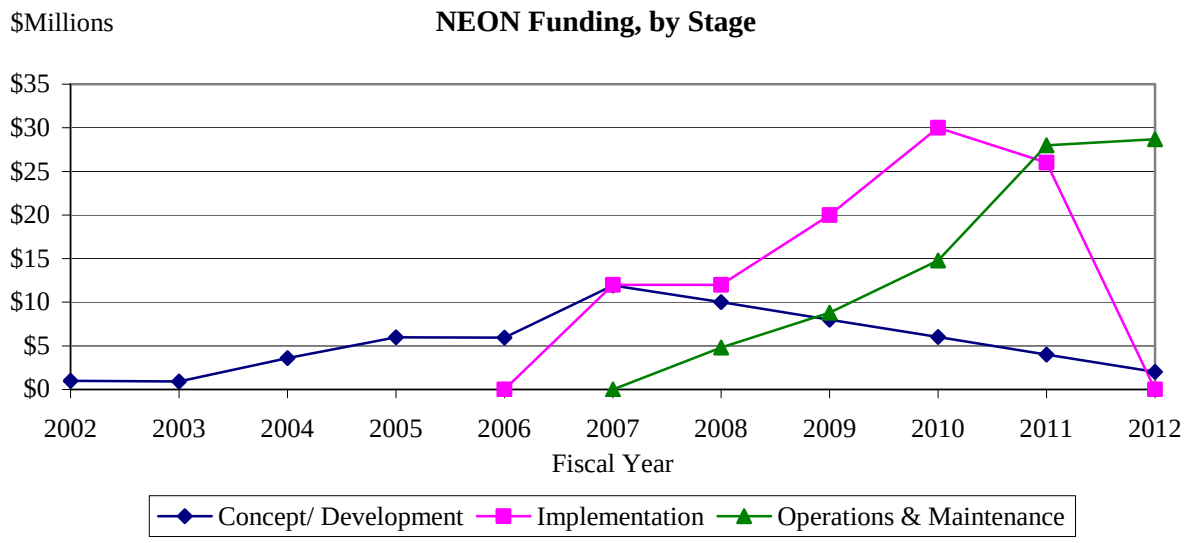
Information pertaining to the data in the table is provided below.

- 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 US 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 project execution plan for simultaneous national deployment. In FY 2006, support led to completion of the NEON Science Plan and Requirements and the Networking and Informatics Plan. Review of the preliminary Project Execution Plan is scheduled. Support will be continued for research and development of NEON enabling technologies from FY 2006 through the construction phase.

- Implementation: Total construction costs for NEON will be determined from the project execution plan developed for research, networking, and education infrastructure due June 1, 2006. After a thorough cost review, a revised budget for NEON infrastructure and maintenance and operations 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 assemble and evaluate the NEON fundamental technology unit (BioMesoNet, sensor micronets, and enabling cyberinfrastructure) that will be deployed.

- Operations and Maintenance: Initial operations support will begin in FY 2008 as construction is commenced on NEON networking, and informatics infrastructure. Operations and maintenance support will increase as NEON is brought online.



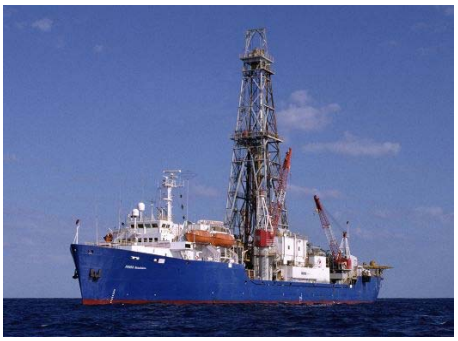
Future Science Support: Since NSF supports 63 percent of the fundamental ecological research performed at U.S. academic institutions, advances in the field of ecology, and the infrastructure to enable those advances, depend largely on support from NSF. Current research infrastructure is inadequate to 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 could. Along with direct operations and maintenance support for NEON, NSF will support research performed using the NEON platform through ongoing research and education programs. The annual support for such activities once the research platform reaches full operations is estimated to be at least $12.0 million annually.

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 hundreds of thousands of individuals will be able to access NEON data, information and research products via the Internet.

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 ocean environments. The vessel will accommodate a scientific and technical staff of approximately 50. The converted drillship will provide the U.S. facility contribution to the Integrated Ocean Drilling Program (IODP), which began on 1 October 2003. The IODP is co-led by the NSF and the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan. European and Asian nations are also participating in the program.



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*

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, preparation of classroom modules on IODP research initiatives, and outreach displays at museums and educational/teaching institutions.

