MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION $213,270,000

The FY 2005 Budget Request for Major Research Equipment and Facilities Construction (MREFC) is $213.27 million, an increase of $58.30 million, or 37.6 percent, above the FY 2004 Estimate of $154.97 million.

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	Change Over FY 2004 Amount	Change Over FY 2004 Percent
Major Research Equipment and Facilities Construction	$179.03	$154.97	$213.27	$58.30	37.6%

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.

Once a project has been submitted for MREFC funding, it must undergo a multi-phase review and approval process. The process begins with a review by the internal NSF MREFC Panel, which makes recommendations to the NSF Director with attention to criteria such as scientific merit, importance, readiness and cost-benefit. The Director then selects candidates for National Science Board (NSB) consideration. The NSB then approves, or not, projects for inclusion in future budget requests and establishes priorities. 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 received funding.

NSF believes that the highest priority within the MREFC Account must be the current projects. To that end, highest priority in FY 2005 is to continue to request funding for the Atacama Large Millimeter Array ($49.67 million); EarthScope: USArray, Plate Boundary Observatory and San Andreas Fault Observatory at Depth ($47.35 million); and the IceCube Neutrino Observatory ($33.40 million).

In addition, three new starts are requested in FY 2005 and two new starts in FY 2006. In priority order, these are: the National Ecological Observatory Network in FY 2005; the Scientific Ocean Drilling Vessel in FY 2005; Rare Symmetry Violating Processes in FY 2005; Ocean Observatories in FY 2006, and the Alaska Region Research Vessel in FY 2006.

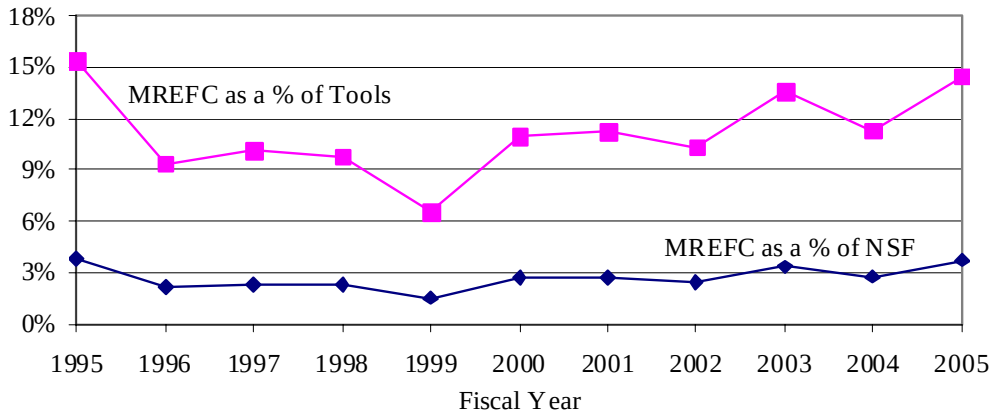
On January 14, 2004, the National Academy of Science released a study it conducted of NSF's processes for prioritization and oversight of activities funded through the MREFC Account. The NSF is now carefully evaluating the findings and recommendations contained in this study as it looks ahead to future activities in this area.

MREFC Account[1]
(Dollars in Millions)

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Request	FY 2006 Request	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
ONGOING PROJECTS							
ALMA Construction	29.81	50.70	49.67	48.84	47.89	46.49	37.37
EarthScope: USArray, SAFOD, PBO	29.81	43.24	47.35	50.24	26.80		
High-Performance Instrumented Airborne Platform for Environmental Research	13.00						
IceCube Neutrino Observatory	25.75	41.75	33.40	34.30	35.30	36.30	31.01
Large Hadron Collider	9.69						
Network for Earthquake Engineering Simulation	13.47	8.05					
South Pole Station	12.69	1.29					
Terascale Computing Systems	44.83	9.94					
NEW STARTS							
National Ecological Observatory Network			12.00	16.00	20.00	20.00	20.00
Scientific Ocean Drilling Vessel			40.85	59.94			
Rare Symmetry Violating Processes			30.00	42.66	44.00	20.25	8.00
Ocean Observatories Initiative				24.76	63.44	65.00	47.30
Alaska Region Research Vessel				49.32	32.88		
Totals	**$179.03**	**$154.97**	**$213.27**	**$326.06**	**$270.31**	**$188.04**	**$143.68**

NOTE: Totals may not add due to rounding.
[1]Does not include funding provided for early concept and development or follow-on operations and maintenance. These funds are provided through the R&RA Account and are discussed in the following individual Activity narratives and in the Tools chapter.
[2]FY 2003 Actual include $35.0 million in carryover from prior year appropriations for Terascale Computing Systems due to the NSB meeting schedule. The award was approved in October 2002, and the funds were subsequently obligated. $66.06 million appropriated in FY 2003 is carried over into FY 2004 for HIAPER ($12.53 million), the IceCube Neutrino Observatory ($3.67 million), the Large Hadron Collider ($33,819), the Polar projects ($49.71 million) and Terascale Computing Systems ($107,959). This FY 2003 carryover will be reflected in the Current Plan following an FY 2004 appropriation.

MREFC Funding As A Percent Of Tools And Of The Total NSF Budget



FIRST PRIORITY: ONGOING PROJECTS IN FY 2005

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 5000m altitude near San Pedro de Atacama in the Second Region of Chile, the ALMA host country.

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 1mm wavelength with the same 0.1" resolution achieved by the Hubble Space Telescope (HST) 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.

The ALMA array operations site, located at 5,000 meter altitude near San Pedro de Atacama in the Second Region of Chile. *Credit: Division of Astronomical Sciences, NSF.*

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 ~1000 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 are equal partners in ALMA. The North American side of the project, consisting of the U.S. and Canada, is led by Associated Universities,

Incorporated/National Radio Astronomy Observatory. Funding and execution of the project in Europe is carried out through the European Southern Observatory (ESO). Japan is likely to join ALMA as a third major partner in 2004. 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 Astronomical Sciences (AST) Subactivity in the Mathematical and Physical Sciences (MPS) Activity. An NSF advisory group, consisting of representatives from the Office of General Counsel, the Office of Budget, Finance and Award Administration and the Office of Legislative and Public Affairs, serves as a standing ALMA Project Advisory Team. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide 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 National Radio Astronomy Observatories effort on ALMA is carried out under Cooperative Agreement with the Associated Universities, Inc.

Project Status and Milestones:

Significant project events in FY 2003 included:

- Signature of the international ALMA agreement between the NSF and ESO, implementing the international construction and operations partnership;
- Start of European construction activities;
- Signature of the NSF-NRC Canada Memorandum of Understanding, implementing the North American ALMA partnership; and
- Finalization of long-term access to the ALMA site, and the start of construction in Chile.

The current baseline schedule for ALMA is specified in version 1 of the ALMA Project Plan. The schedule was developed prior to the start of ALMA construction activities, and was 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.

No Level 1 milestones are set for FY 2004. However, the procurement of production antennas for the project will be a major area of effort, with the request for proposals/call for tenders, proposal evaluation, and award of production contracts in the U.S. and Europe, all being major scheduled activities. Level 1 milestones for the project (*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

Funding Profile: U.S.-funded construction activities are scheduled to continue through 2010, with project completion at the end of calendar 2011, and full operation beginning in early 2012. Early science with the array is 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 $344.18 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.

