MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION $250,010,000

The FY 2006 Budget Request for the Major Research Equipment and Facilities Construction (MREFC) Account is $250.01 million, an increase of $76.36 million, or 44.0 percent, above the FY 2005 Current Plan of $173.65 million.

Major Research Equipment and Facilities Construction Funding

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change Over FY 2005 Amount	Change Over FY 2005 Percent
Major Research Equipment and Facilities Construction	$183.96	$173.65	$250.01	$76.36	44.0%

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.

There can be no doubt that 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, NSF has received an increased number of requests for major research facilities and equipment from the S&E community. Many of these requests have received outstanding ratings from research peers, program staff, management and policy officials, and the National Science Board. NSF's Request for the MREFC Account positions the agency to meet the future needs and opportunities of the research community.

In February 2004, the National Academies released a report on "Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation". This report recommends an open process for selecting new projects to be funded, establishing well-defined criteria and including maximum community input. The results of this final prioritization should be "discussed, explained and documented". NSF concurs with these recommendations and is currently refining the MREFC process to ensure that decisions are clearly documented and explained, and selection criteria clearly articulated.

The National Science Board (NSB) provisionally approved a joint NSB-NSF management document on Setting Priorities for Large Research Facility Projects at its October 2004 meeting (http://www.nsf.gov/nsb/documents/2005/memo.pdf)[1]. This document outlines in general terms the changes NSF will implement over the next year.

At the December 2004 National Science Board (NSB) meeting, NSF announced that new guidelines for the development, review and approval of major research facilities will be available by about June 2005.

[1] This document is currently available at this location for public comment for a limited period of time. Afterwards, it will be available upon request through the National Science Board website (http://www.nsf.gov/nsb/contact.htm).

In addition, an NSF Facility Plan will be released in March of each year, beginning in 2005, that will contain information about facilities under construction, as well as facilities under consideration for future support.

Once a project is submitted for MREFC funding, it must undergo a multi-phase review and approval process. The process will continue to include a review by the internal NSF MREFC Panel, comprised of the Deputy Director, the Assistant Directors, the Head of the Office of Polar Programs, and the Chief Financial Officer. The Deputy for Large Facility Projects attends Panel meetings and provides advice and assistance. The MREFC Panel makes recommendations to the NSF Director with attention to criteria such as scientific merit, importance, readiness and cost-benefit. These criteria are being modified to align with the criteria recommended by the National Academies. The Director then selects candidates to send to the National Science Board (NSB) for consideration. The NSB then approves, or not, projects for inclusion in future budget requests and establishes priorities in May of each year. The Director selects from the group of NSB-approved projects those appropriate for inclusion in a particular budget request to OMB, and after discussion with OMB, to the Congress.

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.

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, highest priority in FY 2006 is to continue to request funding for the Atacama Large Millimeter Array ($49.24 million); EarthScope ($50.62 million); the IceCube Neutrino Observatory ($50.45 million); the Scientific Ocean Drilling Vessel ($57.92 million); and Rare Symmetry Violating Processes ($41.78 million).

NSF is requesting no new starts in FY 2006.

Two new starts are requested in FY 2007, and one new start is requested in FY 2008. In priority order, these are: Ocean Observatories in FY 2007; the Alaska Region Research Vessel in FY 2007; and Advanced LIGO in FY 2008[2].

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

MREFC Account[1]

(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate
Ongoing Projects							
ALMA Construction	50.70	49.30	49.24	47.89	46.49	37.37	20.91
EarthScope	43.24	46.97	50.62	26.80			
HIAPER	12.54						
IceCube Neutrino Observatory	38.36	47.62	50.45	28.65	21.78	11.33	0.95
National Ecological Observatory Network				12.00	12.00	20.00	
Network for Earthquake Engineering Simulation	8.05						
Rare Symmetry Violating Processes		14.88	41.78	48.00	30.75	15.00	8.00
Scientific Ocean Drilling Vessel		14.88	57.92	42.20			
South Pole Station	21.03						
Terascale Computing Systems	10.05						
New Starts							
Ocean Observatories Initiative				13.50	42.00	65.50	66.90
Alaska Region Research Vessel				49.32	32.88		
Advanced LIGO					28.48	42.81	46.31
Totals	$183.96	$173.65	$250.01	$268.36	$214.38	$192.01	$143.07

Totals may not add due to rounding.

Estimates for 2007 and beyond do not reflect policy decisions and are presented for planning purposes only.

[1]The FY 2005 total includes $37.13 million carried forward from previous years. This includes $29.87 million for the South Pole Station Modernization project, $115,000 for Polar Support Aircraft upgrades, $34,418 for the South Pole Safety project, and $7.11 million for IceCube.

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, ~~$175,050,000~~ *$250,010,000*, to remain available until expended. *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2005.)*

Major Research Equipment and Facilities Construction Account Funding
FY 2006 Summary Statement

(Dollars in Millions)

	Enacted/ Request	Rescission	Carryover/ Recoveries	Transfers	Total Resources	Obligations Incurred/ Estimated
FY 2004 Appropriation	155.90	-0.92	66.11	--	221.09	183.96
FY 2005 Current Plan	175.05	-1.40	37.13	--	210.78	210.78
FY 2006 Request	250.01	--	--	--	250.01	250.01
$ Change from FY 2005	74.96				39.23	
% Change from FY 2005	43%				19%	

Explanation of Carryover:

Within the Major Research Equipment and Facilities Construction (MREFC) appropriation $37.13 million was carried forward into FY 2005. This includes $37.13 million for the Office of Polar Programs (OPP) activity (i.e., $29.87 million for the South Pole Station Modernization, $115,000 for Polar Support Aircraft upgrades, and $34,418 for the South Pole Safety project, and $7.11 million for IceCube).

FIRST PRIORITY: ONGOING PROJECTS IN FY 2006

Atacama Large Millimeter Array

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

The Atacama Large Millimeter Array (ALMA) VertexRSI test antenna, one of two prototypes constructed at the site of the Very Large Array near Socorro, New Mexico. *Credit: NRAO/AUI.*

Principal Scientific Goals: To function as the most capable imaging radio telescope ever built, ALMA 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 (the baseline ALMA). 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 (AST) in the Directorate for Mathematical and Physical Sciences (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.

Project Status and Milestones: Significant project events during FY 2004 included:

- Groundbreaking at the site near San Pedro de Atacama in the second region of Chile in November 2003.
- The completion of all project agreements with the government of Chile.
- The completion the ALMA construction camp at the site of the mid-altitude Operations Support Facility (OSF), and ongoing progress with road and other site works.
- The establishment by the Government of Chile of a radio quiet zone centered on the ALMA site.
- The entry of Japan into an Enhanced ALMA project in September 2004.
- The receipt and evaluation of bids for the ALMA production antennas.

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. The Project Plan is now under configuration control by the Joint ALMA office. Level 1 construction milestones (i.e., milestones specified in the international ALMA Agreement and in the Project Plan) are:

FY 2005 Milestones:
Central back end system ready to install at Array site
Initial Phase of Civil Works in Chile Complete
First Antenna-based Backend Subsystem ready for installation at site Operations Support Facility (OSF)

FY 2006 Milestones:
First Production Antenna available in Chile at OSF
Initial Front End Subsystem available at OSF

FY 2007 – FY 2011 Milestones:
Start Early Science Observations (FY 2007)
Continue construction schedule

FY 2012 Milestones
Completion of Construction Project
Start Full Science Operations

It should be noted that the current project schedule was developed prior to the start of ALMA construction activities and the entry of Japan into the project. A thorough reexamination of the project baseline and schedule are planned in FY 2005 and may result in a rebaselining.

Funding Profile: The current project schedule calls for U.S.-funded construction activities to continue through 2010, with full project completion at the end of calendar 2011, and full operation beginning in early 2012. Early science with the array is presently scheduled to begin at the end of 2007. The estimated cost to construct ALMA is $702.0 million. The U.S. share of the joint array construction is estimated to be $344.21 million.

A $26.0 million, three-year Design and Development Phase was originally planned for the MMA project. 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 was initiated in FY 2002.

Appropriated and Requested MREFC Funds for ALMA

(Dollars in Millions)

	FY 01 & Earlier	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	Total
ALMA R&D	31.99										31.99
ALMA Construction		12.50	29.81	50.70	49.30	49.24	47.89	46.49	37.37	20.91	344.21
Total, ALMA	$31.99	$12.50	$29.81	$50.70	$49.30	$49.24	$47.89	$46.49	$37.37	$20.91	$376.20

ALMA Funding Profile

(Dollars 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	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 Current Plan				49.30	1.00		$1.00	$49.30	**50.30**
FY 2006 Request				49.24	2.00		$2.00	$49.24	**51.24**
FY 2007 Estimate				47.89	5.00		$5.00	$47.89	**52.89**
FY 2008 Estimate				46.49	10.00		$10.00	$46.49	**56.49**
FY 2009 Estimate				37.37	14.00		$14.00	$37.37	**51.37**
FY 2010 Estimate				20.91	19.00		$19.00	$20.91	**39.91**
FY 2011 Estimate					23.00		$23.00		**23.00**
FY 2012 Estimate					23.00		$23.00		**23.00**
Subtotal, R&RA	$6.50				$97.00		$103.50		
Subtotal, MREFC		$31.99		$344.21				$376.20	
Total, Each Stage		**$38.49**		**$344.21**		**$97.00**			**$479.70**

NOTE: The expected operational lifespan of this project is at least 30 years. A steady state of about $23.0 million annually is anticipated for operations support beginning in FY 2012. 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. Operations funding is provided through the National Radio Astronomy Observatory.

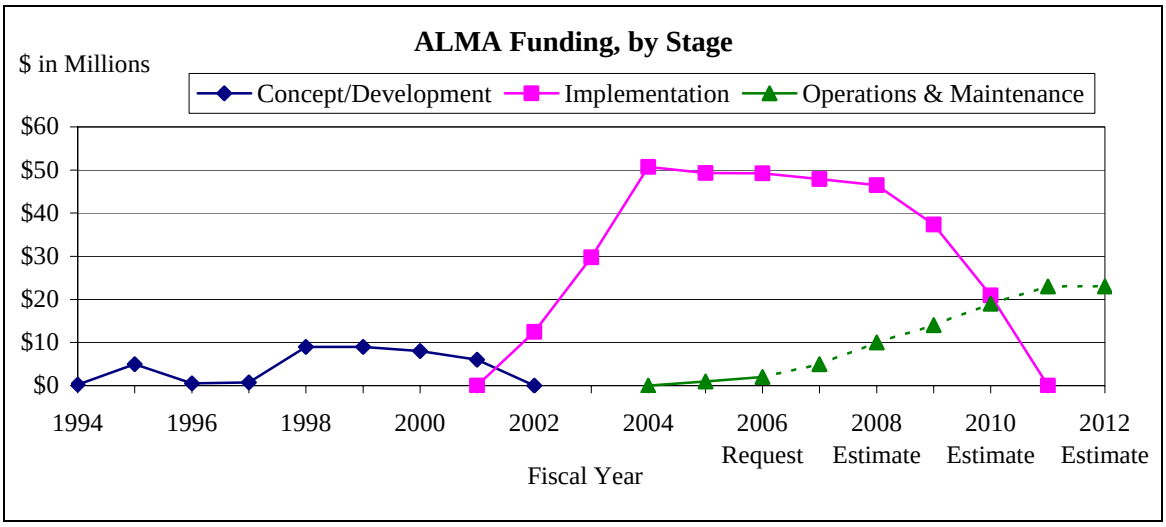
[1]Based on cost review of the original MMA and then projected to ALMA.