NSF Management and Oversight: The project is managed and overseen by a project manager in the Division of Ocean Sciences in the Directorate for Geosciences. The project manager receives advice and oversight support from a NSF Project Advisory Team, which consists of representatives from GEO, the Office of Polar Programs, the Office of Budget, Finance and Award Management, and the Office of General Counsel. The NSF Deputy Director for Large Facility Projects 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 included as one task 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 $57.24 million appropriated in FY 2006. Engineering design and science lab development activities are currently underway. The project schedule is outlined below:

FY 2005 Milestones:

Release RFP for SODV Drilling Contractor and Evaluate Responses (Completed)

Determine Competitive Range of Offerors – Initiate SODV MREFC project (Completed)

FY 2006 Milestones:
Vessel Decision and Drilling Contractor Award (Completed)
Initiate Engineering Design Phase, including Science Lab Development (Completed)
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

FY 2007 Milestones:
Complete Equipment/Structural Removals
Develop Production Engineering Package
Install Habitability and Science Modules
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. In FY 2005, approximately $6.08 million was awarded to initiate contract activity, planning and design. In FY 2005 - FY 2007, approximately $109.0 million of funds from the MREFC account will be required for conversion/equipping/testing of the drillship.

Appropriated and Requested Funds for SODV
(Dollars in Millions)

	FY 2005	FY 2006	FY 2007	Total
SODV	$14.88	$53.09	$42.88	$110.85
Unobligated Balance from FY 2005		$4.14		$4.14
Total, SODV	$14.88	$57.24	$42.88	$115.00

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 2000	0.10						$0.10	-	$0.10
FY 2001	0.20						$0.20	-	$0.20
FY 2002	0.30						$0.30	-	$0.30
FY 2003	1.50						$1.50	-	$1.50
FY 2004	2.10						$2.10	-	$2.10
FY 2005	0.50			6.08			$0.50	$6.08	$6.58
FY 2006 Current Plan				66.04			-	$66.04	$66.04
FY 2007 Request				42.88	21.30		$21.30	$42.88	$64.18
FY 2008 Estimate					57.00		$57.00	-	$57.00
FY 2009 Estimate					58.60		$58.60	-	$58.60
FY 2010 Estimate					60.70		$60.70	-	$60.70
FY 2011 Estimate					62.00		$62.00	-	$62.00
FY 2012 Estimate					64.00		$64.00	-	$64.00
Subtotal, R&RA	$4.70		-		$323.60		$328.30		
Subtotal, MREFC		-		$115.00		-		$115.00	
Total, Each Stage		$4.70		$115.00		$323.60			$443.30

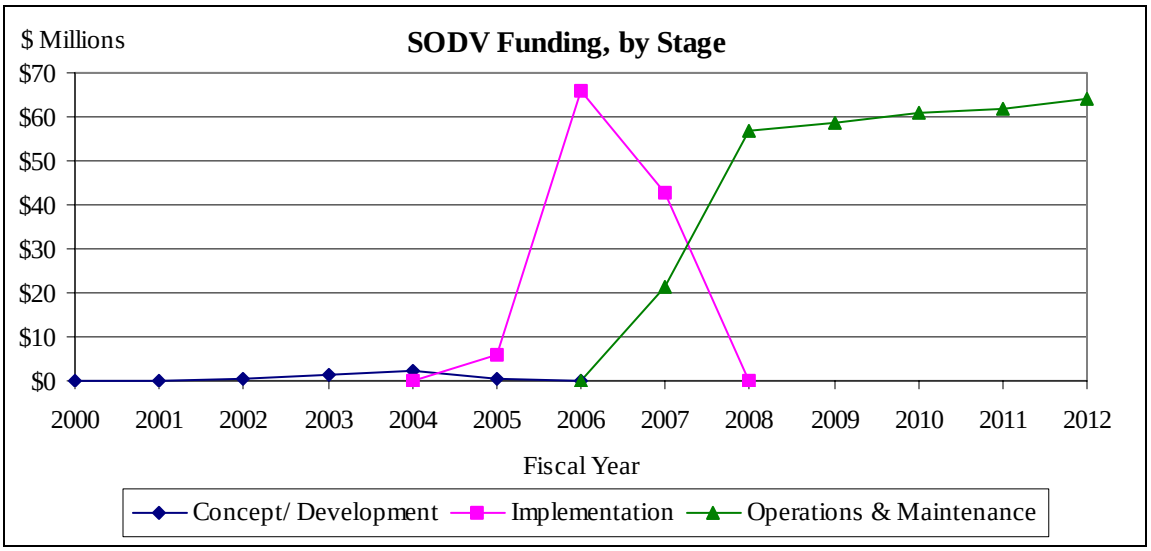
A steady state of about $57 million in operations support is expected to occur beginning in FY 2008 as the SODV vessel begins full operations, but these estimates are developed based on current cost profiles and will be updated as new information becomes available. The expected operational lifespan of this project is 15 years, beginning in FY 2007.

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..

- Implementation: The MREFC funds in FY 2005-07 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.



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 Goals: Support science at the South Pole and maintain U.S. presence at the South Pole in accordance with U.S. policy.