The image above is an artist's conception of the ALMA Antennas in a compact array. *Credit: National Radio Astronomy Observatory/Associated Universities Incorporated (NRAO/AUI) and the European Southern Observatory (ESO).*

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

	FY 98	FY 99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	FY 06	FY 07	FY 08 Through FY 10	Total
ALMA R&D	9.00	9.00	8.00	5.99								31.99
ALMA Construction					12.50	29.81	50.70	49.67	48.84	47.89	104.77	344.18
Total, ALMA	$9.00	$9.00	$8.00	$5.99	$12.50	$29.81	$50.70	$49.67	$48.84	$47.89	$104.77	376.17

ALMA Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation[1]		Operations & Maintenance[2]		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 1994 & Earlier	0.25						$0.25		**$0.25**
FY 1995	0.35						$0.35		**$0.35**
FY 1996	0.50						$0.50		**$0.50**
FY 1997	0.75						$0.75		**$0.75**
FY 1998		9.00						$9.00	**$9.00**
FY 1999		9.00						$9.00	**$9.00**
FY 2000		8.00						$8.00	**$8.00**
FY 2001		5.99						$5.99	**$5.99**
FY 2002				12.50				$12.50	**$12.50**
FY 2003				29.81				$29.81	**$29.81**
FY 2004 Estimate				50.70				$50.70	**$50.70**
FY 2005 Request				49.67	1.00		$1.00	$49.67	**$50.67**
FY 2006 Estimate				48.84	2.00		$2.00	$48.84	**$50.84**
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	$1.85				$97.00		$98.85		
Subtotal, MREFC		$31.99		$344.18				$376.17	
Total, Each Phase		**$33.84**		**$344.18**		**$97.00**			**$475.02**

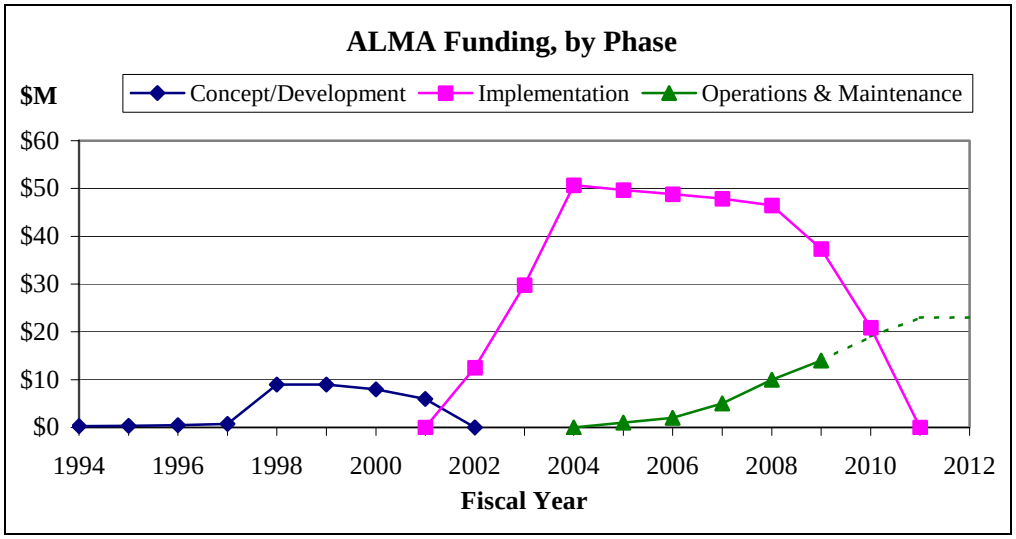
NOTE: The expected operational lifespan of this project is at least 30 years. A steady state of about $23 million annually (FY 2012 dollars) is anticipated for operations support beginning in FY 2012. Operations estimates for FY 2006 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.
[1]Based on cost review of original MMA and then projected to ALMA.
[2]Operations funding of $1.0 million in FY 2005 is provided through the National Radio Astronomy Observatory.

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

- Concept/Development: Prior to FY 1998, the National Radio Astronomy Observatory (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 64 12-meter antennas having a total collecting area of 7,200 square meters, with 4 receiver bands extending into the submillimeter. The table describes the U.S. contribution to ALMA and does not address the reduction in costs due to 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: EarthScope 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. It is planned as a distributed facility – parts of EarthScope are expected to inhabit nearly every county within the U.S. over the project's life span. NSF, 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 will be 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.

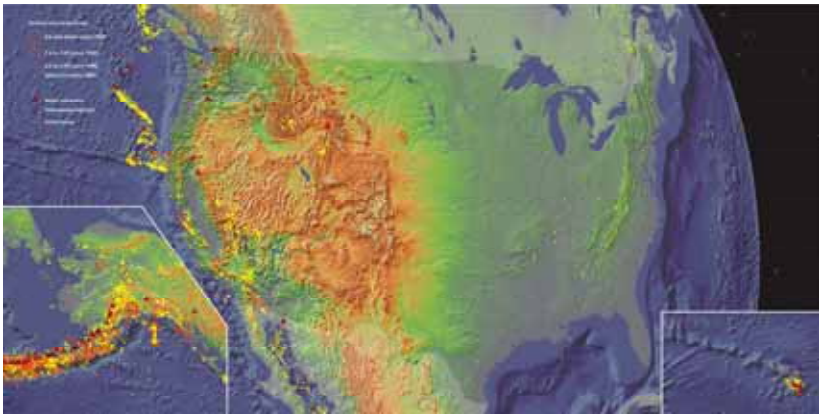
Principal Scientific Goals: Enhanced understanding of earthquakes and seismic hazards, magmatic systems and volcanic hazards, lithospheric dynamics, regional tectonics, continental structure and evolution, fluids in the crust, and associated educational aspects.

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

Partnerships and Connections to Industry: Geotechnical and engineering firms will use data and models 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: NSF oversight is provided by the EarthScope Program Officer and the Section Head for Special Projects, located in the Earth Sciences (EAR) Subactivity in the Geosciences (GEO) Activity. Other internal oversight is provided by a Project Advisory Team including staff from GEO, the Office of the General Counsel and the Office of Budget, Finance and Award Management. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance. Following the recommendations of a National Academy of Sciences 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.

Current Project Status: FY 2003 highlights include dedicated workshops to refine the EarthScope science plan, organize education and outreach, strengthen coordination with EarthScope partners at NASA and the USGS, and refine communications/information technology capabilities. In partnership with the International Continental Scientific Drilling Programme, work was completed on the pilot hole instrumentation package development. In FY 2003, Cooperative Agreements were initiated for construction of the EarthScope facility. Major FY 2004 milestones will include the initiation of airborne imaging of potential study sites, initial equipment acquisition and installation, awarding of the San Andreas Fault Observatory at Depth drilling contract, and construction of the down-hole monitoring string.



EarthScope is a bold undertaking to apply modern observational, analytical and telecommunications technologies to investigate the structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanic eruptions. *Credit: EarthScope.*

EarthScope's Project Execution Plan has been developed and is under review and discussion. The milestones listed below are preliminary and will likely be revised as the project's schedule is finalized.

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);
Acquisition begins for GPS and borehole strain systems (2nd quarter);
Airborne imaging of potential study sites (2nd quarter);
Down-hole monitoring equipment constructed (3rd quarter);
San Andreas Fault Observatory at Depth main hole drilling contract competed and awarded (3rd quarter);
Begin drilling (4th quarter);
Delivery of 50 portable GPS systems (4th quarter);
Delivery and installation of 100 GPS and 20 borehole-strain systems (4th quarter); and
NSF conducts first annual review of EarthScope (4th quarter).

FY 2005 Milestones:

Delivery and installation of 50 transportable array sites;
Delivery and installation of 500 flexible pool short period sites;
Delivery and installation of 5 Global Seismic Network (GSN) and 10 National Seismic Network (NSN) permanent stations in cooperation with the Advanced National Seismic System (ANSS);
Main hole completed at San Andreas Fault Observatory;
Down-hole monitoring instrumentation installed;
Airborne imaging of potential study sites;
Delivery and installation of 175 GPS and 30 borehole-strain systems;
Delivery and deployment of 50 portable GPS systems; and
NSF conducts annual review of project status.