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 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 amount will be determined after a baseline review which will be conducted in 2005. 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. The first full year of ALMA science operations is anticipated to be FY 2012.



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.

EarthScope

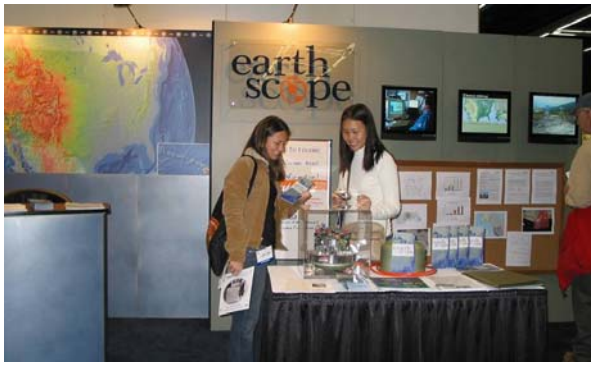
Project Description: The EarthScope Facility is a distributed, multi-purpose geophysical instrument array that will make major advances in our knowledge and understanding of the structure and dynamics of the North American continent. EarthScope instrumentation is expected to inhabit nearly every county 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 3000 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.

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 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 a National Academies review of EarthScope, an EarthScope Science and Education Advisory Committee (ESEC) was formed to provide an advisory structure to ensure coordination of facility construction and operation, science, education and outreach, and information technology efforts.



EarthScope Education and Outreach includes displays at National Parks such as Sunset Crater and professional meetings, such as the 2004 National Science Teachers Association National Convention, pictured here. *Credit: EarthScope*

Current Project Status: Phase 1 drilling at the San Andreas Fault Observatory at Depth (SAFOD) site successfully concluded in September 2004. The main SAFOD hole is logged, sampled, tested, and cased to 10,010 feet; 26 feet of core was obtained at 4,796 feet; and 38 feet of core was obtained at 10,025 feet (the bottom of the Phase 1 hole). Passive systems have been deployed for monitoring until drilling resumes in June 2005. The long anticipated magnitude 6.0 Parkfield earthquake occurred approximately 20 km southeast of the SAFOD site on September 28, 2004. There was no damage at the site, but seismic and GPS deployment plans were altered and accelerated in response to the earthquake. Overall, GPS and seismic station equipment acquisition and installation are slightly behind schedule. GPS and seismic data become available to the community as each installation is completed. Data from EarthScope has already been used in earthquake studies, earthquake responses, presentations at professional meetings, and in some university and other educational settings. FY 2004 highlights also include dedicated workshops to refine the EarthScope science plan, organize education and outreach activities, strengthen coordination with EarthScope partners at NASA and the USGS, and refine communications/information technology capabilities. The Facility project office was opened and staffed in 2004 and has created a reporting/management system that is earned value management based. One of the most important accomplishments of 2004 is the creation of an R&RA funded Education and Outreach program. A national search for the EarthScope Education and Outreach Manager is underway.

The EarthScope project has been represented at over a dozen professional meetings and conferences through an exhibit booth, presentations, and scientific sessions. In the fall, EarthScope also hosted a well-publicized tour of the SAFOD site for the NSF Director, staff, the media, and Congressional staff.

The EarthScope Facility Project Execution Plan has been reviewed and updated. The initial milestones are listed below. These milestones will be reviewed quarterly and the project will undergo a baseline review in the fall of 2005. Thus, these milestones may be revised as the project continues.

FY 2003 Milestone:

Award for EarthScope MREFC construction phase (Completed);

FY 2004 Milestones:

Compete and award contracts for broadband and short-period seismic systems (Completed);
Community planning on permanent seismic sites and first array deployment (Completed);
San Andreas Fault Observatory at Depth (SAFOD) main hole drilling contract competed and awarded;
Down-hole monitoring equipment constructed;
Phase 1 drilling of SAFOD main hole (Completed);
Installation of 90 equivalent permanent GPS, 6 equivalent borehole strain, and 1 equivalent long baseline strainmeter systems;
Equipment for 28 portable GS sites available;
Installation of 14 equivalent Advanced National Seismic System (ANSS) and 28 equivalent Transportable Array stations;
Equipment for 240 Flexible Array sites available; and
NSF conducts first annual review of EarthScope.

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 conducts 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:

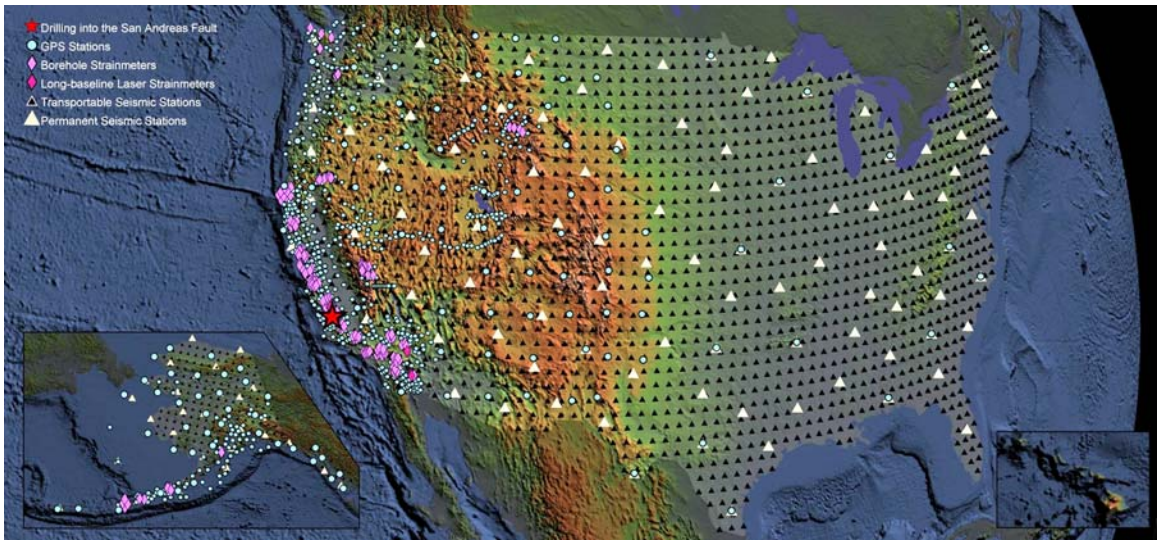
Use site characterization and monitoring data to choose four coring intervals at depth in San Andreas Fault Observatory;
Main hole Phase 3 drilling begins at SAFOD;
Installation of 780 equivalent permanent GPS and 162 equivalent borehole strain systems;

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, and began the implementation of a five-year period of acquisition, construction and commissioning in FY 2003. The total project cost for EarthScope implementation is $197.44 million.



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*

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

FY 2003	FY 2004	FY 2005	FY 2006 Request	FY 2007	Total
$29.81	$43.24	$46.97	$50.62	$26.80	$197.44

EarthScope Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 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 Current Plan				46.97	4.69		$4.69	$46.97	**51.66**
FY 2006 Request				50.62	7.32		$7.32	$50.62	**57.94**
FY 2007 Estimate				26.80	12.52		$12.52	$26.80	**39.32**
FY 2008 Estimate					23.41		$23.41		**23.41**
FY 2009 Estimate					24.00		$24.00		**24.00**
Subtotal, R&RA	$9.36				$74.04		$83.40		
Subtotal, MREFC				$197.44				$197.44	
Total, Each Stage		**$9.36**		**$197.44**		**$74.04**			**$280.84**

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 2007. 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.

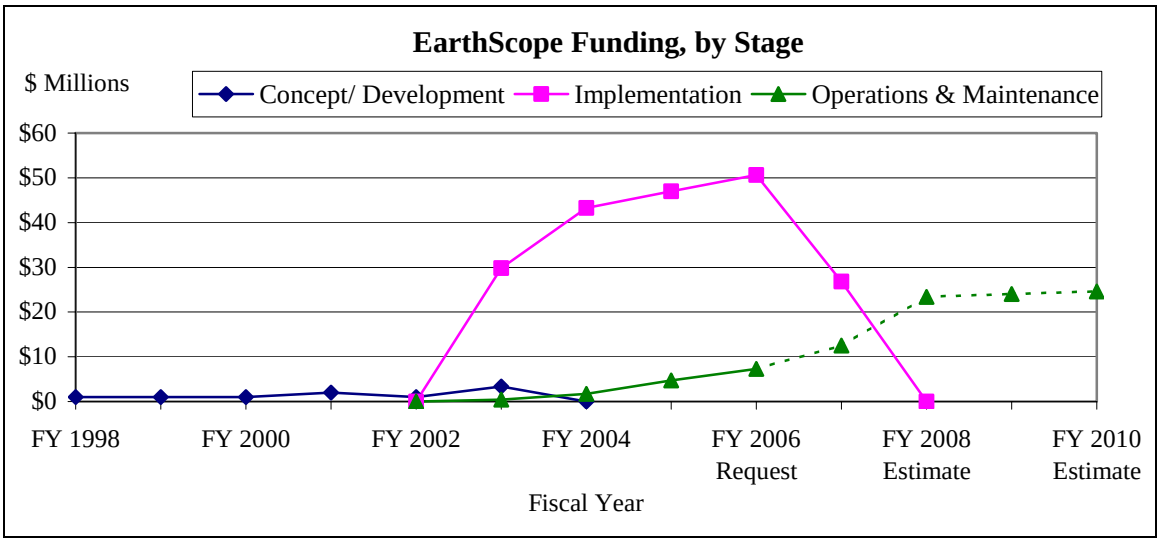
Information pertaining to the data in the table is provided below.

- 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 the construction and installation. This funding supported meetings, workshops, instrumentation prototype development, installation technique development, and site selection activities.

- Implementation: The project will put 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 will begin to phase-in during the first year of construction. When EarthScope is completed it will be managed, operated and maintained by a

consortium 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.

High performance Instrumented Airborne Platform for Environmental Research (HIAPER)

Final MREFC funding for HIAPER was appropriated in FY 2003. $12.54 million was carried over into FY 2004 for instrument development. For information on the operation of HIAPER, please see the section on the National Center for Atmospheric Research (NCAR) in the Facilities chapter of this document.

IceCube Neutrino Observatory

Project Description: IceCube will be the world's first high-energy neutrino observatory and will be located under the ice at the South Pole. 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

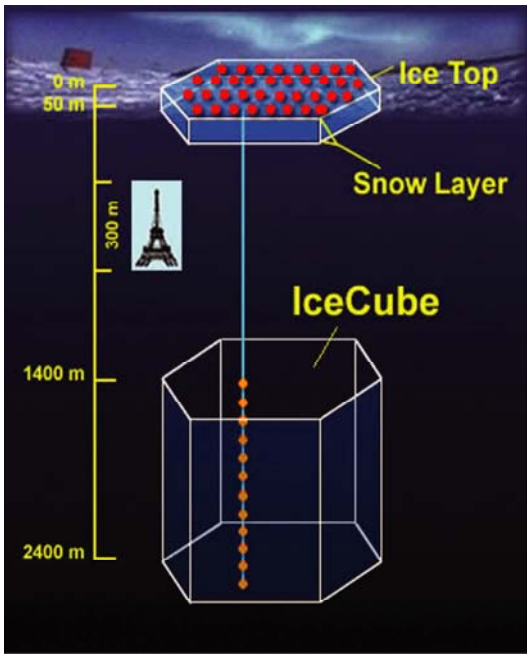
shower detectors to both calibrate and eliminate background events from the IceCube DOM array; construction of a data acquisition and analysis system; and associated personnel and logistics support.