Principal Education Goals: 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: The Office of Polar Programs (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 on a periodic basis by OPP staff and the project's PAT. The NSF Deputy Director for Large Facility Projects regularly briefs the Chief Financial Officer and the NSF Director on project status.

Aurora Australis – the Southern lights, over the National Science Foundation's (NSF) Amundsen-Scott South Pole Station. This image shows the atmospheric phenomenon over a wing of the new station that NSF is building. *Credit: USAP*

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 estimated projection had been for conditional acceptance (i.e., occupation and operations) of the entire station by the end of FY 2007, with some work on punchlist items possibly occurring in FY 2008. Although no funds were requested for SPSM in the FY 2006 Budget Request to Congress, the update in the Request on SPSM indicated that the cost-to-complete at the time of budget submission was $136.96 million. The Budget Request also indicated "an updated project cost and schedule review will be completed shortly after the end of the 2004/2005 operating season." That review has now been completed and has been reviewed by the SPSM Project Advisory Team and OPP management. At the end of the 2004/2005 season, the delivery of project material was 4.3 million pounds behind schedule. This delay has resulted in the station's completion being moved at least to FY 2008, rather than FY 2007 as previously estimated. There is some possibility that final completion will be further delayed, perhaps in order to accommodate logistics support for high priority

science projects at South Pole Station. Such delay would not impact full use of planned station facilities and is unlikely to cause significant cost increases. The new "cost to complete" total for the project is $142.71 million. Total funding for SPSM through FY 2006 is $133.51 million; the amount of additional funding required to complete the project is $9.13 million.

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	FY08
Station Equipment	FY02/03	FY03/04	FY04/05	N/A	FY08

Funding Profile: SPSM funding totals $133.51 million through FY 2006, exceeding the most recent NSB-approved cost estimate of $133.44 million. Based on an updated project cost and schedule review completed after the 2004/2005 operating season, the estimated total cost to complete SPSM is $142.71 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	Total
SPSM Appropriations	70.00	39.00	5.40	13.47	-	5.96	1.29	-	-	9.13	144.25
Reprogramming				-1.00	-0.50	-0.24			0.12		-1.62
	$70.00	$39.00	$5.40	$12.47	-$0.50	$5.73	$1.29	-	$0.12	$9.13	$142.64

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.

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

the unusual logistics 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 $120.41 million through FY 2005.

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 Current Plan				8.59			-	$8.59	$8.59
FY 2007 Request				9.13	15.00		$15.00	$9.13	$24.13
FY 2008 Estimate				4.51	15.38		$15.38	$4.51	$19.89
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
Subtotal, R&RA	$16.40		-		$95.74		$112.14		
Subtotal, MREFC		-		$142.64		-		$142.64	
Total, Each Stage		$16.40		$142.64		$95.74			$254.78

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.

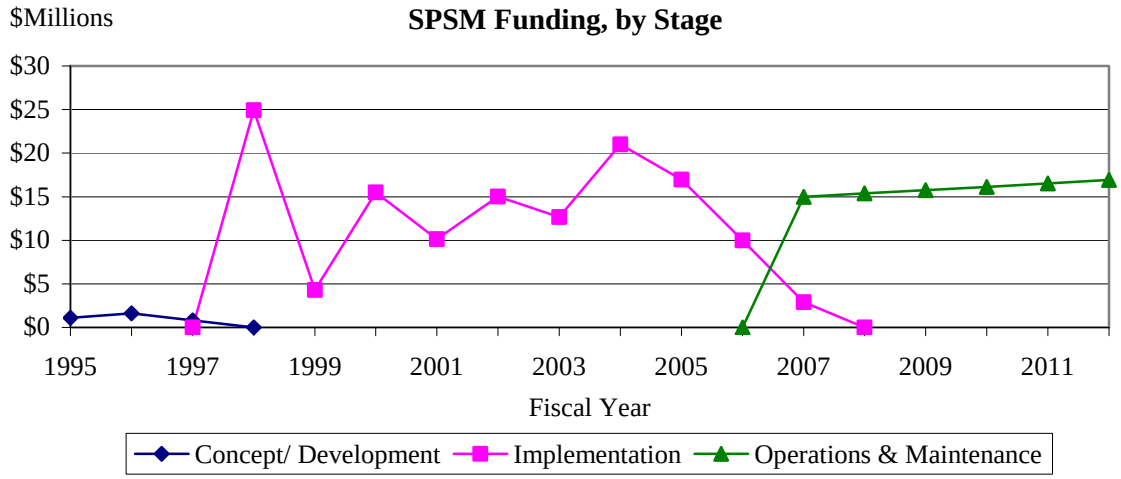
Information on the data in the table is provided below.

- 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 2007. 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 $8.0 million.