FY 2006 Milestones:

Delivery and installation of 200 transportable array sites;
Delivery and installation of flexible pool sites: 200 broadband and 1000 short period seismic systems;
Delivery and installation of 5 GSN and 10 NSN permanent stations (in cooperation with ANSS);
San Andreas Fault site characterization studies carried out;
Delivery and installation of 200 GPS and 50 borehole-strain systems;
Deployment of 50 portable GPS systems; and
NSF conducts annual review of project status;

FY 2007 Milestones:

Delivery of 150 and installation of 200 transportable array sites;
Delivery of flexible pool sites: 200 broadband and 500 short period;
Installation of flexible pool sites: 200 broadband and 1000 short period;
Delivery and installation of 5 NSN permanent stations (in cooperation with ANSS);
Use site characterization and monitoring data to choose four coring intervals at depth in San Andreas Fault Observatory. Commence coring operations;
Delivery and installation of 200 GPS and 50 borehole-strain systems; and
NSF conducts annual review of project status;

FY 2008 Milestones:

Redeployment of USArray;
Install permanent monitoring instrumentation in four core intervals and main hole of San Andreas Fault Observatory at Depth;
Delivery and installation of 200 GPS and 50 borehole-strain systems; and
NSF conducts annual review of project status.

FY 2009 – FY 2013 Milestones:

Redeployment of USArray on a continual basis;
Complete analysis of San Andreas Fault cores, cuttings and logs. 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 has developed over the past decade. NSF has 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.

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

FY 2003	FY 2004	FY 2005 Request	FY 2006	FY 2007	Total
$29.81	$43.24	$47.35	$50.24	$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 Estimate				43.24	1.70		$1.70	$43.24	**$44.94**
FY 2005 Request				47.35	3.45		$3.45	$47.35	**$50.80**
FY 2006 Estimate				50.24	5.27		$5.27	$50.24	**$55.51**
FY 2007 Estimate				26.80	10.41		$10.41	$26.80	**$37.21**
FY 2008 Estimate					13.00		$13.00		**$13.00**
FY 2009 Estimate					13.33		$13.33		**$13.33**
FY 2010 Estimate					13.66		$13.66		**$13.66**
FY 2011 Estimate					14.00		$14.00		**$14.00**
FY 2012 Estimate					14.35		$14.35		**$14.35**
Subtotal, R&RA	$9.36				$89.56		$98.92		
Subtotal, MREFC				$197.44				$197.44	
Total, each phase		**$9.36**		**$197.44**		**$89.56**			**$296.36**

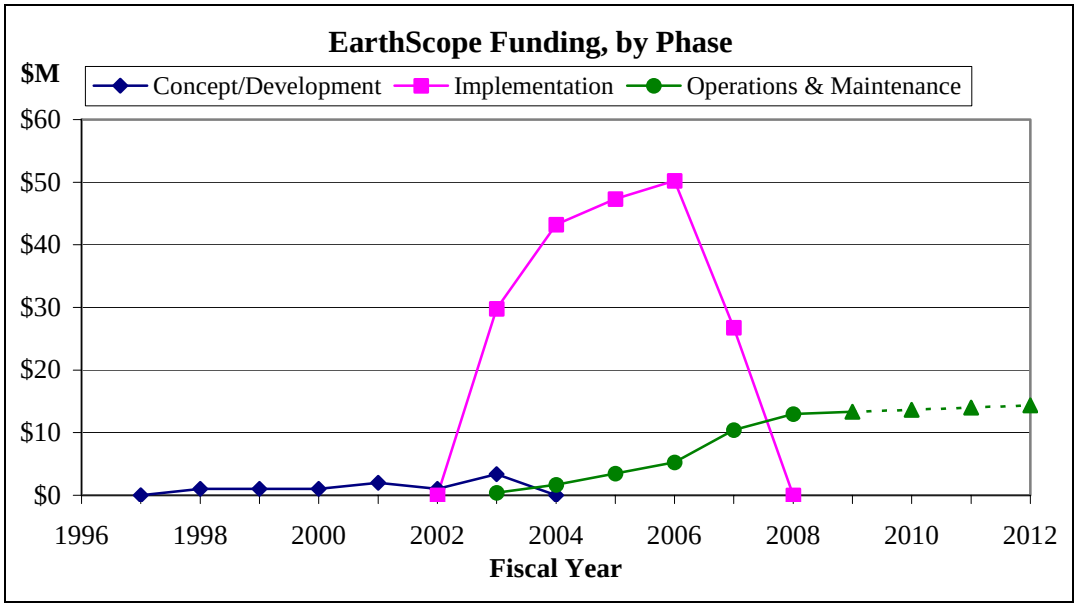
NOTE: The expected operational lifespan of this project is 15 years after construction is complete in FY 2007. A steady state of $13 million in operations support is anticipated by FY 2008. Operations estimates for FY 2008 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

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

- Concept/Development: FY 1998-FY 2000 funds were used to support workshops, instrument development, and installation technique development appropriate to EarthScope, from existing programs within the Division of Earth Sciences. Dedicated funding was established for FY 2001-03 supporting pre-EarthScope activities that would facilitate the construction and installation. This funding supports meetings, workshops, instrumentation prototype development, installation technique development, and site selection activities.

- Implementation: During FY 2003-07, 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 EarthScope, 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 $15 million, once the facility reaches full operations.

High Performance Instrumented Airborne Platform for Environmental Research (HIAPER)

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

HIAPER - Shored aircraft checked weekly (and often daily) using specialized laser instruments. *Credit: National Center for Atmospheric Research (NCAR) and NSF.*

Principal Scientific Goals: HIAPER will be a research platform with altitude, range, and endurance capabilities that will enable investigators to perform critical earth system science research. With a maximum altitude for the aircraft of 51,000 feet, the ability to carry significant payloads to such high altitudes will enable scientists to conduct important atmospheric studies in and near the tropopause. The modified aircraft will be capable of covering a range of 6000 nautical miles in a single flight, which will allow for such varied missions as research flights covering the borders of the continental U.S., the world's large ocean basins, and even studies of the South Pole environment conducted from South America or New Zealand. The platform will serve the entire geosciences community: atmosphere, cryosphere, biosphere, and hydrosphere.

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

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

Management and Oversight: The project is managed and overseen by a project director in the Atmospheric Sciences (ATM) Subactivity in the Geosciences (GEO) Activity. The project director receives advice and oversight support from a NSF Project Advisory Team, which consists of representatives from GEO, the Office of General Counsel, the Office of Budget, Finance and Award Management (BFA), the Mathematical and Physical Sciences (MPS) Activity, and the Office of Polar Programs. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance. A separate HIAPER Advisory Committee, consisting of representatives of the university research community, national laboratories, the University Corporation for Atmospheric Research (UCAR), NCAR and NSF provides advice and recommendations to the Director of NCAR and to the project director at NSF.

Current Project Status: In late December 2001 UCAR and Gulfstream Aircraft Corporation (GAC), a subsidiary of General Dynamics, signed a contract for the acquisition of a Gulfstream V. The green airframe was delivered to Lockheed-Martin in June, 2002 for extensive airframe structural modifications to meet science requirements. Modifications and instrumentation activities are on schedule.

Milestones for the project are outlined below:

FY 2002 Milestones (Completed):
- Negotiation of final contract between UCAR and GAC;
- Approval of contract by NSF;
- Contract between UCAR and GAC for acquisition of green airframe and structural modifications;
- Production of green airframe;
- Staff HIAPER project office at National Center for Atmospheric Research (NCAR);
- NSF Instrumentation Workshop conducted at NCAR.

FY 2003 Milestones (Completed):
- NCAR Director's Independent Review of Project
- Release of Instrument Development Announcement of Opportunity
- Critical Design Review - Systems
- Structural Modifications Initiated by Lockheed Martin

FY 2004 Milestones:

Structural Modifications completed by Lockheed Martin
Instrumentation Development Grants awarded
Flight testing and FAA STC Certificate for Modified Aircraft
Receipt of Modified Aircraft at UCAR

FY 2005 Milestones:

Research Infrastructure and Data Systems Installed
Preparation for Deployments and progressive science mission flights

FY 2006 Milestone:

First Deployment

This is an illustration of what HIAPER will look like when completed, including the approved color scheme. *Credit: NCAR and NSF.*

Funding Profile: In FY 2000, $8.50 million was provided for the project, and an additional $12.47 million was appropriated in FY 2001. In FY 2002 Congress appropriated $35.0 million. The final appropriation of $25.53 million was received in FY 2003, $12.53 million of which was carried over into FY 2004. The total estimated construction cost for the project is $81.50million.