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.

January 9, 2005: Tower, drill cable connected, hose end in tower. Second drill shift installing a windbreaker to reduce heat loss. *Credit: the United States Antarctic Program.*

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 work force 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 U.S. Department of Energy, through its Lawrence Berkeley Laboratory, is also participating.



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.*

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. The University of Wisconsin has in place an external Scientific Advisory Committee, an external Project Advisory Panel, and a high-level Board of Directors (including the Chancellor) providing for their oversight of the project. IceCube is managed by a Project Director and a Project Manager. Internally, NSF has appointed a Project Coordinator to manage and oversee the NSF award, and established an internal Project Advisory Team (PAT) comprised of representatives from the Office of Budget, Finance, and Award Management, the Office of General Counsel, the Directorate for Mathematical and Physical Sciences (MPS), and the Office of Polar Programs (OPP), and chaired by the Project Coordinator. The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. 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 the Fall 2004, and comprehensive annual external reviews are planned for each subsequent spring following the annual deployment season. This is interspersed with written monthly progress reports and quarterly reports, site visits, weekly teleconferences, and weekly internal NSF project oversight and management meetings. Oversight and funding responsibility for IceCube construction are the responsibility of OPP; support for operations, research, education, and outreach using IceCube will be shared by OPP and MPS as well as other organizations and international partners.

Current Project Status: The primary IceCube Project tasks carried out to date are: (1) completion and testing 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 US, Germany, and Sweden; (3) production and testing of the DOMs needed for deployment of four DOM strings this austral summer season (November 2004 to mid-February 2005) at Pole; (4) shipping and assembly of the entire drilling and deployment camp at Pole, including the shipment and re-testing at Pole of the needed DOMs and cables; (5) design, construction, and installation of the initial data acquisition system at Pole; (6) completion of plans for commissioning and verification of the initial DOM strings; and (7) placement at Pole of the building that will serve as the IceCube permanent counting house next season (2005/2006).

Major milestones for IceCube are below:

FY 2004 and 2005 Milestones:
- Begin production of digital optical modules and data acquisition and handling system (DAQ) (Completed);
- Deliver EHWD system and DOM deployment system to the South Pole (Completed);
- Deliver initial DOM strings, IceTop modules, and initial elements of the DAQ to South Pole (Completed);
- Assemble the EHWD and DOM deployment systems (Completed);
- Establish drill camp and move new counting house building into place (Completed); and
- Drill, deploy, and test initial DOM strings and corresponding IceTop modules [pending].

FY 2006 Milestones:
- Ramp up to near-full DOM production at all facilities and IceTop module production;
- Drill, deploy and test up to 12 DOM strings and corresponding IceTop modules, including installing and testing the associated DAQ elements; and
- Commission new counting house.

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:
- Continue DOM and IceTop module production; and
- Continue to drill, deploy and test 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 of IceCube.

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

Funding Profile: $15.0 million was appropriated in FY 2002 for startup activities for IceCube; $24.54 million was appropriated in FY 2003 for continuation of startup activities; $41.75 million was appropriated in FY 2004 to initiate construction; and $47.62 million was appropriated in FY 2005 for continued construction. The FY 2006 Request is $50.45 million for continued construction of IceCube. The total project cost for IceCube is $271.80 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 Request	FY 2007	FY 2008	FY 2009	FY 2010	Total
$15.00	$24.54	$41.75	$47.62	$50.45	$28.65	$21.78	$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 carryover from prior year appropriations.

IceCube Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2001	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 Current Plan				47.62				$47.62	**47.62**
FY 2006 Request				50.45				$50.45	**50.45**
FY 2007 Estimate				35.71	3.50		$3.50	$35.71	**39.21**
FY 2008 Estimate				21.78	7.00		$7.00	$21.78	**28.78**
FY 2009 Estimate				11.33	9.00		$9.00	$11.33	**20.33**
FY 2010 Estimate				0.95	11.00		$11.00	$0.95	**11.95**
FY 2011 Estimate					12.00		$12.00		**12.00**
FY 2012 Estimate					12.00		$12.00		**12.00**
Subtotal, R&RA	$0.50				$54.50		$55.00		
Subtotal, MREFC				$242.07				$242.07	
Total, Each Stage		**$0.50**		**$242.07**		**$54.50**			**$297.07**

NOTE: The expected operational lifespan of this project is 25 years after construction is complete in FY 2010. Operations support begins in FY 2007. Operations support is estimated at $3.5 million for FY 2007 and ramps up to an estimated level of $12.0 million in FY 2011 and beyond. These operations estimates are developed for planning purposes and are based on current cost profiles. Efforts are underway to further develop operating cost estimates; they will be updated as new information becomes available.

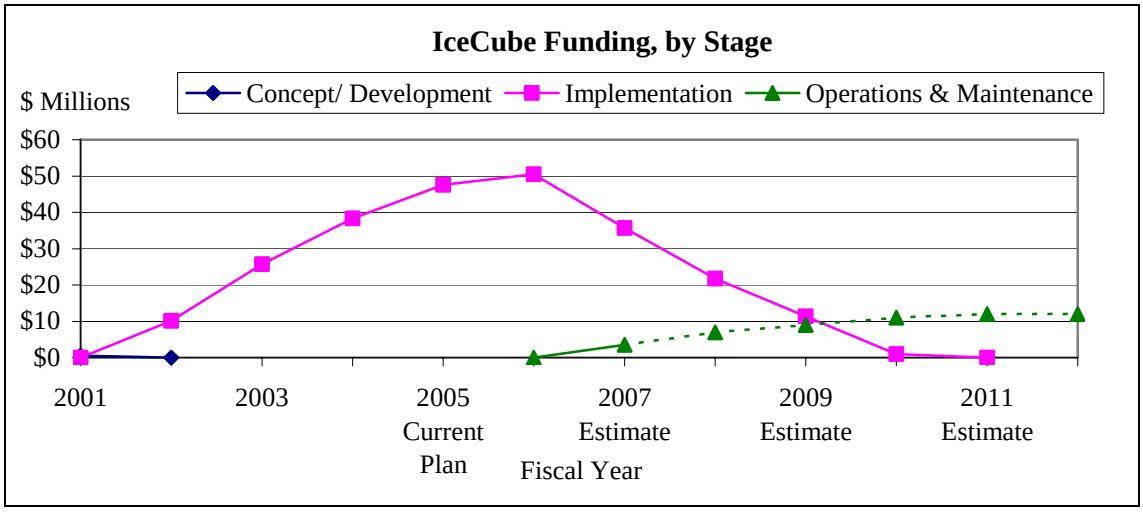
Information pertaining to the data in the table is provided below.

- 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. NSF's FY 2002 appropriation included $15.0 million for 'start-up' design and development of the IceCube project. NSF's FY 2003 appropriation included $24.50 million for continued startup activity. 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 estimated currently at $271.77 million. Of this amount $242.07 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 FY 2006 funding Request is $50.45 million. The plan is to drill holes and deploy strings of DOMs in each austral summer season (November through mid-February), beginning in the FY 2005 austral summer season (2004/2005). 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 is for data analysis that will be carried out by the collaborating U.S. and foreign IceCube institutions, the other half being for direct operations and maintenance support (IceCube-specific logistics, system engineering, operation and maintenance of the data acquisition and data handling data 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 $2.0 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 minorities 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.

National Ecological Observatory Network

Project Description: NEON will be a continental scale research instrument platform consisting of geographically distributed infrastructure that is networked via state-of-the-art communications technology. Cutting-edge lab and field instrumentation, site-based experimental infrastructure, natural history archive facilities and/or computational, analytical and modeling capabilities, linked via a network will compose NEON.

NEON will transform ecological research by enabling studies on major environmental challenges at regional to continental scales. Scientists and engineers will use NEON to conduct real-time ecological studies spanning all levels of biological organization and temporal and geographical scales. NSF disciplinary and multi-disciplinary programs will support NEON research projects and educational activities. Data from standard measurements made using NEON will be publicly available.

Principal Scientific Goals: Collectively, the network of observatories will allow comprehensive, continental-scale experiments on ecological systems and will represent a virtual laboratory for research to obtain a predictive understanding of the environment. Important ecological questions confronting the U.S. will be addressed using NEON.

Principal Education Goals: NEON's knowledge base, real time and continuous network data, simulation and observation capabilities, and networked communication will be an asset for formal and informal education and training. NEON will serve as a model to foster the NSF goal of integration of research and education by creating a research-intensive and collaborative learning environment. NEON will provide a creative and innovative educational platform to address the NSF Directorate for Biological Sciences education goals (experiential learning, biosphere literacy, and broadening career horizons).

The National Ecological Observatory Network (NEON), a collaborative research platform of geographically distributed infrastructure, will be connected via the latest information technology. NEON will address pressing environmental questions on regional to continental scales. *Credit: The Directorate for Biological Sciences, NSF.*

Partnerships and Connections to Industry: Several federal agencies have expressed interest in partnering with NEON, including the National Park Service, the National Forest Service, NASA, NOAA, USGS, EPA, National Marine Sanctuaries and the USDA Agricultural Research Sites. Private foundations, such as the Santa Fe Institute, the Turner Foundation, Nature Serve, and The Nature Conservancy have also expressed interest. NEON-generated information will be useful to natural resource industries, such as forestry and fisheries. NEON's technological and networking infrastructure will be forging new technological frontiers and thus, will require partnerships with industry for development, deployment, and operation.

Management and Oversight: The Division of Biological Infrastructure within the BIO Directorate manages NEON. The NEON Program Officer in consultation with a BIO-NEON committee, which includes the Deputy for Large Facility Projects, formulates the programmatic development of NEON, i.e. drafting, release and review of program announcements, etc. A NEON Project Advisory Team, which includes individuals from all NSF directorates and the Office of Budget, Finance and Award Management, the Office of General Counsel, the Office of Legislative and Public Affairs, and the Office of Polar Programs, provides internal oversight. The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. In addition, a sub-committee of the BIO Advisory Committee will provide external advice to the NEON Program Officer about specific programmatic elements.

The NEON Program Officer ensures NEON coordination with other NSF observatories and networks by serving on the NSF Networks and Observing Systems for the Environment (NOSE) working group and

on the PATs for other large facility projects, such as the Network for Earthquake Engineering Simulation (NEES) and 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 subcommittee of the Interagency Working Group for Global Earth Observation System, an activity of the National Science and Technology Council, Committee on Environment and Natural Resources.

Current Project Status:

Planning activities over the past year: The American Institute of Biological Sciences (AIBS) organized six community workshops between August and September 2004 to identify NEON-specific science questions and requirements based on the environmental grand challenges identified in the NRC NEON report "NEON: Addressing the Nation's Environmental Challenges", the NSB Environment report and the NRC report "Grand Challenges in Environmental Sciences"[3].