Department of Justice Settlement

Background: A project was initiated in 1998 both to modify and to upgrade and maintain three NSF-owned LC-130s to meet Air Force safety and operability standards that differ from those of the previous U.S. Navy operators. Modifications specified by the Air Force included avionics, airframe, safety, propulsion, and record data; storage and project administration costs were also included. Ski-equipped LC-130 aircraft are the backbone of the U.S. Antarctic Program's (USAP) air transport system and also support NSF's research in the Arctic. In FY 1998 $4.30 million from the Research and Related Activities (R&RA) account was provided for early engineering design, and between FY 1999 and FY 2002 $32.90 million from the Major Research Equipment and Facilities Construction (MREFC) account was expended for the modifications. The work included scheduled maintenance requirements.

Project Management: The contract for the modifications was awarded and administered by the Air Force C-130 Systems Program Office at Warner Robins Air Logistics Center (Warner Robins, GA; WRALC), which is the C-130 engineering authority for the Air Force. The solicitation also sought Programmed Depot Maintenance services in accordance with Air Force standard operating procedures. In March 1999, the Air Force awarded the contract for the work to Raytheon Services E-Systems. The contract was subsequently transferred to L-3 Communications, Inc. (L3) when it acquired Raytheon Services E-Systems.

The Warner Robins Air Logistics Center served as the procurement office with oversight and contract administration responsibilities. The contract was assigned for administration in accordance with FAR 42.202 to the Defense Contract Management Command, Dallas. NSF, responsible for the management of the USAP, served as the funding agency for the contract. To date, NSF has reimbursed WRALC for all its fees and costs relating to the performance and administration of the contract. The Defense Contracts Management Agency (DCMA) accepted the three aircraft on behalf of the Government.

Request for Equitable Adjustment: In June 2002, L3 Communications informed WRALC that it was experiencing substantial financial loss on the contract. In September 2002, L3 Communications indicated they would be submitting a request for equitable adjustment (REA) in the amount of $14.9 million. In January 2004 the contractor submitted a proposal to settle the REA in the amount of $2,999,941. In support of its proposal, the contractor submitted certified cost and pricing data for the proposed settlement amount.

Settlement Funding: In response to the contractor's settlement proposal, WRALC conducted a legal review and litigation risk assessment for the contractor's REA. It concluded that the Government was partly liable for L3 Communications' $14.9 million of uncompensated incurred costs based on the legal theories of defective specifications, mistake in bid caused by the Government providing late, defective, or unsuitable property, data and information, superior knowledge, constructive change, estoppel, detrimental reliance, and *quantum meruit* (i.e., "reasonable value of services"). The WRALC further concluded that the Government's litigation exposure came to about $7.5 million, including various fees and costs to litigate the matter. The WRALC recommended that the Government settle the matter for $3.0 million, as proposed by L3 Communications.

As a result of the WRALC legal review and litigation risk assessment, the Air Force and NSF discussed how the agencies would fund the costs to settle the REA submitted by L3 Communications or satisfy a judgment against the Government. Based on the facts provided by WRALC, NSF did not disagree with the Air Force's legal review and litigation risk assessment. Based on the review and assessment presented by WRALC, NSF agreed in principal that a settlement for $3.0 million in this case would best serve the interest of the Government.

In light of the Air Force's stated willingness to bear partial responsibility for the additional costs, NSF and WRALC officials, over the course of several months, endeavored to find a legal basis that would allow the Air Force to contribute funds to settle the contractor's REA. Based on an opinion issued by the Office of Legal Counsel in the Department of Justice, NSF advised the Air Force that a performing agency has the discretion to pay for actual costs, without seeking reimbursement from the ordering agency if the interagency agreement was based on authority other than the Economy Act.

On July 16, 2004, the Air Force informed NSF that under the Economy Act it was unable to use its appropriated funds to settle the REA even though NSF had relied on authorities other than the Economy Act when agreeing to fund the contract that Air Force would administer. It also notified NSF that "under the circumstances, we believe that referring the matter to the Department of Justice for an opinion would not be helpful." The Air Force did not articulate a policy, budgetary, or operational rationale for its decision.

Because the NSF lacked the necessary funding in its budget and the agencies had reached an impasse on whether the Air Force could contribute funds to the settlement, the Air Force denied the contractor's claim. L3 Communications appealed the agency's decision to the Armed Services Board of Contract Appeals (ASBCA). Pursuant to a settlement agreement, the Air Force agreed to pay the contractor $2,999,941 in return for L3 Communications agreeing to settle all present and future disputes, claims, and appeals, arising under or related to the contract. The ASBCA issued an opinion awarding the contractor $2,999,941 to be paid from the Judgment Fund, established under 31 U.S.C. § 1304.

Current Status: On March 15, 2005, the Judgment Fund Branch, Department of the Treasury, requested that the NSF reimburse the Judgment Fund for the settlement amount. The FY 2007 Budget Request of $3.0 million funds the necessary reimbursement to the Judgment Fund.