Appropriated MREFC Funds for HIAPER
(Dollars in Millions)

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

HIAPER Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 1998	0.30						$0.30		**$0.30**
FY 1999	0.40						$0.40		**$0.40**
FY 2000		0.50		8.00				$8.50	**$8.50**
FY 2001		0.40		12.07				$12.47	**$12.47**
FY 2002				35.00				$35.00	**$35.00**
FY 2003[1]				13.00				$13.00	**$13.00**
FY 2004 Estimate				12.53				$12.53	**$12.53**
FY 2005 Request					0.30		$0.30		**$0.30**
FY 2006 Estimate					3.00		$3.00		**$3.00**
FY 2007 Estimate					3.06		$3.06		**$3.06**
FY 2008 Estimate					3.13		$3.13		**$3.13**
FY 2009 Estimate					3.21		$3.21		**$3.21**
Subtotal, R&RA	$0.70				$12.70		$13.40		
Subtotal, MREFC		$0.90		$80.60				$81.50	
Total, each phase		**$1.60**		**$80.60**		**$12.70**			**$94.90**

NOTE: The expected operational lifespan is 25 years, pending the full integration of scientific instrumentation. A steady state of about $3.0 million in operations support would occur in or about FY 2006, assuming completion of the project in FY 2004. Operations estimates for FY 2006 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.
[1]FY 2003 appropriations totaled $25.53 million. Of this amount, $13.0 million was spent in FY 2003, and the remainder, $12.53 million, was carried over into FY 2004.

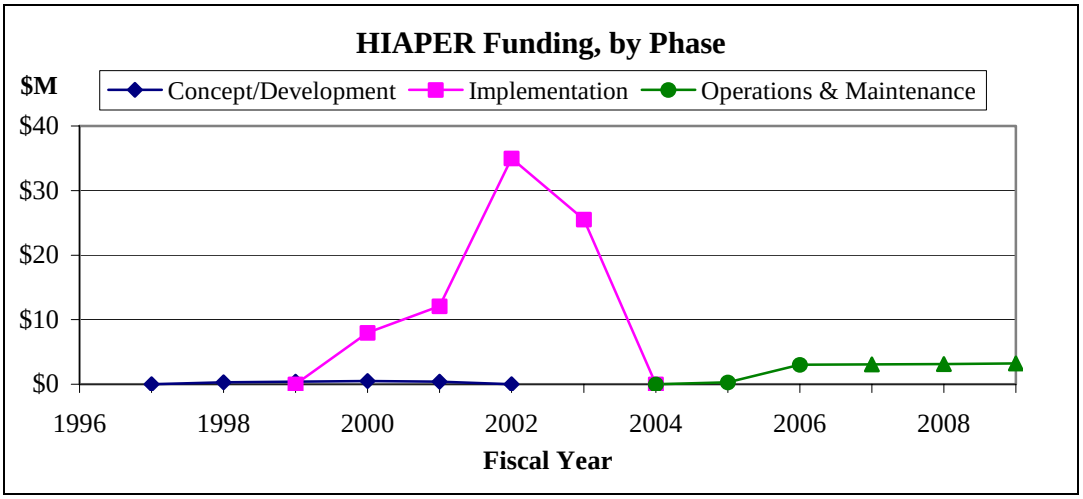
Information pertaining to the data in the table is provided below.

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

- Implementation: The full appropriated amounts for FY 2000-02 were required in order to acquire and modify the airframe. Funding was provided to Gulfstream to secure a production slot, and the rest of the funds were held until the contract was negotiated, approved by NSF and signed by UCAR and GAC. With HIAPER fully funded, a green airframe has been acquired and the structural modifications required to integrate scientific instrumentation and complete the project have begun. Instrumentation will be developed in FY 2004-05, and integrated into the aircraft in FY 2005. The total construction cost for the project is $81.50 million.

- Operations and Maintenance: The aircraft will be maintained and operated by the Research Aviation Facility at NCAR. The intent is to operate the aircraft as a fully certified (FAA Airworthiness Certification) platform rather than a public use aircraft. Additional follow-on instrumentation will be

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



Future Science Support: Along with direct operations and maintenance support for HIAPER, NSF will support research performed at the facility, through ongoing research and education programs. The annual support for such activities is estimated to be about $10.0 to $12.0 million, once the facility reaches full operations.

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 will be constructed by the IceCube Consortium, led by the University of Wisconsin (UW). Approximately one cubic kilometer of ice will be 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. 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. 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 principle 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

The IceCube cable assembly is delivered by ski-equipped C-130 (LC-130) to Amundsen-Scott South Pole Station in January 2004. *Credit: the United States Antarctic Program.*

deploying installation of 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.

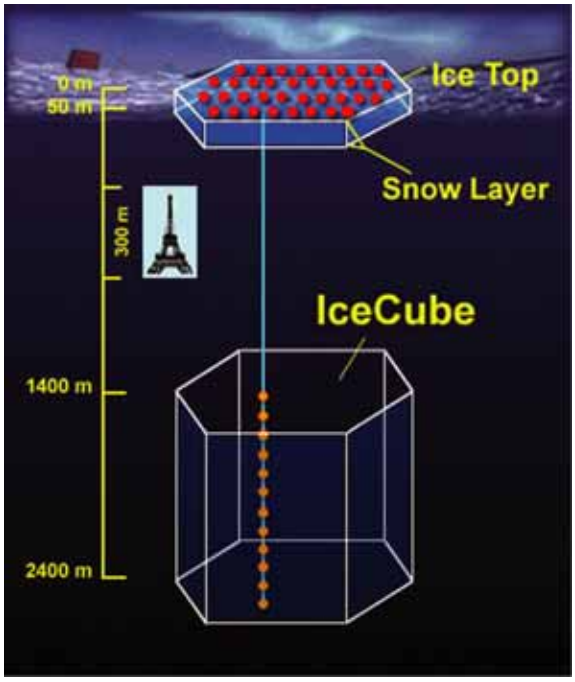
This picture shows the "IceTop" section of IceCube. The deep detector array comprising 4,800 digital optical monitors will be placed at depths up to 2,450 meters in the ice while the surface array, known as IceTop, will comprise 320 DOMs and will be placed at a depth of 1 meter. All components of the array will be connected to a central instrumentation support facility, the Counting House. *Credit: the United States Antarctic Program.*

Principal Education Goals: IceCube provides a vehicle for helping to achieve national and Agency 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. 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. Substantial foreign contributions. are anticipated. The U.S. Department of Energy, through its Lawrence Berkeley Laboratory, is also participating.

Management and Oversight: With strong international participation, IceCube has an interim management structure that provided the framework for the Start-up Project funded in FY 2002 and FY 2003. 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, and has appointed both a Project Director and a Project Manager. Internally, NSF has appointed a Project Coordinator to manage and oversee the NSF award, and has established an internal Project Advisory Team comprised of representatives from the Office of Budget, Finance, and Award Management, the Office of General Counsel, the Mathematical and Physical Sciences (MPS) Activity, and the Office of Polar Programs (OPP), and chaired by the Project Coordinator. Oversight and funding responsibility for IceCube construction are the responsibility of OPP; support for research, education, and outreach using IceCube will be shared by OPP and MPS as well as other organizations and international partners.



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

Current Project Status: The IceCube project has been funded to date through a $15.0 million appropriation in FY 2002 for 'startup funding' and a $24.54 million appropriation in FY 2003 for continuation of startup activities. The primary tasks funded to date are: production and testing of the Enhanced Hot Water Drill (EHWD) system for drilling the required deep-ice holes into which digital optical modules (the photo-detectors that are the central elements of the IceCube detector) will be placed; production of the digital optical module deployment system; design of the data acquisition system and software requirements; specification of the requirements, design, and pre-production testing of the IceTop Surface Array; software system architecture and detector simulations; and planning for detector verification. Progress to date has been steady. The construction of the EHWD is complete and the drill is in the Integration Verification, and Testing phase. Key elements of the EHWD have been shipped to the South Pole for assembly this austral summer season (2003/2004), in anticipation of first drilling and deployment of DOM strings next season (2004/2005). A DOM production facility has been completed at UW, including a new dark freezer laboratory for testing strings of DOM strings in extreme colds extending down to –80° C. Preproduction DOMs are under construction that will be used in an exhaustive period of environmental testing scheduled for Spring 2004. UW has made structural management changes to improve their internal oversight of the project. A permanent Project Director was hired by UW in October 2003, and he has now taken charge of the project. In anticipation of FY 2004 funding of construction, NSF has scheduled a full baseline review of the project for February 2004. The FY 2004 Estimate funding is $41.75 million.