Award for NEON Design Consortium and Project Office: In FY 2004 and FY 2005, Congress instructed NSF to continue planning and development activities for NEON through the Research and Related Activities (R&RA) Account. On September 15, 2004, BIO made a 2-year, $6.0 million award to the AIBS to establish a NEON Design Consortium and Project Office, funding the award through R&RA. The NEON Design Consortium is refining the science and education requirements, developing the reference design, designing the baseline for the networking and cyberinfrastructure, drafting the Project Execution Plan and defining the governance and management structures for NEON.

Fostering Technology and Cyberinfrastructure Development: Two workshops were conducted in coordination with the Ocean Observatories Initiative, and the Long Term Ecological Research program to define the cross cutting needs, challenges, and opportunities in sensors and cyber infrastructure. The workshops addressed emerging issues of interoperability among evolving observing systems, leveraging emerging technologies and research frontiers, fostering collaboration, and stimulating robust technology development.

Major milestones for NEON are listed below.

FY 2004 Milestones:

- Held a prospective PI meeting for the NEON Design Consortium and Project Office competition
- Awarded NEON Design Consortium and Project Office (Completed)
- Held six workshops to formulate science questions from the NRC Grand Challenges
- Held two workshops to identify and evaluate options for NEON governance and management

FY 2005 Milestones:

- Establish NEON Design Consortium and Project Office (completed)
- Appoint NEON Advisory Board and Design Consortium subcommittees (completed)
- Refine the NEON requirements, facilities and infrastructure reference design, and develop the governance and management structures for NEON. (Ongoing)
- Research and development on environmental sensors, networks, and cyber tools that will advance the development of NEON as a network of nationally deployed infrastructure (Ongoing)

[3] These reports can be found on the National Academies Press website:
NEON: Addressing the Nation's Environmental Challenges (http://www.nap.edu/books/0309090784/html/)
Grand Challenges in Environmental Challenges (http://www.nap.edu/books/0309072549/html/)

FY 2006 Milestones:

Final NEON Science Plan and Requirements
Baseline Networking and Informatics Plan and Review
Preliminary Project Execution Plan for NEON research infrastructure
Evaluation of the NEON Design Consortium and Project Office
Research and development on environmental sensors, networks, and cyber tools that will advance the development of NEON as a network of nationally deployed infrastructure

FY 2007 Milestones:

Final Project Execution Plan for NEON
Baseline NEON Infrastructure and Review
Initiate construction of NEON networking, informatics, and education, training and outreach infrastructure
Initiate construction of NEON research infrastructure
Research and development on environmental sensors, networks, and cyber tools for NEON

FY 2008 – FY 2011 Milestones:

Continued construction of NEON research, networking, informatics, and education, training and outreach infrastructure
Research and development on environmental sensors, networks, and cyber tools for NEON

Funding Profile: In FY 2005, NSF requested $12.0 million in the MREFC Account and $4.0 million in R&RA to baseline and develop the final design for NEON infrastructure and initiate construction of NEON networking and informatics infrastructure. While the FY 2005 omnibus appropriation did not provide MREFC funding, Congress instructed NSF to continue NEON planning through the R&RA Account. In FY 2005 the NEON Design Consortium and Project Office was established to refine the NEON requirements, develop the facilities and infrastructure reference design, the preliminary baseline definition for networking and informatics, the infrastructure requirements for education, training, and outreach and design the governance and management structures for NEON.

In FY 2006, the NEON Design Consortium and Project Office will complete the final NEON Science Plan and Requirements, baseline the Networking and Informatics Plan, and review, and complete the preliminary Project Execution Plan for NEON.

Requested MREFC Funds for NEON
(Dollars in Millions)

FY 2006 Request	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	Total
$0.00	$12.00	$12.00	$20.00	$30.00	$26.00	$100.00

NEON Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation[1]		Operations & Maintenance		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 1998	0.01						$0.01	$0.00	**0.01**
FY 1999	0.03								
FY 2000	0.17								
FY 2001	0.10						$0.10	$0.00	**0.10**
FY 2002	1.00						$1.00	$0.00	**1.00**
FY 2003	0.92						$0.92	$0.00	**0.92**
FY 2004	3.60						$3.60	$0.00	**3.60**
FY 2005 Current Plan	5.95						$5.95	$0.00	**5.95**
FY 2006 Request	6.00						$6.00	$0.00	**6.00**
FY 2007 Estimate	6.00			12.00			$6.00	$12.00	**18.00**
FY 2008 Estimate	4.00			12.00	4.00		$8.00	$12.00	**20.00**
FY 2009 Estimate	4.00			20.00	8.00		$12.00	$20.00	**32.00**
FY 2010 Estimate	3.00			30.00	16.00		$19.00	$30.00	**49.00**
FY 2011 Estimate	2.00			26.00	20.00		$22.00	$26.00	**48.00**
Subtotal, R&RA	$36.78		$0.00		$48.00		$84.58		
Subtotal, MREFC		$0.00		$100.00		$0.00		$100.00	
Total, Each Stage		**$36.78**		**$100.00**		**$48.00**			**$184.58**

NOTE: The expected operational lifespan of this project is 30 years after construction is complete in FY 2011. A steady state of $20.0 million in operations support is anticipated by FY 2011. Annual operations and maintenance estimates for FY 2008 and beyond are developed strictly for planning purposes and are calculated as 20% of the estimated MREFC costs summed to that year. They will be updated as new information becomes available.

[1]FY 2007-11 implementation funding level will be contingent upon the Project Execution Plans for research infrastructure, networking and informatics, and education, outreach, and training.

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

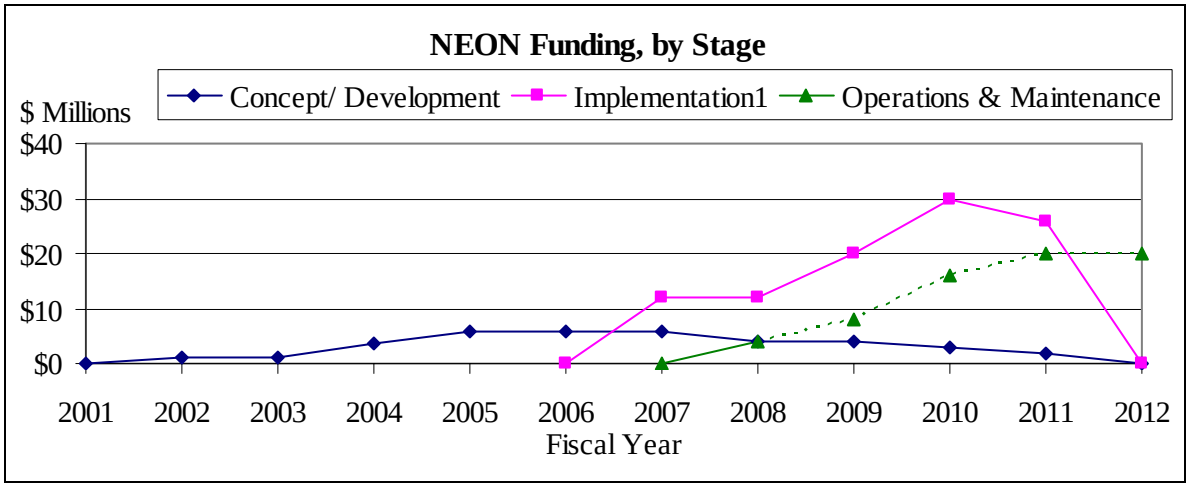
- Concept/Development: In FY 2001-2003 workshops were funded to address the information technology needs, instrument array design and development, and data, information management architectures and synthesis of a region-based implementation of NEON. In FY 2003, the National Research Council's study endorsed the concept for a continent-wide implementation of NEON along with a central governance management structure. In FY 2004 a solicitation was released and an award made for the NEON Design Consortium and Project Office to provide the central management for NEON planning and to develop the preliminary project execution plan for a continental implementation strategy based on nationally significant ecological research challenges. In FY 2005, support continues for the NEON Design Consortium and Project Office to continue the preliminary project execution plan development and

NEON will apply emerging technologies (sensor, analytical, communication and information) to investigate the structure and dynamics of U.S. ecosystems and to forecast biological change. *Credit: The Bigfoot Project (www.fsl.orst.edu/larse/bigfoot)*

funding for NEON research and development on enabling technologies. In FY 2006, support will be provided to complete the final NEON Science Plan and Requirements, baseline the Networking and Informatics Plan and review, and complete the preliminary Project Execution Plan. 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. In FY 2007, MREFC funds will be used to baseline and develop the final design for NEON infrastructure. Initial construction of NEON networking and informatics infrastructure will begin in FY 2007.

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



Future Science Support: 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.

It is estimated that 1,400 field biologists will use NEON annually. A larger number of scientists, students, resource managers and decision makers will make use of NEON data, both directly and indirectly, through the network capabilities and data distribution and sharing technologies via the network and the internet.

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

Final MREFC funding for NEES was appropriated in FY 2004. For information on this project, please see the Facilities chapter of this document.

Rare Symmetry Violating Processes

Project Description: A collaboration representing almost 30 institutions from the U.S., Canada, Switzerland, Italy, Japan, and Russia submitted a proposal through New York University for RSVP in FY 2000. This project will address new physics at the cutting edge of the sensitivity frontier and represents an investment that is complementary to that at the energy frontier (e.g., the Large Hadron Collider).

RSVP is an NSF-funded, university-led project that uses the national laboratory infrastructure developed by the U.S. Department of Energy (DOE) to advance the frontiers of particle physics. As such, RSVP represents a new paradigm for university/national laboratory collaboration and for NSF/DOE interagency collaboration in this field. Significant effort is being invested early in RSVP planning to define the appropriate management interfaces in order to reflect the roles and responsibilities of all the parties – government agencies, project management, universities, national laboratories, scientists, students, and technicians.

The RSVP experiments address two great mysteries, the predominance of matter over antimatter in the Universe today and the difference between the electron and the muon, the former by studying matter-antimatter symmetry (CP)-violating decays of K-mesons and the latter by searching for muon-to-electron conversion. By extending current sensitivities for these rare processes by orders-of-magnitude, RSVP could shed light on the existence of atomic matter in the Universe, the nature of dark matter, and even provide evidence for superstrings.

At the sensitivity frontier, reactions occur very rarely. Therefore, the RSVP experiments will be performed at the DOE's Brookhaven National Laboratory (BNL) Alternating Gradient Synchrotron (AGS), which has the highest beam intensity in the world at the energies required. The AGS is currently being used as an injector for the Relativistic Heavy Ion Collider (RHIC), for which it is needed only a few hours per day.

Principal Scientific Goals: RSVP consists of two complementary experiments:

- A search for the conversion of muons to electrons that would be able to detect this process even if it is as rare as 1 event for 10^{17} detected muons.
- A study of the decay of a kaon to a pion, a neutrino, and an anti-neutrino.

Recently, a High Energy Physics Advisory Panel (HEPAP) subpanel produced the report "Quantum Universe, The Revolution in 21st-Century Particle Physics." Quantum Universe identified nine interrelated questions that define the field. RSVP addresses three of these questions. The report also re-affirmed RSVP experiments as integral to the national program for addressing the fundamental questions that define elementary particle physics.