SECOND PRIORITY: NEW STARTS IN FY 2007 AND FY 2008

NSF's second priority are those projects that have received NSB-approval for inclusion in a budget request but which have not yet received funding. NSF is requesting funding for two new starts in FY 2007 and one new start in FY 2008. In priority order, these are:

- the Alaska Region Research Vessel in FY 2007,
- the Ocean Observatories Initiative in FY 2007, and
- Advanced LIGO in FY 2008.

Alaska Region Research Vessel

Project Description: The Alaska Region Research Vessel (ARRV) is proposed to replace the R/V *Alpha Helix*, which, at 40 years, is 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 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 (up to three feet thick) ice 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 upwards of 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, and fisheries 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 will be the Program Director for Ship Acquisition and Upgrades, within the Integrative Programs Section (IPS) in the Division of Ocean Sciences (in GEO), with additional staff in IPS providing project management assistance. The Section Head (IPS) and another Section member 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), the Office of the General Counsel, and the NSF Deputy Director for Large Facility Projects. The Awardee will hire a Systems Integration

Manager to establish and staff an Office to provide a management team for the vessel construction phase and to report to the NSF coordinator. 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. The next action will be for NSF to issue a competitive solicitation for a cooperative agreement for the construction and operation of this ship.

The Federal Oceanographic Facilities Committee (FOFC) 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[7]. An update of this Plan will be published later this year.

Milestones for ARRV are outlined below:

FY 2006 Milestones:

Prepare and issue a solicitation to build and operate the ARRV via a Cooperative Agreement.
Complete an external merit review process of proposals received.

FY 2007 Milestones:

Negotiate a Cooperative Agreement with the selected institution.
Awardee establishes the Project Management Office 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.
Monthly and in-depth quarterly reviews with NSF oversight, to include on site inspections.
Launch vessel.

FY 2009 Milestones:

Complete vessel construction and outfitting.
Undergo sea trials.
Finalize acceptance and delivery of vessel to operating institution.
Incorporate vessel into the UNOLS ship scheduling process.

[7] This report is available online: http://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: Recognizing from the outset of operations in Alaskan waters in 1980 that the R/V *Alpha Helix* was of marginal size and capability for the region, 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 has since funded the concept design, detailed design and model testing for a replacement vessel and is prepared to initiate a two-year construction phase.

Requested MREFC Funds for ARRV
(Dollars in Millions)

FY 2007 Request	FY 2008	Total
$56.00	$42.00	$98.00

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 Actual	0.30						$0.30	-	$0.30
FY 2006 Current Plan	0.10						$0.10	-	$0.10
FY 2007 Request				56.00			-	$56.00	$56.00
FY 2008 Estimate				42.00			-	$42.00	$42.00
FY 2009 Estimate					3.50		$3.50	-	$3.50
FY 2010 Estimate					7.00		$7.00	-	$7.00
FY 2011 Estimate					7.50		$7.50	-	$7.50
FY 2012 Estimate					8.00		$8.00	-	$8.00
Subtotal, R&RA	$2.31		-		$26.00		$28.31		
Subtotal, MREFC		-		$98.00		-		$98.00	
Total, Each Stage		$2.31		$98.00		$26.00			$126.31

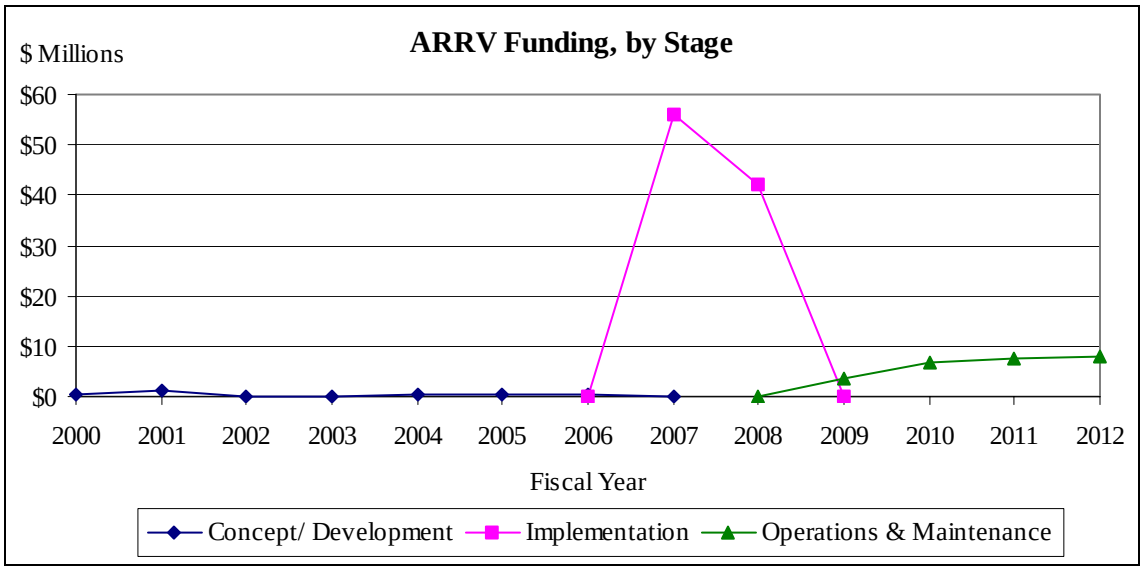
Ship operations are estimated to be approximately $7 million for the first full year. The expected operational service life of the ARRV is 30 years after construction is complete. Operations estimates for FY 2011 and beyond are developed strictly for planning purposes and are based on current cost profiles. 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 be prepared to go into the construction phase in FY 2007. It is anticipated that the vessel will be constructed over a two-year period and will be ready for sea trials and commissioning. It will be ready to conduct science activities within two and a half years after construction is initiated.