Major milestones for IceCube are below:

FY 2004 Milestones:

Deliver EHWD system and DOM deployment system to the South Pole; and
Begin production of digital optical modules and data acquisition and handling system (DAQ).

FY 2005 Milestones:

Deliver initial DOM strings, IceTop modules, and initial elements of the DAQ to South Pole;
Assemble the EHWD and DOM deployment systems;
Drill, deploy, and test initial DOM strings and corresponding IceTop modules; and
Establish drill camp and move new counting house building into place.

Projected outyear milestones (FY 2006-2010) are based on current project planning and represent a general outline of anticipated activities. These activities are also dependant on weather conditions and the Antarctic logistics schedule.

FY 2006 Milestones:

Continue DOM and IceTop module production;
Continue to drill, deploy and test DOM strings and IceTop modules, including installing and testing the associated DAQ elements; and
Commission new counting house.

FY 2007-10 Milestones:

Continue DOM and IceTop module production; and
Continue to drill, deploy and test DOM strings and IceTop modules, including installing and testing the associated DAQ elements.

FY 2011 Milestones:

Complete DOM and IceTop module production, string deployment, and the DAQ;
Complete the calibration, testing, and commissioning of the full IceCube array; and
Commence full operations.

Funding Profile: $15.0 million was appropriated in FY 2002 for startup activities for IceCube and $24.54 million was appropriated in FY 2003 for continuation of startup activities. The FY 2004 Estimate is $41.75 million to initiate construction of the full IceCube project.

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

FY 2002	FY 2003	FY 2004	FY 2005 Request	FY 2006	FY 2007	FY 2008	FY 2009	Total
$15.00	$24.54	$41.75	$33.40	$34.30	$35.30	$36.30	$31.01	$251.60

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 Estimate				45.42				$45.42	**$45.42**
FY 2005 Request				33.40				$33.40	**$33.40**
FY 2006 Estimate				34.30				$34.30	**$34.30**
FY 2007 Estimate				35.30				$35.30	**$35.30**
FY 2008 Estimate				36.30				$36.30	**$36.30**
FY 2009 Estimate				31.01				$31.01	**$31.01**
FY 2010 Estimate					10.40		$10.40		**$10.40**
FY 2011 Estimate					10.60		$10.60		**$10.60**
FY 2012 Estimate					10.90		$10.90		**$10.90**
Subtotal, R&RA	$0.50				$31.90		$32.40		
Subtotal, MREFC				$251.60				$251.60	
Total, Each Phase		**$0.50**		**$251.60**		**$31.90**			**$284.00**

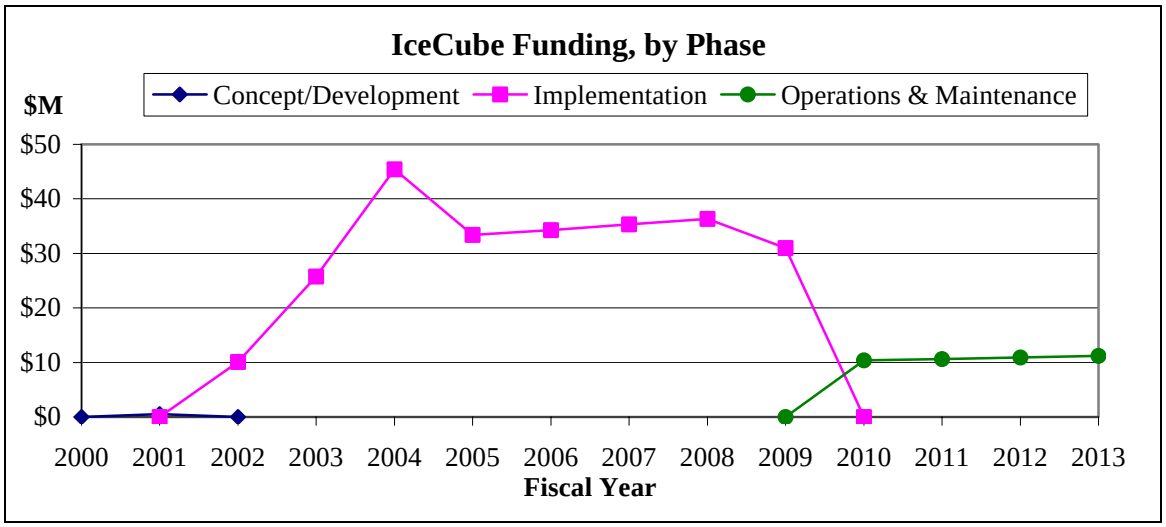
NOTE: The expected operational lifespan of this project is 25 years after construction is complete in FY 2011. Operations support in FY 2010 is estimated at $10.40 million, and is estimated to remain at that corresponding level of effort in subsequent years.. Operations estimates for 2010 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

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

- Concept/Development: $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 $24.5 million for continued startup activity. Those investments focused on state-of-the art drill and electronics development and acquisition.

- Implementation: The total cost of the construction project, including the $15.0 million appropriated in FY 2002 and $24.5 million in FY 2003 for start-up activities, is estimated currently at $251.60 million and will extend through FY 2011. A review of the IceCube project will be conducted in February 2004 to provide a solid project baseline scope, cost, and schedule. The FY 2004 Estimate provides $41.75 million to initiate construction of the full IceCube project; and $33.40 million is requested in FY 2005. 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 2011. FY 2003 and FY 2004 amounts include carryover from previous years.

- 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 2011. Transition to full operations will begin in FY 2010. 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. 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 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.

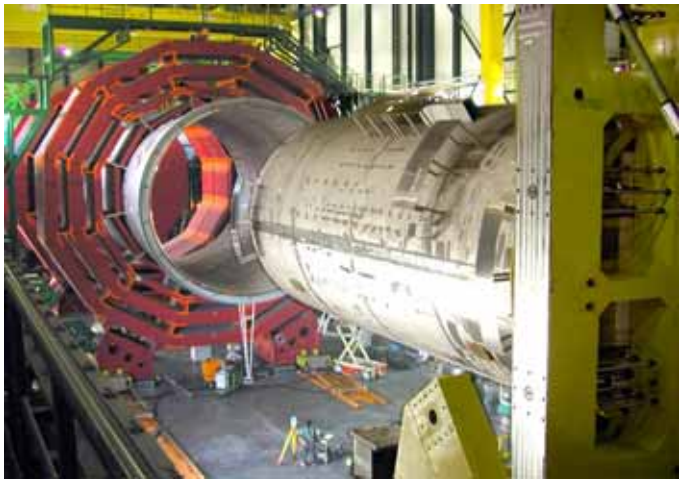
Associated Research and Education Activities: Besides the training of next generation astrophysicists, IceCube will encourage the creation of new links to K-12 teachers for the purpose of scientific/professional development of secondary school teachers, reaching into the classroom with new inquiry-based 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.

Large Hadron Collider

Project Description: The Large Hadron Collider (LHC) will be the premier facility in the world for research in elementary particle physics. The facility will consist of a superconducting particle accelerator providing two, counter-rotating beams of protons, each beam having an energy up to 7 TeV ($1TeV=10^{12}$

electron volts). The U.S. is involved in the construction of two particle detectors, A Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS). Each will be constructed to characterize the different reaction products produced in the very high-energy proton-proton collisions which will occur in intersection regions where the two beams are brought together.