Principal Education Goals: RSVP will be used as a vehicle to enhance education at the K-16 levels, to stimulate public interest in science, and to involve members of underrepresented groups. Planning for education and outreach activities is part of the scope of the RSVP FY 2004 pre-construction awards. BNL and SUNY-Stony Brook are contributing to this planning. In addition to new education and outreach activities, RSVP will also participate in other successful educational efforts such as QuarkNet and Cyberinfrastructure Grid Projects such as iVDGL.

Partnerships and Connections to Industry: RSVP will have strong connections to industry through instrument development and construction and through magnet construction.

Management and Oversight: RSVP will be a university-led, NSF-supported activity, running at a DOE laboratory, with NSF providing only incremental AGS operating costs. AGS "landlord responsibilities" rest with the DOE Nuclear Physics program, as defined in a Memorandum of Understanding.

Management and oversight of RSVP will be provided through the Physics (PHY) Division in the Mathematical and Physical Sciences (MPS) Directorate. A designated Program Officer in PHY has been assigned to maintain primary oversight responsibility, with assistance from the Physics Project Advisory Team (PHY/PAT) with representation from MPS, the Office of Budget, Finance and Award Management, the Office of General Counsel, the Office of International Science and Engineering and the Office of Legislative and Public Affairs. The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance.

A Project Execution Plan (PEP) is being developed. The successful experience of the U.S. LHC detector project, now nearing completion, provides a model for the management of large projects involving leadership by university researchers and partnership with DOE laboratories.

Current Project Status: Planning for RSVP has been conducted with NSF support beginning in FY 2001. Significant concept and design work was carried out with DOE support prior to this. The activities to date include R&D for the technology needed for the project, simulations of the data expected, and design of major components. This work was largely carried out by the scientific collaborations that developed the major RSVP experiments through project managers hired by specific sub-projects.

In FY 2004, a Project Director was appointed to provide overall management of the RSVP project. The Project Director set up an RSVP Project Office at Columbia University and recruited a Deputy Project Director. Both have extensive experience in project management. The Project Office organized a series of focused reviews by external experts to examine the subsystems of RSVP that they identified as representing the most significant cost and schedule drivers. This series of reviews will be completed by the spring of 2005, with its final product being a detailed technical, cost, and schedule baseline design for RSVP. The baseline design will provide the basis for NSB approval to initiate the construction project. Milestones for the construction and operation of RSVP will be specified in detail in the baseline design.

The preliminary milestones listed below will be revised as the project's baseline is established.

FY 2005 Milestones:
- Complete cost, schedule, and technical baseline reviews of all subsystems.
- Complete magnet engineering design.
- Establish final baseline for cost, schedule, and scope.
- Submit baseline for NSF/NSB review and approval to initiate construction.

FY 2006 Milestones:
- Finalize and document designs.
- Complete detailed project execution plan.
- Initiate procurement process.
- Initiate construction of subsystems.
- Conduct NSF oversight review.

FY 2007 Milestones:
- Complete construction of AGS beams for RSVP.
- Begin detector installation.
- Complete technical design work.
- Conduct NSF oversight review.

FY 2008 Milestones:
- Complete detector construction and installation.
- Complete delivery and installation of magnet coils.
- Conduct magnet acceptance tests.
- Complete testing of detector components.
- Conduct NSF oversight review.

FY 2009 Milestones:
- Complete construction and installation.
- Perform engineering runs.
- Conduct NSF oversight review.

FY 2010 Milestones:
- Initiate first data runs.
- Conduct NSF oversight review.

Funding Profile: Through FY 2004, $10.0 million has been provided for concept and design development of RSVP through the R&RA Account. The total construction cost of the project is estimated at $158.41 million over six years, an increase over the original estimate of $13.50 million that results from stretching the proposed construction schedule from five to six years and taking into account the reduced initial year funding in the FY 2005 appropriated level. The current funding plan is presented below.

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

FY 2005	FY 2006 Request	FY 2007	FY 2008	FY 2009	FY 2010	Total
$14.88	$41.78	$48.00	$30.75	$15.00	$8.00	$158.41

RSVP Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2001	0.90						$0.90	$0.00	**0.90**
FY 2002	1.20						$1.20	$0.00	**1.20**
FY 2003	1.90						$1.90	$0.00	**1.90**
FY 2004	6.00						$6.00	$0.00	**6.00**
FY 2005 Current Plan	2.30			14.88			$2.30	$14.88	**17.18**
FY 2006 Request				41.78			$0.00	$41.78	**41.78**
FY 2007 Estimate				48.00			$0.00	$48.00	**48.00**
FY 2008 Estimate				30.75	5.30		$5.30	$30.75	**36.05**
FY 2009 Estimate				15.00	8.50		$8.50	$15.00	**23.50**
FY 2010 Estimate				8.00	8.50		$8.50	$8.00	**16.50**
FY 2011 Estimate					13.50		$13.50	$0.00	**13.50**
FY 2012 Estimate					14.30		$14.30	$0.00	**14.30**
FY 2013 Estimate					14.80		$14.80	$0.00	**14.80**
FY 2014 Estimate					15.20		$15.20	$0.00	**15.20**
Subtotal, R&RA	$12.30		$0.00		$80.10		$92.40		
Subtotal, MREFC		$0.00		$158.41		$0.00		$158.41	
Total, Each Stage		**$12.30**		**$158.41**		**$80.10**			**$250.81**

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.

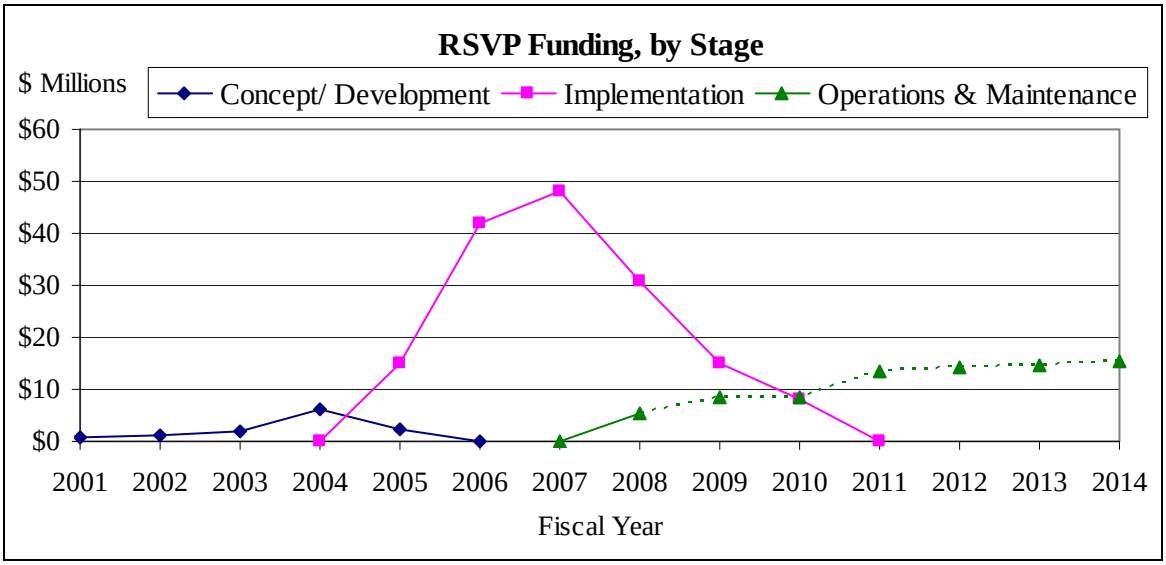
Information on the data in the table is provided below.

- Concept/Development: The major tasks for FY 2005 include finalizing the cost, schedule, and scope baseline that will be used to manage the construction project and completion of a technical design and documented cost estimate for the major solenoid magnet system required for the muon-to-electron conversion detector. This work is now under the direction of the Project Director and Deputy Project Director appointed in FY 2004. All R&D and planning work is under periodic review by technical panels convened by the Project Director. NSF will convene an independent panel of experts to review the baseline plan prior to seeking NSB approval for initiation of construction.

- Implementation: Funding during this phase of the project will provide support for the construction of two beamlines at the AGS and associated beam instrumentation at the site. For the K-meson decay detector, universities will construct the critical beam, catcher, radiator and veto counter assemblies. The muon-to-electron conversion experiment involves novel, state-of-the-art superconducting magnets that will be constructed by industry after a full technical design is complete. Other components of the latter experiment, e.g., collimators, targets, beam stops, and calorimeters, will be constructed at universities.

- Operations and Maintenance: Support for operations and maintenance will phase in as the project is under construction. Initial funds provided through R&RA in FY 2004 supported project managers for the three RSVP sub projects and a project management office. Test beam operations are expected to begin in FY 2008 and will ramp up as detector elements are completed. Operations costs will rise to

an estimated level of $15 million in FY 2013. A baseline estimate and NSF review of these costs will be conducted in FY 2006.



Future Science Support: Along with direct support for operations and maintenance, NSF will also support physics research performed at this facility, through ongoing physics research and education grants. The baseline to be completed in FY 2005 will quantify these costs, which are subject to review and concurrence by the NSF.

Other Project Support: Canadian RSVP funding consists of three parts from the National Sciences and Engineering Council of Canada (NSERC), the Canada Foundation for Innovation (CFI), and the TRIUMF Laboratory, Canada's national laboratory for particle and nuclear physics, operated as a joint venture by a consortium of Canadian universities. To date, approximately $7.0 million in project support has been secured by Canadian research groups from these institutions.

Scientific Ocean Drilling Vessel

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. It 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 United States facility contribution to the Integrated Ocean Drilling Program, 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.

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 for Large Facility Projects is a member of the PAT and provides advice and assistance. A conversion oversight committee has been established to provide technical, financial and scheduling recommendations and advice for the SODV project.