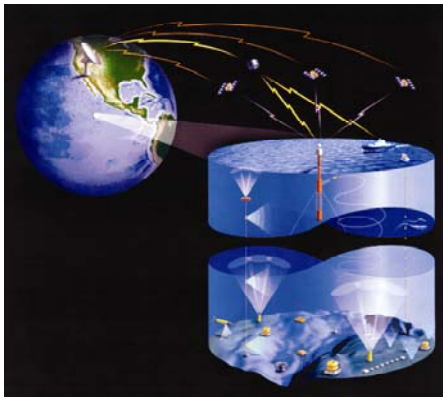
- Operations and Maintenance: Following commissioning, the ship will be managed by the awardee institution which will maintain and operate the vessel for NSF through a cooperative agreement. The vessel will be scheduled through the University-National Oceanographic Laboratory System (UNOLS) process, 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 million.



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, habitablilty and ice capability.

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. The observatory infrastructure of the OOI will be operated as a shared-use facility with open community access to data.



This image is an artist's rendition depicting the OOI, which portrays the seafloor junction boxes, the bouys and the cable network. OOI is expected to transform the way we observe the ocean environment.

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 GEO's Digital Library for Earth Science Education (DLESE), and the Division of Ocean Science's (OCE's) 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 have been involved in conceptual design reviews of proposed OOI components and systems and will be important participants in the construction and implementation phase of the OOI.

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 Project Advisory Team (PAT) that includes representatives from GEO, Biological Sciences, Engineering; the Office of Budget, Finance and Award Management; the Office of International Science and Engineering; the Office of General Counsel; and the Office of Legislative and Public Affairs. The NSF Deputy Director for Large Facility Projects 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 Executive Steering Committee under which will be established scientific and technical advisory committees. Advisory committee membership will be drawn from individuals with expertise in ocean observing science and engineering. During the construction phase, Implementing Organizations (IOs) contracted by the Project Office 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, the Navy, the National Aeronautics and Space Administration, and the Coast Guard.

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. The Project Office has established an advisory structure that provides a direct link between Project Office planning and the research community.

To continue community planning for OOI implementation, detailed conceptual proposals for ocean science research experiments were solicited through the Ocean Observatories Project Office. These proposals were peer reviewed and are now being used to further refine designs for the OOI and to identify specific experimental instrumentation needs of the user community. This process will help refine cost estimates for ocean observatory science and enabling infrastructure to be constructed though the OOI. The initial implementation plan arising from this exercise will be reviewed and discussed at the March 2006 OOI Design and Implementation workshop whose aim is to provide the community with a final opportunity to iterate these plans prior to the Construction Phase. 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:
- Review of Internal Management Plan by Facilities Panel
- Completion of Project Development Plan
- OOI Conceptual Design Review
- Complete design of data management and archiving system
- Completion of OOI Project Execution Plan
- Selection of Implementing Organizations
- Initiate EA/EIS and permitting process

FY 2007 Milestones:
- Submission of Project Execution Plan to Large Facilities Office
- OOI Preliminary Design Review/Final Design Review
- Initial implementation of data management and archiving system
- EA/EIS and permitting
- Staffing up of Implementing Organizations
- Coastal Observatories
- Site surveys

FY 2008 Milestones:
- First Phase of the global array
- First Phase of the coastal array
- Shore station construction for the RCO
- RCO cable route surveys
- EA/EIS permitting process for the RCO cable route

FY 2009 Milestones:
- Regional Cabled Network
- Initial installation and inspection of cable backbone section
- Initial installation of science nodes and instrumentation on backbone section

FY 2010 Milestones:
- Regional Cabled Network
- Final installation and inspection of cable backbone section
- Final installation of science nodes and instrumentation on backbone section

FY 2011 Milestones:
- Second phase of the global array
- Second phase of the coastal array
- Initial commissioning and testing of the RCO

FY 2012 Milestones:
- Second phase of the global array
- Second phase of the coastal array
- Final commissioning and testing activities for the RCO