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



Photograph of the Compact Muon Solenoid (CMS), one of two particle detectors the U.S. is constructing for the international Large Hadron Collider project. *Credit: LHC project.*

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

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

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

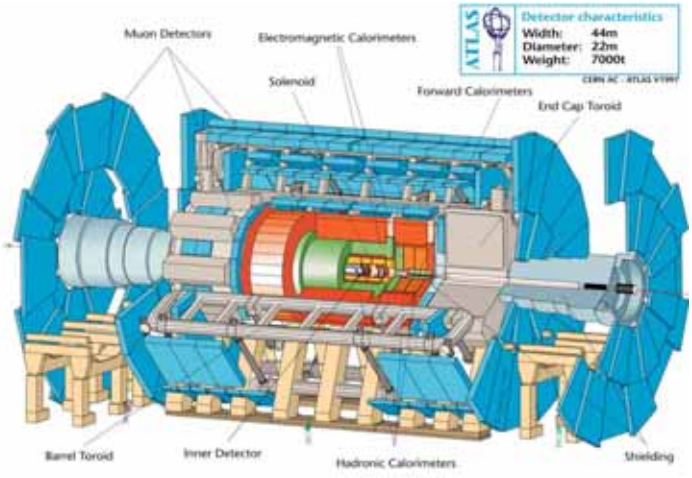
Connections to Industry: Major procurements of components of both warm and superconducting magnets, as well as high-speed electronics, are performed through U.S. industries. Major developments in Grid computing are also valuable outcomes.

Management and Oversight: A program director in the Physics Subactivity of the Mathematical and Physical Sciences (MPS) Activity is responsible for day-to-day project oversight. The NSF program director also convenes an internal Project Advisory Team, including staff from the Office of Budget, Finance and Award Management, the Office of the General Counsel, the Office of Legislative and Public

Affairs, and MPS. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance.

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

Current Project Status: An External Review Committee (ERC), reporting to the CERN Council in June, 2002, identified issues relevant to completion of the LHC project. In the report, the ERC stated that it "believes that the design of the LHC is excellent and that it will reach design specifications". However, the ERC did find that the projected cost increases that became apparent before this report arose from "serious weaknesses in cost awareness and control, as well as in contract management and financial reporting." NSF has been working closely with CERN management on these issues. It is important to note that NSF funding for the U.S. LHC Construction Project has been completed and that the NSF cost has not increased.



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

In September 2002, CERN management released an Action Plan to address the recommendations of the External Review Committee. A schedule delay was foreseen at that time, largely a result of delays in the delivery of superconducting cable for the LHC magnets. In December 2002, the CERN council accepted a proposal to revise the 1996 financial framework for the LHC. The revised framework makes LHC completion in 2007 a priority, representing a two-year delay from the original plan. The proposal addresses items including accountability, staffing, management, cost awareness, control and reporting, and annual reviews. Most of CERN's resources are committed to the project, leaving only a very limited non-LHC experimental program.

A second External Review committee reported to the Council in December 2003. They noted that the LHC is the most challenging project ever attempted by CERN and the accomplishments to date deserve great praise. However, CERN Project Management still has a challenging job ahead to avoid further cost overruns and significant delays.

Under the current challenging schedule, a period of beam commissioning starting in the Spring of 2007, will be followed by the start of the LHC physics data taking runs in the latter half of 2007. While both experiments may benefit from the extended LHC schedule by having additional time to optimize their installation plans, the U.S. collaborators continue on the original baseline schedule, to avoid any increases in labor and costs. The entire U.S. LHC activity is being maintained within the funding cap set forth in the original U.S. funding guidance for the project.

The NSF-supported components of the ATLAS and CMS detectors are scheduled for completion in FY 2005, with the final year of appropriated construction funding in FY 2003. The U.S. ATLAS construction

project, as of November 2003, was 85 percent complete. All but $2.60 million of the $60.80 million NSF MREFC funds for ATLAS have been obligated. The U.S. CMS project is 82 percent complete. All but $960,000 of the $20.20 million NSF MREFC funds for CMS have been obligated. Milestones for both projects are being completed in the anticipated years. U.S. cost performance has been excellent, with material contracts typically below estimates, and labor costs tracking close to plan. The U.S. strategy aims for the completion of the U.S. deliverables within baseline cost and with a slightly extended schedule that takes the LHC construction delay into account. FY 2003 milestones have been met.

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

FY 2004 Milestones:

US ATLAS

Complete delivery of Liquid Argon Forward Calorimeter (Section A);
Complete delivery of Silicon Strip Modules;
Complete production of Transition Radiation Tracker (Modules and Barrel); and
Complete Muon Chamber production.

US CMS

Complete delivery of Electromagnetic (EM) Calorimeter Photodiodes;
50% of Silicon Tracker Rods completed; and
Start production of the Front End electronics for the EM Barrel Calorimeter.

FY 2005-2006 Milestones:

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

FY 2007 Milestone:

First data taking using both ATLAS and CMS detectors.

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

The total U.S. contribution to the construction project will be $530.85 million, with $450.0 million from the DOE and $80.85 million from NSF. NSF and DOE will jointly provide a total contribution of $331.0 million for the detector construction, while DOE will provide the entire U.S. contribution ($200 million) for the accelerator construction. There are two other major detectors being constructed, ALICE and LHC-B, in which the U.S. does not play a role.

This is a photograph of a partially complete segment of the ATLAS detector. *Credit: LHC project.*

Appropriated MREFC Funds for LHC
(Dollars in Millions)

FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Total
$22.00	$15.90	$16.36	$16.90	$9.69	$80.85

Large Hadron Collider Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance		Totals		**Grand Total**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	
FY 1996	1.20						$1.20		**$1.20**
FY 1997	1.50						$1.50		**$1.50**
FY 1998	1.50						$1.50		**$1.50**
FY 1999	1.50		0.15	22.00	0.16		$1.81	$22.00	**$23.81**
FY 2000				15.90	0.53		$0.53	$15.90	**$16.43**
FY 2001				16.36	2.30		$2.30	$16.36	**$18.66**
FY 2002				16.90	1.60		$1.60	$16.90	**$18.50**
FY 2003				9.69	5.00		$5.00	$9.69	**$14.69**
FY 2004 Estimate					7.00		$7.00		**$7.00**
FY 2005 Request					9.00		$9.00		**$9.00**
FY 2006 Estimate					14.00		$14.00		**$14.00**
FY 2007 Estimate					19.00		$19.00		**$19.00**
FY 2008 Estimate					24.00		$24.00		**$24.00**
FY 2009 Estimate					25.00		$25.00		**$25.00**
Subtotal, R&RA	$5.70		$0.15		$107.59		$113.44		
Subtotal, MREFC				$80.85				$80.85	
Total, each phase		**$5.70**		**$81.00**		**$107.59**			**$194.29**

NOTE: A steady state of $25.0 million in operations support is anticipated by FY 2009. The estimated operational lifespan of this project is approximately 20 years. Operations estimates for FY 2005 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

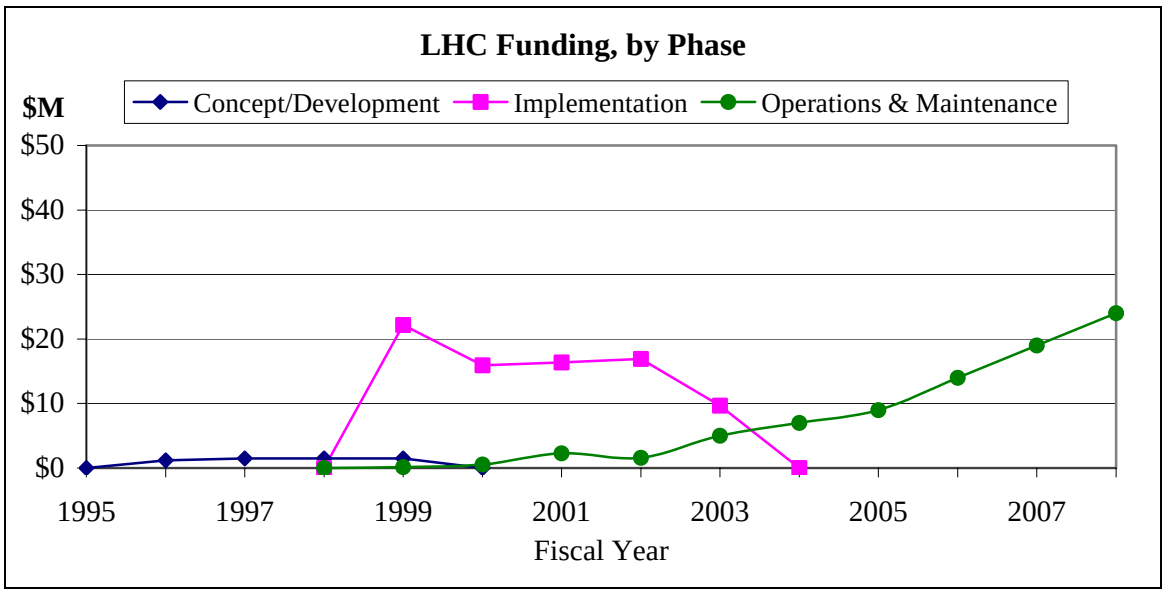
Information pertaining to the data in the table is provided below.