Pictured above is the *JOIDES Resolution*, the current drillship of the Ocean Drilling Program. MREFC funds are requested in FY 2007 to modify this or a similar ship to provide the Integrated Ocean Drilling Program with light drillship capability. *Credit: Joint Oceanographic Institutions (JOI).*

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 has issued an RFP to acquire, upgrade and operate a commercial vessel for scientific ocean drilling and Contract Award is anticipated by mid-2005. The SODV Project received $14.88 million in FY 2005. Engineering design, science lab development and long lead item equipment procurement activities will be the primary FY 2005 SODV activities. The project schedule is outlined below:

FY 2004 Milestones:
- Solicited Drilling Contractor capabilities, recommendations, interest (Completed)
- Developed initial MREFC Project Execution Plan (Completed)
- Prepared RFP for Drilling Contractor (Completed)

FY 2005 Milestones:
- Release RFP for SODV Drilling Contractor and Evaluate Responses
- Determine Competitive Range of Offerors – Initiate SODV MREFC project
- Vessel Decision and Drilling Contractor Award
- Initiate Engineering Design Phase
- Initiate Long Lead Item Equipment Procurement

FY 2006 Milestones:
- Complete Engineering Design Phase
- Issue Drilling Contractor Solicitation for Conversion Shipyard
- Shipyard Contract Award
- Initiate Shipyard Conversion of Drillship

FY 2007 Milestones:
- Outfit Scientific Laboratories
- Vessel Acceptance Trials
- Vessel Commissioning and Acceptance –Terminate SODV MREFC project

Vessel Scientific Operations Begin

Funding Profile: Planning through FY 2004 cost approximately $3.60 million. In FY 2005, approximately $5.40 million will be provided to initiate contract activity, planning and design. In FY 2005 - FY 2007, approximately $110.0 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
$14.88	$57.92	$42.20	$115.00

SODV Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2000	0.10						$0.10	$0.00	**0.10**
FY 2001	0.20						$0.20	$0.00	**0.20**
FY 2002	0.30						$0.30	$0.00	**0.30**
FY 2003	1.50				1.80		$3.30	$0.00	**3.30**
FY 2004	2.10				33.65		$35.75	$0.00	**35.75**
FY 2005 Current Plan	0.50	4.88		10.00	27.22		$27.72	$14.88	**42.60**
FY 2006 Request				57.92	30.00		$30.00	$57.92	**87.92**
FY 2007 Estimate				42.20	40.00		$40.00	$42.20	**82.20**
FY 2008 Estimate					54.70		$54.70	$0.00	**54.70**
FY 2009 Estimate					58.60		$58.60	$0.00	**58.60**
FY 2010 Estimate					60.70		$60.70	$0.00	**60.70**
Subtotal, R&RA	$4.70		$0.00		$306.67		$311.37		
Subtotal, MREFC		$4.88		$110.12		$0.00		$115.00	
Total, Each Stage		**$9.58**		**$110.12**		**$306.67**			**$426.37**

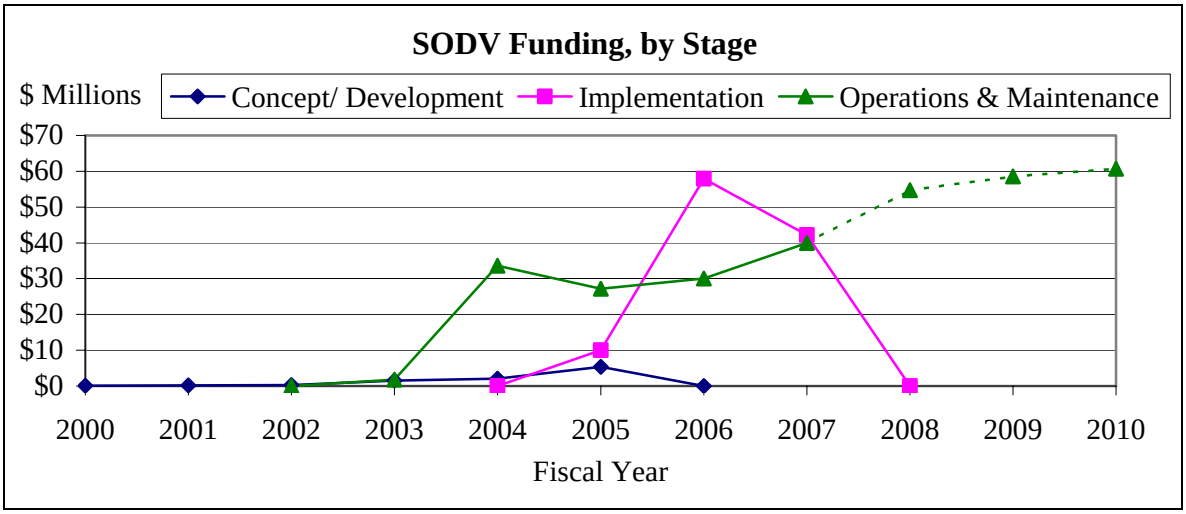
R&RA operations funds in 2005 and 2006 will support drilling operations from the *JOIDES Resolution*. A steady state of about $55 million in operations support is expected to occur beginning in FY 2008 as the SODV vessel begins full operations, but these estimates are developed based on current cost 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 began immediately upon awarding the contract in September 2003. This 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; initiation of planning for shipboard and shore-based support of the program, including laboratory configuration, core storage, data management systems, and logistics.

- Implementation: The MREFC funds in FY 2005-07 are required for the vessel conversion, including construction of laboratory and other scientific spaces, equipping of laboratories with instrumentation, computers and support equipment, 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. 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 is 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 $31 million.

South Pole Station

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 currently 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 accord 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).

Progress continues on the new U.S. research station at the South Pole. This season marked completion of all steel and panel enclosure work for all wings. On January 30, 2005, the project accepted for conditional occupancy the wings for housing, science space, and emergency power. *Credit: USAP*

Management and Oversight: The Office of Polar Programs (OPP) has the overall management 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 Project Advisory Team with members from OPP and the Office of Budget, Finance and Award Management. The NSF Deputy Director for Large Facility Projects is a member of the PAT and provides advice and assistance.

Current Project Status: The original estimate for SPSM was $127.90 million. NSB approved a change in project scope, increasing station capacity from 110 people to 150 people, as well as a project schedule extension, increasing the cost estimate to $133.44 million (+$2.52 million for increased scope; +$3.02 million due to weather-induced schedule delays). Weather delays in previous years adversely impacted planned material deliveries resulting in revised schedules. The estimated projection has been for conditional acceptance (i.e., occupation and operations) of the entire station by the end of FY 2007, with demolition/retrograde of the old station and work on punchlist items occurring in FY 2008. The current status of the project, both schedule and budget, is currently under review. The milestones shown below will be updated based on the new projections.

Activity	Procurement	Transport to Antarctica	Airlift to South Pole	Start Construction	Conditional Acceptance
Vertical Circular Tower	FY98	FY99	FY99/00 (00)	FY00 (01)	FY02
Quarters/Galley	FY98	FY99	FY00/FY01	FY01 (02)	FY03
Sewer Outfall	FY98	FY99	FY00	FY01	FY02 (01)
Fuel Storage (100K gallons)	FY98	FY98	FY99	FY99	FY99
Medical/Science	FY99 (98)	FY00 (99)	FY01/02 (00)	FY02	FY04
Communications/Administration	FY99 (98/99)	FY01 (00)	FY02/03 (01)	FY03 (02)	FY05 (03)
Dark Sector Lab	FY98	FY99	FY99/00 (00)	FY00 (01)	FY04 (01)
Water Well	FY00 (98)	FY01 (99)	FY01/02 (00)	FY02 (01)	FY02
Remote RF Building	FY99 (98/99)	FY00	FY01	FY01 (02)	FY01 (03)
Emergency Power/Quarters	FY99	FY01	FY02/03 (01/02)	FY03	FY05
Liquid nitrogen and helium facility	FY02 (99)	FY03 (00)	FY04 (01)	FY04 (02)	FY04 (03)
Quarters/Multipurpose	FY99 (00)	FY02 (01)	FY04 (02/03)	FY05	FY06
Electronic Systems and Communications	FY00/03 (99/00)	FY01/04 (00/01)	FY01/05 (01/02)	FY01 (03)	FY06 (04)
Warehousing, SEH and Waste Management	FY99 (01)	FY02/03 (02)	FY04 (03)	FY06 (04)	FY07 (05)
Station Equipment	FY02/03 (01)	FY03/04 (03)	FY04/05 (04)		FY05

Funding Profile: SPSM has received appropriations totaling $133.78 million through FY 2004, exceeding the most recent NSB-approved cost estimate of $133.44 million. Using the last updated schedule, the estimated total cost of SPSM is $136.96 million. An updated project cost and schedule review will be completed shortly after the end of the 2004/2005 operating season. No funds are being requested in for FY 2006.

Appropriated and Requested MREFC Funds for SPSM

(Dollars in Millions)

FY 2003 and Prior Years	FY 2004	FY 2005 Current Plan	FY 2006 Request	Estimated Future Requests	Total
$132.49	$1.29	$0.00	$0.00	$3.18	$136.96

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 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 expenditures to date total $116.13 million, through the first quarter of FY 2005.

South Pole Station Modernization Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 1997 & Earlier	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				21.03				$21.03	**21.03**
FY 2005 Current Plan				16.98				$16.98	**16.98**
FY 2006 Request				10.00				$10.00	**10.00**
FY 2007 Estimate				2.91	15.00		$15.00	$2.91	**17.91**
FY 2008 Estimate					15.38		$15.38		**15.38**
FY 2009 Estimate					15.76		$15.76		**15.76**
Subtotal, R&RA	$16.40				$46.14		$62.54		
Subtotal, MREFC				$133.44				$133.44	
Total, Each Stage		**$16.40**		**$133.44**		**$46.14**			**$195.98**

NOTE: A steady state of operational support is anticipated at $15 million by FY 2007, slightly higher than the current operational costs. The expected lifespan of the modernized station is 25 years, through FY 2031. 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.

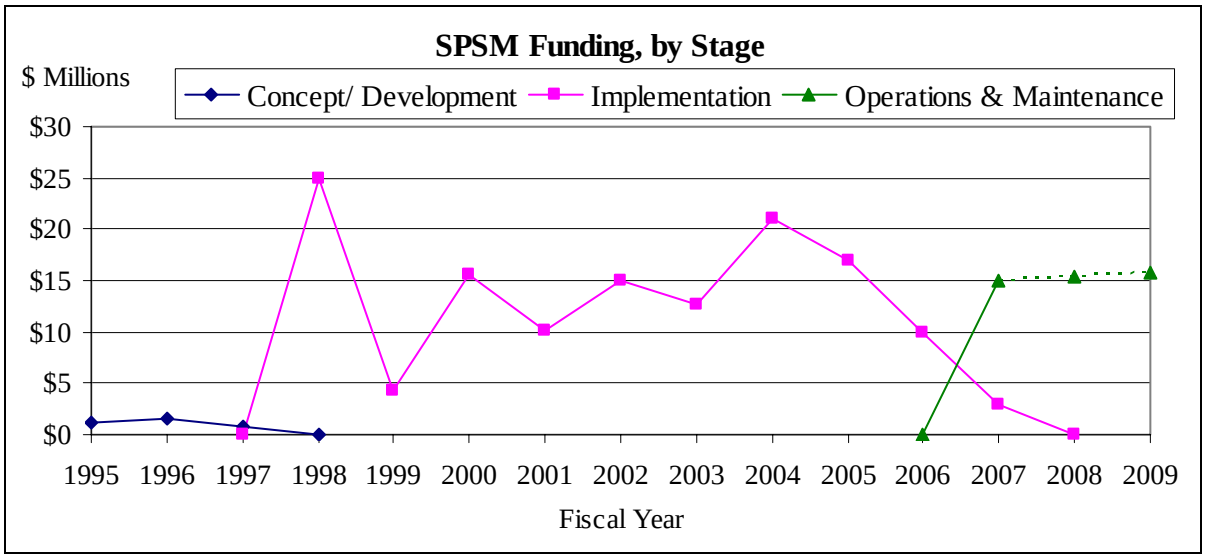
Information on the data in the table is provided below.

- 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.