Funding Profile: NSF expects to spend approximately $52 million in concept and development activities through FY 2007. The total construction cost for OOI is $309.50 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	FY 2009	FY 2010	FY 2011	FY 2012	Total
$13.50	$48.00	$77.00	$78.00	$53.00	$40.00	$309.50

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 Current Plan	5.20						$5.20	-	$5.20
FY 2007 Request	8.30			13.50			$8.30	$13.50	$21.80
FY 2008 Estimate				48.00	3.00		$3.00	$48.00	$51.00
FY 2009 Estimate				77.00	7.00		$7.00	$77.00	$84.00
FY 2010 Estimate				78.00	12.00		$12.00	$78.00	$90.00
FY 2011 Estimate				53.00	25.00		$25.00	$53.00	$78.00
FY 2012 Estimate				40.00	40.00		$40.00	$40.00	$80.00
FY 2013 Estimate					50.00		$50.00	-	$50.00
FY 2014 Estimate					50.00		$50.00	-	$50.00
Subtotal, R&RA	$52.42		-		$187.00		$239.42		
Subtotal, MREFC		-		$309.50		-		$309.50	
Total, Each Stage		$52.42		$309.50		$187.00			$548.92

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.

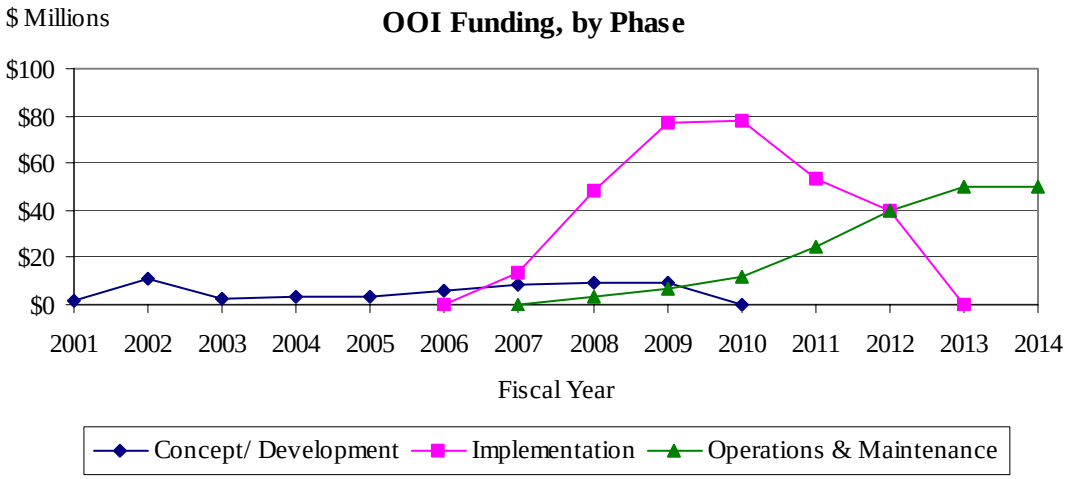
Information pertaining to the data in the table is provided below.

- Concept/Development: R&RA funding has supported 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. The Monterey Bay Aquarium Research Institute has been awarded $11.60 million 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.

- 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.

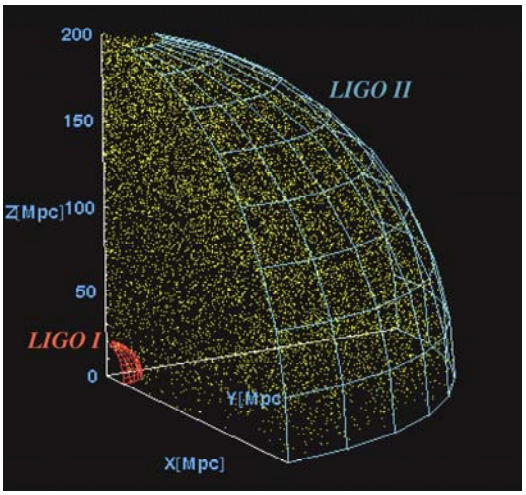
- Operations and Maintenance: Access to OOI Infrastructure will be determined by peer review and all data will be openly accessible. OOI Infrastructure will be maintained and operated by the Ocean Observatories Project Office. Future development of more complex sensor packages for the OOI infrastructure 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.



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 million, once the network is fully implemented.

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). 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 arm lengths 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 10 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 will achieve its objectives as planned and may detect the first gravitational waves. AdvLIGO will greatly increase the sensitivity to ensure the detection of gravitational waves and to launch the new field of gravitational-wave astronomy.



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.

The LIGO project was planned in two phases from the very 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 LIGO program has strongly stimulated the interest in gravitational-wave research around the world, producing very 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 super-dense objects in the universe will produce gravitational radiation that will travel to Earth. Detection of these gravitational waves is of great importance, both for fundamental physics and for

astrophysics. Furthermore, even though the universe is believed to be filled with gravitational waves from a host of cataclysmic cosmic phenomena, scientists have never directly detected a gravitational wave and 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.