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

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

- Management and Operations: FY 1999-2003 funding primarily represents investments in university computing infrastructure and software development for remote access, to allow university scientists and students to participate in LHC research as well as other projects. Estimated funding for FY 2004

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



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

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

Project Description: NEES will provide a national, networked simulation resource of fifteen geographically distributed, shared use next-generation experimental research equipment sites with teleobservation and teleoperation capabilities. This facility will transform the environment for earthquake engineering research and education through collaborative and integrated experimentation, computation, theory, databases, and model-based simulation to improve the seismic design and performance of U.S. civil and mechanical infrastructure systems. Research equipment includes shake tables, geotechnical centrifuges, a tsunami wave basin, large-scale laboratory experimentation systems, and field experimentation and monitoring installations. NEES equipment will be located at academic institutions (or at off-campus field sites) throughout the U.S., networked together through a high performance Internet system, and operated during FY 2005-14 by a NEES Consortium. The NEES award for system integration is located at the University of Illinois at Urbana-Champaign. The NEES award for consortium development was made to a non-profit organization, the Consortium of Universities for Research in Earthquake Engineering.

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

This illustrates random waves generated by the Oregon State Tsunami Wave Basin, the world's leading facility for studying the effects of large waves. State-of-the-art information technology allows real-time research to be shared over the internet with remote collaborators, other researchers, and students. In addition, access to archived data will allow replay and "post-game" analysis of interesting phases of the tsunami experiment. *Credit: Oregon State University.*

Principal Education Goals: To engage engineering, science, and other students in earthquake engineering discovery through on-site use of experimental facilities, telepresence technology, archival experimental and analytical data, and computational resources with the aim of integrating research and education.

Connections to Industry: There are no specific project partnerships at this time. However, through the Congressionally mandated National Earthquake Hazards Reduction Program (NEHRP), Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), NSF, and U.S. Geological Survey (USGS) participate to support research related to earthquake hazard mitigation. Connections to industry include equipment and instrumentation acquisition by awardees from private firms; and private engineering consultants and engineering firms engaging in NEES research or using data and models developed through NEES.

Management and Oversight: The NSF Program Manager for NEES and the NSF Equipment Project Coordinator are located in the Civil and Mechanical Systems (CMS) Subactivity in the Engineering (ENG) Activity. Oversight is supported by the NSF Project Advisory Team consisting of representatives from the Office of General Counsel, the Office of Budget, Finance and Award Management, and the Biosciences, Geosciences, Computer and Information Science and Engineering, and Social and Behavioral Sciences Activities. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance.

Current Project Status: NEES is currently under construction through the end of FY 2004. Sixteen awards (Phases 1 and 2) have been made to establish equipment sites at fifteen institutions, one award for system integration, and one award for consortium development. All awards are the result of competitive program solicitations. The organizational structure and policies for a NEES Consortium are under development by the earthquake engineering community. Milestones for NEES are outlined below:

FY 2004 Milestones:

- Complete equipment construction and calibration of all Phases 1 and 2 equipment;
- All equipment sites networked and operational;
- Coordinate outreach and training activities for equipment sites as they become operational;
- Complete testing of network system;
- Network system operational; and
- NEES Consortium management structure completed for operation in FY 2005.

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

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

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

NEES Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation			Operations & Maintenance		Totals			Grand
	R&RA	MREFC	R&RA	MREFC	EHR	R&RA	MREFC	R&RA	MREFC	EHR	Total
FY 1995	0.15							$0.15			**$0.15**
FY 1996											
FY 1997											
FY 1998	0.11							$0.11			**$0.11**
FY 1999											
FY 2000		0.36		7.34					$7.70		**$7.70**
FY 2001	0.44	0.03		28.11	1.10			$0.44	$28.14	$1.10	**$29.68**
FY 2002				24.40					$24.40		**$24.40**
FY 2003				13.47					$13.47		**$13.47**
FY 2004 Estimate				8.05					$8.05		**$8.05**
RY 2005 Estimate						20.00		$20.00			**$20.00**
FY 2006 Estimate						20.40		$20.40			**$20.40**
FY 2007 Estimate						20.87		$20.87			**$20.87**
FY 2008 Estimate						21.39		$21.39			**$21.39**
FY 2009 Estimate						21.93		$21.93			**$21.93**
Subtotal, R&RA	$0.70					$104.59		$105.29			**$105.29**
Subtotal, MREFC		$0.39		$81.37					$81.76		**$81.76**
Subtotal, EHR					$1.10					$1.10	**$1.10**
Total, Each Phase		**$1.09**			**$82.47**		**$104.59**				**$188.15**

NOTE: The expected operational lifespan of this project is 10 years after construction is complete in FY 2005. A steady state of $20 million in operations support is anticipated by FY 2005. Operations estimates for FY 2006 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

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

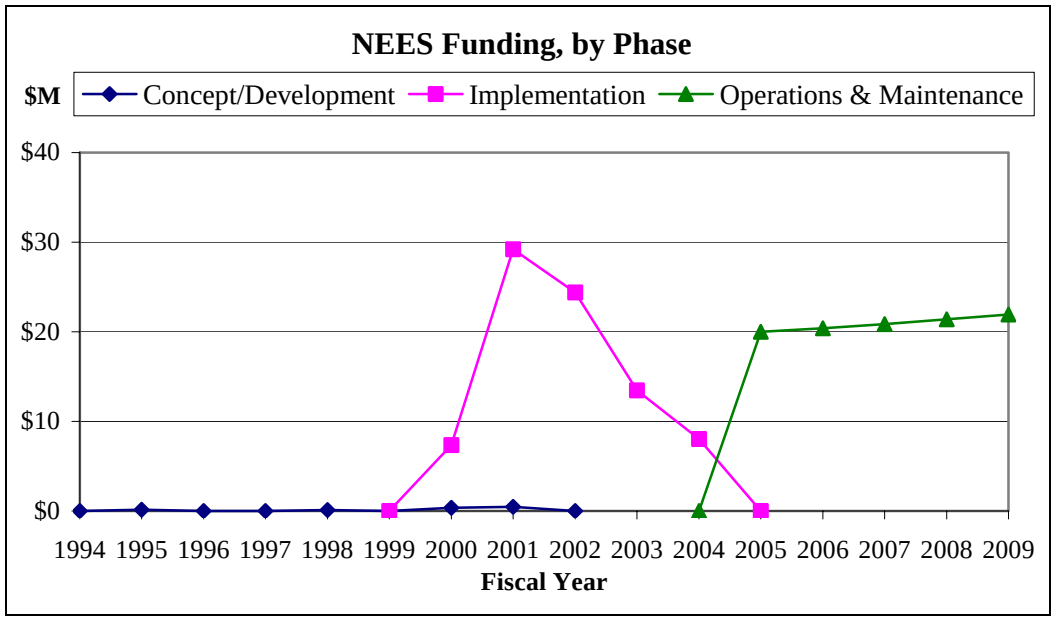
- Concept/Development: R&RA support for planning, design and development included early workshops on experimental needs of the earthquake engineering community and on refinement of ideas for experimental systems in FY 1995 and FY 1998. During this period, the community also developed an action plan at NSF's invitation. Additional R&RA support focused on an international workshop to foster long term working relationships for experimental earthquake engineering research and national workshops and study to develop long-term NEES research concepts and plans (FY 2001). MREFC funds supported planning, design and development specifically for a scoping study of the NEES network system (user and system architecture requirements), including a community

workshop for broader input on user requirements prior to the full system integration award being made by NSF.