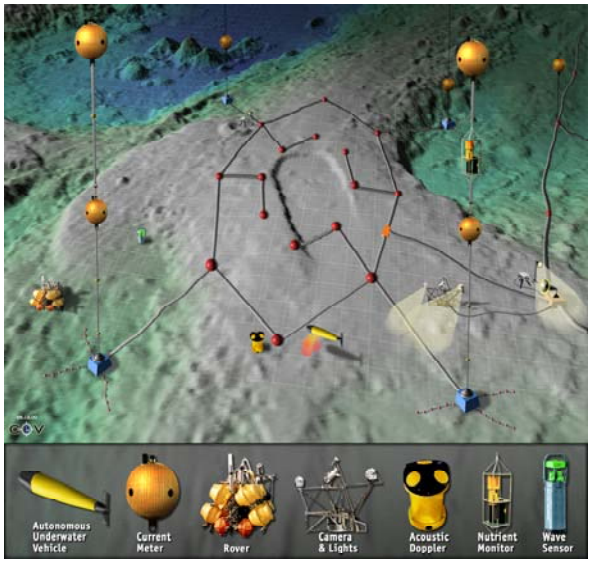
Terascale Computing Systems

Final MREFC funding for Terascale Computing Systems was appropriated in FY 2004. For information on this project, please see the Facilities chapter of this document.

SECOND PRIORITY: NEW STARTS IN FY 2007 AND FY 2008

Ocean Observatories Initiative

Project Description: This project will construct an integrated observatory network that will provide the oceanographic research and education communities with continuous and 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.



Example of a seafloor cabled observatory experimental site, part of the Ocean Observatories MREFC project. Moorings from seafloor nodes extend observational capabilities from the seafloor and below to within the water column. Associated instrumentation including underwater vehicles are also shown. *Credit: Division of Ocean Sciences, NSF.*

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. This project will establish facilities to 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, 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 will be managed and overseen by a program manager in OCE in the Directorate for Geosciences (GEO). The program manager will receive advice and oversight support from an NSF Project Advisory Team (PAT) that includes representatives from GEO, the Biological Science , 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 for Large Facility Projects is a member of the PAT and provides advice and assistance. The management structure proposed for the acquisition and implementation 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 Executive Director of the Ocean Observatory Project Office established through a cooperative agreement with NSF. This Director will be

accountable to an Executive Steering Committee under which will be established Scientific and Technical Advisory Committees. The Executive Steering and Advisory Committees will draw their membership from individuals with expertise in ocean observing science and engineering. The design of the OOI network and experiments utilizing OOI infrastructure will be selected on a peer-reviewed basis. This project will be coordinated with the National Integrated Ocean Observing System (IOOS) that will support operational mission objectives of agencies such as the National Oceanic and Atmospheric Administration (NOAA), Navy, the National Aeronautics and Space Administration (NASA), and the Coast Guard.

Current Project Status: Numerous community workshops have been held and reports written since 2000 to 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 reports for each of the three components of the OOI. 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. In March 2004 a cooperative agreement was awarded to establish the Ocean Observatory Project office. The primary tasks of this office are: to identify and facilitate committees for continued refinement of the OOI network design; 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 Executive Steering Committee that provides a direct link between Project Office planning and the research community.

Using R&RA funds, the Ocean Technology Program has continued to provide support for proposals whose goals are to ensure that the infrastructure needed to enable OOI experimentation is available for the implementation phase of the OOI. As part of this process, an announcement is being released by NSF to advance interactive observing technologies and understanding of the coastal benthic boundary layer. To accomplish this goal, one or more pilot/testbed study sites will be established to develop and enhance new and technologies are needed to investigate coastal processes at appropriate temporal and spatial scales. Furthermore, to continue community planning for OOI implementation, detailed conceptual proposals for ocean science research experiments are being solicited through the Ocean Observatories Project Office. These proposals will be used to further refine designs for OOI and to identify specific experimental instrumentation needs of the user community. A primary goal of this request is to determine the nature and cost of ocean observatory science and enabling infrastructure to be constructed though 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 2005 Milestones:
- Project Management
  - Completion of OOI Science Plan
  - Release call for Community Experiments
  - Completion of OOI Internal Management Plan

FY 2006 Milestones:
- Project Management
  - Systems engineering review of OOI
  - Complete design of data management and archiving system
  - Completion of OOI Project Execution Plan
- Coastal Observatories
  - Issue Program Solicitation for establishment of coastal observing infrastructure

FY 2007 Milestones:
- Project Management
  - Submission of Project Execution Plan to Large Facilities Office
  - Implementation of data management and archiving system
- Deep-Sea Buoys
  - Design and testing of moored buoyed systems
- Regional Cabled Network
  - Cable-route surveys and planning
  - Issue Program Solicitation for establishment of regional cabled network

FY 2008 Milestones:
- Coastal Observatories
  - Issue Program Solicitation for establishment of coastal observing infrastructure
  - Construction and deployment of coastal observing infrastructure
- Deep-Sea Buoys
  - Design and testing of capabilities needed for buoy installation
- Regional Cabled Network
  - Design, inspection and testing of cables, connectors, nodes, and shore equipment
  - Purchase of fiber optic cable
  - Physical (hardware and software) system integration and testing prior to deployment
  - Preparation of shore facilities and installation of equipment

FY 2009 Milestones:
- Coastal Observatories
  - Issue Program Solicitation for establishment of coastal observing infrastructure
  - Construction and deployment of coastal observing infrastructure
- Deep-Sea Buoys
  - Design and testing of capabilities needed for buoy installation
  - Issue Program Solicitation for establishment of moored buoy infrastructure
- Regional Cabled Network
  - Installation and subsequent inspection of cable backbone section
  - Installation of science nodes on backbone section

FY 2010 Milestones:
- Coastal Observatories
  - Construction and deployment of coastal observing infrastructure
- Deep-Sea Buoys
  - Design and testing of capabilities needed for buoy installation
  - Installation of deep-sea buoys
  - Issue Program Solicitation for establishment of moored buoy infrastructure
- Regional Cabled Network
  - Testing and commissioning of backbone section

FY 2011 Milestones:
- Deep-Sea Buoys
  - Installation of deep-sea buoys
- Regional Cabled Network
  - Final system testing and commissioning

Funding Profile: NSF expects to spend approximately $30 million in concept and development activities through FY 2005. The total construction cost for OOI is $269.10 million beginning in FY 2007. 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	$42.00	$65.50	$66.90	$46.20	$35.00	$269.10

OOI Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2003 & Earlier	15.50						$15.50	$0.00	**15.50**
FY 2004	3.00						$3.00	$0.00	**3.00**
FY 2005 Current Plan	4.00						$4.00	$0.00	**4.00**
FY 2006 Request	4.00						$4.00	$0.00	**4.00**
FY 2007 Estimate	4.00			13.50	3.00		$7.00	$13.50	**20.50**
FY 2008 Estimate				42.00	7.00		$7.00	$42.00	**49.00**
FY 2009 Estimate				65.50	12.00		$12.00	$65.50	**77.50**
FY 2010 Estimate				66.90	20.00		$20.00	$66.90	**86.90**
FY 2011 Estimate				46.20	30.00		$30.00	$46.20	**76.20**
FY 2012 Estimate				35.00	50.00		$50.00	$35.00	**85.00**
FY 2013 Estimate					50.00		$50.00	$0.00	**50.00**
Subtotal, R&RA	$30.50		$0.00		$172.00		$202.50		
Subtotal, MREFC		$0.00		$269.10		$0.00		$269.10	
Total, Each Stage		**$30.50**		**$269.10**		**$172.00**			**$471.60**

NOTE: A steady state of about $50.0 million in operations support is expected to occur in or about FY 2012. 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.

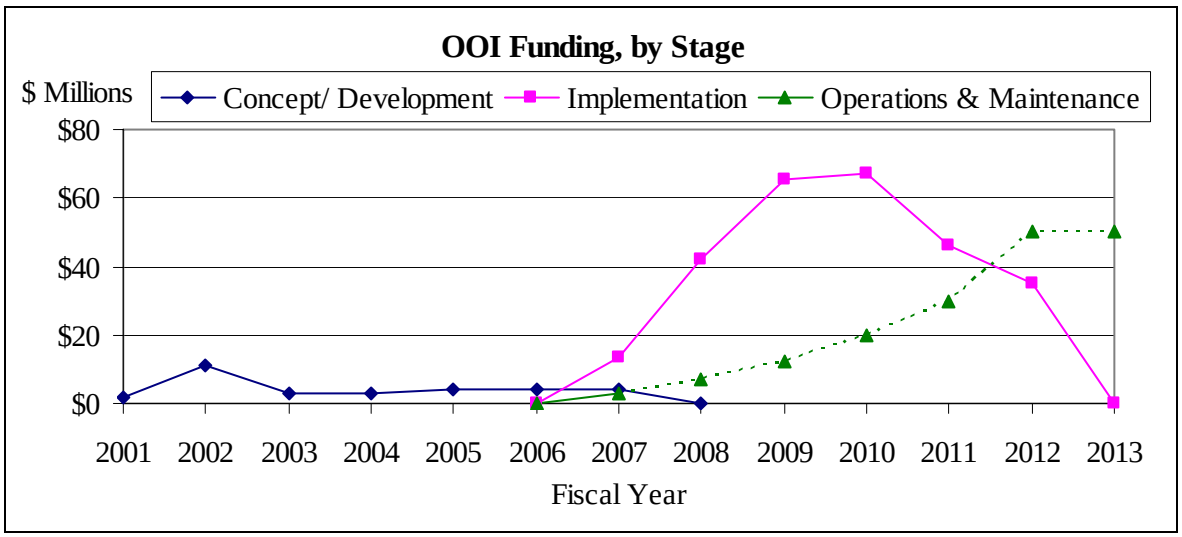
Information pertaining to the data in the table is provided below.

- Concept/Development: R&RA funding has supported workshops to identify the observatory infrastructure needed to address the high priority science requiring time-series measurements. Specific design characteristics and platform requirements were developed through conceptual design reviews and best practices consultations with industry and academic experts. In FY 2002 a proposal from the Monterey Bay Aquarium Research Institute resulted in a $6.90 million award to establish an advanced cabled observatory in Monterey Bay to both advance scientific goals as well as create a valuable 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.

- Implementation: Funds requested for this phase will construct a regional cabled network consisting of interconnected sites on the seafloor spanning several geological and oceanographic features and

processes; several relocatable deep-sea buoys; 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 OOI Program 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.

Alaska Region Research Vessel

Project Description: The Alaska Region Research Vessel (ARRV) is proposed to replace the R/V *Alpha Helix*, which, at 39 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*, which cannot operate in ice, or in severe winter weather in the open seas. The ARRV will operate 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.

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 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.

Principal Scientific Goals: Satellite observations have shown the perennial ice in the arctic thinning at 9 percent per decade, which will 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 an oceanographic platform in the Alaska region to conduct field research.

Principal Education Goals: The ARRV will provide a sophisticated and larger platform for scientists, graduate and undergraduate students to participate in complex multidisciplinary research activities and will train the next generation scientists with the latest equipment and technology. Broadband 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.

An artist's rendition of the Alaska Region Research Vessel (ARRV), planned to replace the aging R/V *Alpha Helix*. The ice-strengthened ARRV would operate in the challenging seasonal ice covered Alaskan waters, expanding current capabilities in the region. *Credit: Glosten Associates, Inc*

Management and Oversight: The NSF Coordinator will be the Program Director for Ship Acquisition and Upgrade Program, Integrative Programs Section (IPS) in the Division of Ocean Sciences, with other staff in IPS providing program management assistance. The Section Head (IPS) and another Section member hold the Master's Certificate in Project Management through NSF-sponsored training. Internal oversight for the construction cooperative agreement will be provided by a Project Advisory Team (PAT) including staff from GEO, the Office of Budget, Finance and Award Management, and the Office of the General Counsel (OGC). The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. The Awardee will hire a Systems Integration Manager to establish and staff an Office to provide management oversight to 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 vessel construction.