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 (MPS), who also participates in the Physics Division Project Advisory Team (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 LIGO Deputy Director for the AdvLIGO Project, David Shoemaker of 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 cycle from 21.8 percent in S-3 to 74.5 percent in S-4 leading to more than a 50 percent triple coincidence operation during the run. In addition, during S-4 all three interferometers showed high sensitivity, achieving levels within a factor of 2 of design sensitivity. The improvements achieved in the intervals between all science runs have been remarkable. S-5, operating at a somewhat better sensitivity than the design goal, began on

November 4, 2005, and has a planned duration of eighteen months. The coincident duty cycle — 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 projected to be at least 70% 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. 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 – 2007.

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 Milestones:
Acquisition of all components needed to begin installation in FY 2010
Prepare for installation

FY 2010-11 Milestones:
Installation begins at Livingston (FY 2010)
Installation begins at Hanford (FY 2011)

FY 2012 Milestones:
Commissioning begins at Livingston
Commissioning begins at Hanford

FY 2013 Milestones:
Livingston operational
Hanford operational

Funding Profile:

Requested MREFC Funds for AdvLIGO
(Dollars in Millions)

FY 2008 Request	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	Total
$28.48	$42.81	$46.31	$36.25	$22.90	$7.60	$184.35

AdvLIGO 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	15.60						$15.60		$15.60
FY 2005	9.20						$9.20		$9.20
FY 2006 Current Plan	9.70						$9.70		$9.70
FY 2007 Request	6.24						$6.24	-	$6.24
FY 2008 Request				28.48	26.55		$26.55	$28.48	$55.03
FY 2009 Estimate				42.81	26.78		$26.78	$42.81	$69.59
FY 2010 Estimate				46.31	24.42		$24.42	$46.31	$70.73
FY 2011 Estimate				36.25	23.70		$23.70	$36.25	$59.95
FY 2012 Estimate				22.90	20.94		$20.94	$22.90	$43.84
FY 2013 Estimate				7.60	33.26		$33.26	$7.60	$40.86
FY 2014 Estimate					39.00		$39.00	-	$39.00
Subtotal, R&RA	$40.74		-		$194.65		$235.39		
Subtotal, MREFC		-		$184.35		-		$184.35	
Total, Each Stage		$40.74		$184.35		$194.65			$419.74

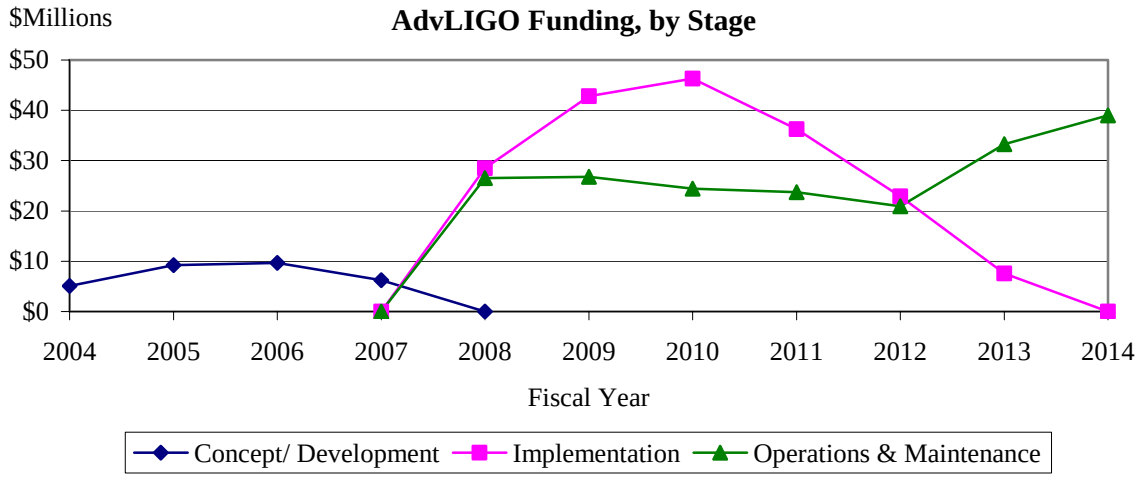
Note: Operations estimates for FY 2008 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

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

- Concept/Development: In the period of FY 2000 to FY 2007 the amount of $40.74 million will have been spent by the LIGO Laboratory for advanced R&D for concept development of AdvLIGO. The additional development work during the construction period will be directed to design development.

- Implementation: Funding during the Major Research Equipment and Facilities Construction (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.



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 LIGO Scientific Collaboration from universities through ongoing research and education programs. The annual support for such activities is estimated to be about $5 million.

In 1997, LIGO founded the LIGO Scientific Collaboration (LSC) to organize the major international groups doing research that was supportive of LIGO. The LSC now has 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. Caltech has nearly completed a successful search for a new LIGO director.

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