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 unique fisheries research. Results from the design studies have been shared with the community on several occasions, 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 at the Seattle offices of the Naval Architects (Glosten Associates) 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 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, as they originally stated in their 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)[4].

Milestones for ARRV are outlined below:

FY 2006 Milestones:

Prepare and issue a solicitation to build and operate the ARRV via a cooperative agreement.
Select the winning proposal through an external merit review process.

FY 2007 Milestones:

Establish the Systems Integration Office and issue the shipyard construction bid package.
Adjudicate the construction bids and select the winner.
Initiate vessel construction.
Establish quarterly in depth reviews of construction progress.

FY 2008 Milestones:

Continue construction of vessel.
Continue detailed reviews of progress.
Launch vessel, continue interior habitability and scientific outfitting.

FY2009 Milestones:

Complete construction and scientific outfitting
Undergo sea trials.
Finalize acceptance and delivery of vessel to awardee.
Incorporate vessel into the UNOLS ship scheduling process.
Vessel begins operations on NSF and other agency funded scientific missions.
NSF conducts final review of project.

Funding Profile: Recognizing from the outset that the R/V *Alpha Helix* was of marginal size and capability for Alaskan waters, replacement planning has been ongoing since the 1980s. NSF funded design studies in 1980 and 1995, but neither were implemented. After community-derived science mission requirements were developed 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
$49.32	$32.88	$82.20

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

ARRV Funding Profile

(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2003 & Earlier	1.61						$1.61	$0.00	**1.61**
FY 2004	0.30						$0.30	$0.00	**0.30**
FY 2005 Current Plan	0.30						$0.30	$0.00	**0.30**
FY 2006 Request	0.30						$0.30	$0.00	**0.30**
FY 2007 Estimate				49.32			$0.00	$49.32	**49.32**
FY 2008 Estimate				32.88			$0.00	$32.88	**32.88**
FY 2009 Estimate					6.50		$6.50	$0.00	**6.50**
FY 2010 Estimate					6.70		$6.70	$0.00	**6.70**
Subtotal, R&RA	$2.51		$0.00		$13.20		$15.71		
Subtotal, MREFC		$0.00		$82.20		$0.00		$82.20	
Total, Each Stage		**$2.51**		**$82.20**		**$13.20**			**$97.91**

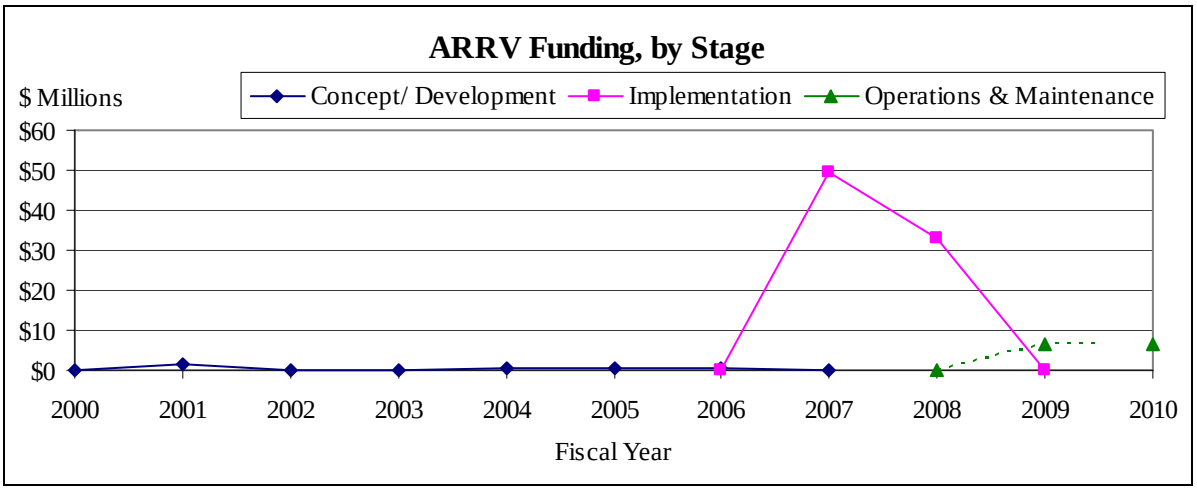
Ship Operations are estimated to be approximately $6 million per year. The expected operational service life of the ARRV is 30 years after construction is complete. Operations estimates for FY 2009 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will 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. Additional OCE funds were used during the concept and development stage to further the design process.

- 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 and to conduct science activities in two 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 process, which will allow NSF-funded scientists access to the vessel to conduct research and train students. The annual ship operation costs are estimated to be about $6 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 infrastructure through ongoing research and education programs. It is anticipated that the ARRV will greatly expand research capabilities in the region, going from about 160 ship operating days with the 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.

Advanced LIGO

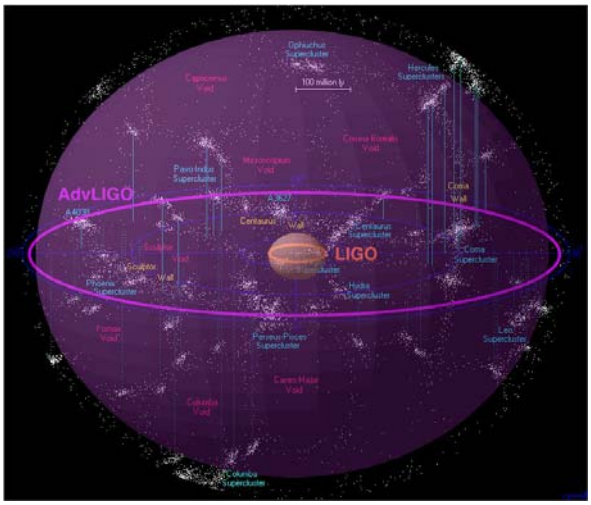
Project Description: Advanced LIGO is the upgrade of the Laser Interferometer Gravitational Wave Observatory (LIGO) that will allow LIGO to approach the ground-based limit of gravitational wave detection. LIGO consists of the world's most sophisticated optical interferometers, operating at two sites (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 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. 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. 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. And, although the universe is believed to be filled with gravitational waves from a host of cataclysmic cosmic phenomena, scientists have never detected a gravitational wave and measured its waveform.



Sky map showing locations of superclusters, walls, and voids of galaxies within about 500 million light years. Superimposed circles show the range of LIGO (orange inner circle) and the 10 times larger range of AdvLIGO (purple outer circle). The milky way is at the center in this representation. *Credit: the underlying black and white image with names of clusters and voids is by Richard Powell; the superimposed color circles were added by Beverly Berger, Division of Physics, NSF.*

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 a Visitor's Center at the Livingston, LA site.

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), comprising staff from the Office of General Counsel, the Office of Legislative and Public Affairs, the Office of Budget, Finance and Award Management, and the Office of International Science and Engineering. The NSF Deputy for Large Facility Projects is a member of the PAT and provides advice and assistance. 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, stepped up interaction with the project personnel, scheduled reviews and site visits at least twice yearly and more frequently if need arises. The NSF LIGO program director will work closely with the LIGO Deputy Director for the AdvLIGO Project who has already been named. 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. The first science run, S-1, accumulated nearly 100 hours of triple coincidence data in the period from August 23, 2002 to September 9, 2002, with a sensitivity of about a factor of 100 from the design goal. Results from S-1 have been reported in five published articles. Work on instrumental refinements between the end of S-1 and the beginning of S-2 in February 2003 produced sensitivities about ten times better than those observed in S-1, i.e., only a factor of about 10 from the design goal. S-2 lasted 59 days (February 14, 2003 – April 14, 2003) with over 300 hours in triple coincidence accumulated. Results from S-2 were presented in 2004 at major scientific conferences. In S-3 (October 31, 2003 – January 8, 2004), the sensitivity achieved with the best of the three interferometers was only about a factor of 3.5 from the design goal, strengthening expectations that the sensitivity for S-4 that should commence sometime early in 2005 will be at or very near the targeted level.

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 upgrade will include 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. $40.74 million of R&RA funds will have been spent from FY 2000 – 2007 on advanced R&D for AdvLIGO within the LIGO Laboratory.

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 Milestones:
Installation begins at Livingston

FY 2011 Milestones:
Installation begins at Hanford

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
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2007 & Earlier	40.74						$40.74		**40.74**
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**

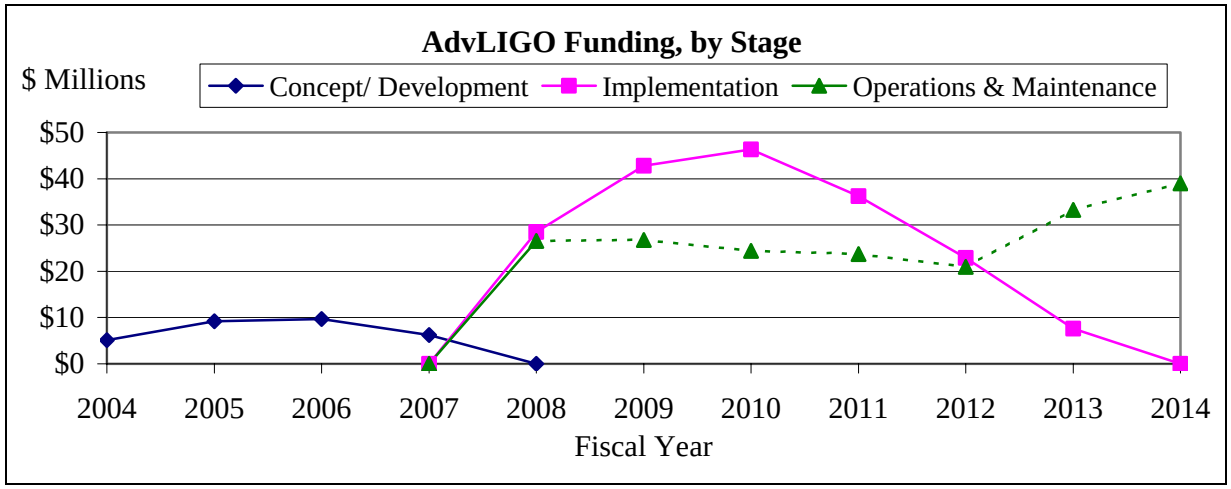
Note: Operations estimates for FY 2007 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

Information pertaining to the data in the table is 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 would be directed to design development.

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

- Management and Operations: R&RA funds will be used to maintain the existing experimental facilities and infrastructure during the construction and installation of the new instrumentation to continue the analysis of the data obtained during the operation of the original LIGO.



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

Science Support: Along with direct operations and maintenance support for LIGO, NSF supports science and engineering research directly related to LIGO activities 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 44 collaborating institutions with over 440 participating scientists. The role and membership responsibilities of each participating institution are determined by a MOU between the LIGO Laboratory and the institution. The LSC plays a major role in many aspects of the LIGO effort including: R&D for detector improvements, R&D for Advanced LIGO, data analysis and validation of scientific results, and setting priorities for instrumental improvements at the LIGO facilities.