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

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

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



Future Science Support: Along with direct operations and maintenance support for NEES, NSF will support research performed at NEES equipment sites through ongoing research and education programs. In addition, NSF has initiated grand challenge research projects that will utilize a number of NEES experimental sites, data, and computational resources to comprehensively address major research questions in earthquake engineering and seismic hazard mitigation. The annual support for such activities once the facility reaches full operations is estimated to reach about $15.0 million.

South Pole Station

Project Description: South Pole Station Modernization (SPSM) will provide 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 will be 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: SPSM's primary connection to industry is through the Raytheon Polar Services Company (RPSC), the U.S. Antarctic Program support contractor. In addition, there are approximately 385 separate subcontractors for supplies and technical services.

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 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 will provide advice and assistance.

Current Project Status: The original estimate for SPSM was $127.90 million. A change in project scope increasing station capacity from 110 people to 150 people, as well as a project schedule extension, increased the cost estimate to $133.44 million (+$2.52 million for increased scope; +$3.02 million due to weather-induced schedule delays). Additional weather delays last year again adversely impacted planned material deliveries resulting in a further revised schedule. The current projection is 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 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 $132.49 million through FY 2003. The FY 2004 Estimate includes $1.29 million. Using an updated (extended) schedule, the estimated total cost of SPSM is $136.96 million. SPSM expenditures to date total $74.2 million. Based on industry estimation standards, and taking into account work remaining, it is anticipated that the estimated completion costs could range from $133.8 to $143.3 million. The cost estimate is updated annually. No funds are being requested in the FY 2005 Budget Request.

Appropriated and Requested MREFC Funds for South Pole Station Modernization
(Dollars in Millions)

	FY 2002 and prior years	FY 2003 Approp	FY 2004 Estimate	FY 2005 Request	Est Future Requests	Total
South Pole Station Modernization	$126.49	$6.00	$1.29	$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.

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 1994 & Earlier	12.90						$12.90		**$12.90**
FY 1995	1.10						$1.10		**$1.10**
FY 1996	1.60						$1.60		**$1.60**
FY 1997	0.80						$0.80		**$0.80**
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 Estimate				20.00				$20.00	**$20.00**
FY 2005 Request				18.00				$18.00	**$18.00**
FY 2006 Estimate				10.00				$10.00	**$10.00**
FY 2007 Estimate				2.91	15.00			$2.91	**$2.91**
FY 2008 Estimate					15.38				
FY 2009 Estimate					15.76		$15.76		**$15.76**
Subtotal, R&RA	$16.40				$46.13		$32.16		
Subtotal, MREFC				$133.44				$133.44	
Total, each phase		**$16.40**		**$133.44**		**$46.13**			**$165.60**

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.

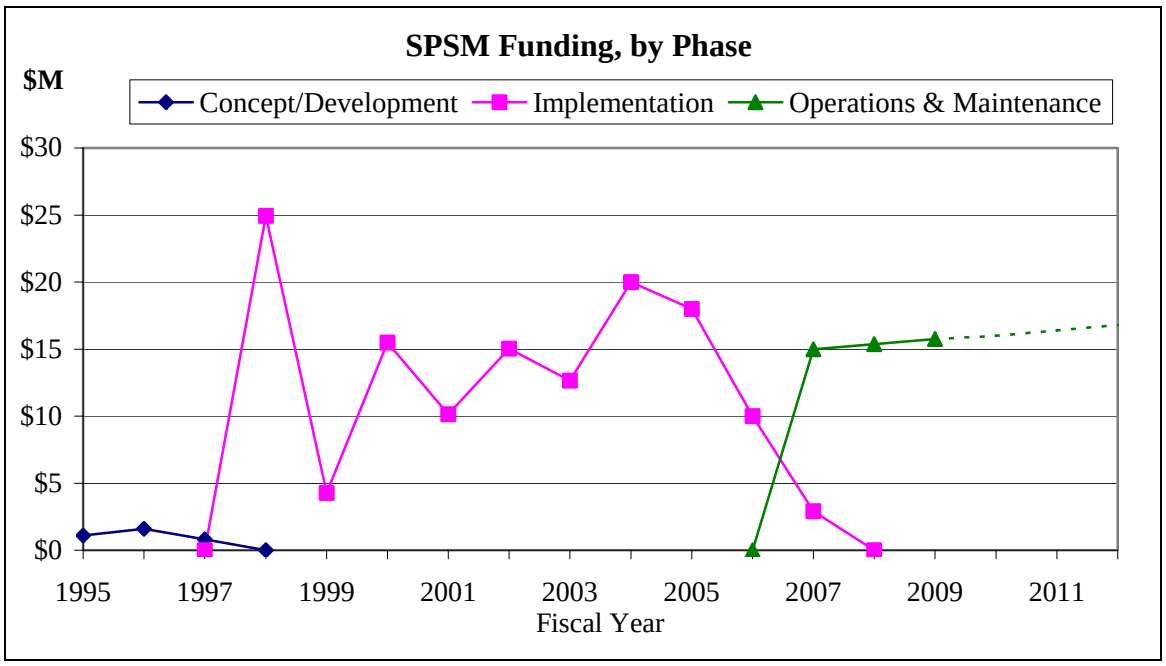
Information on the data in the table is provided below.

- 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.

This is a recent picture of South Pole Station. Another major portion of the new station, containing medical facilities, was approved by NSF for conditional occupancy on 1/28/04. *Credit: the United States Antarctic Project, NSF.*

- 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 slightly 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 $8.3 million.

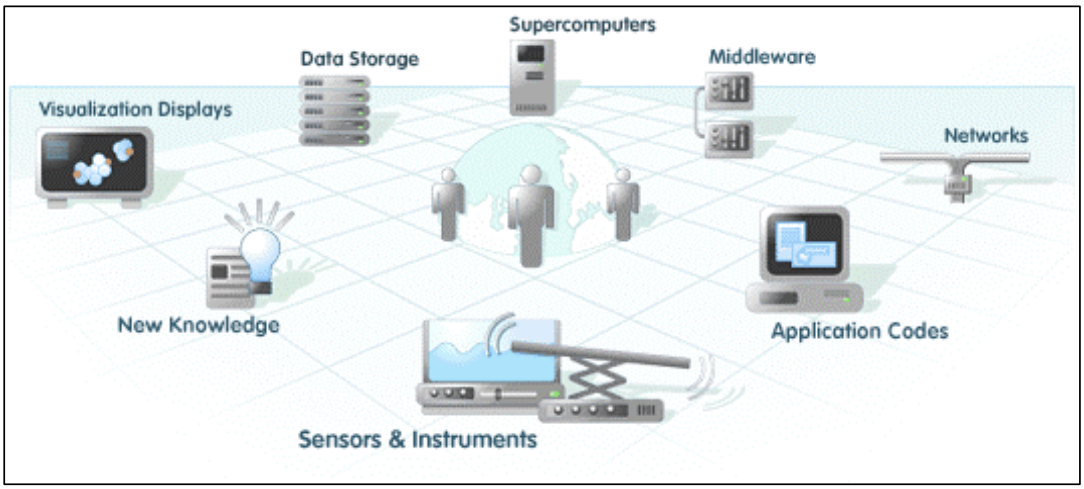
Terascale Computing Systems: Terascale Computing System, Distributed Terascale Facility and Extensible Terascale Facility

Project Description: The NSF Terascale Computing Systems project provides access to scalable, balanced, terascale computing resources for the broad-based academic science and engineering community served by NSF through a series of MREFC construction projects.

A Terascale Computing System (TCS), with peak performance of 6 teraflops, has been built by the Pittsburgh Supercomputer Center (PSC) in partnership with the Compaq Computer Corporation (now Hewlett Packard) under an award made in FY 2000.

A Distributed Terascale Facility (DTF), initiated in FY 2001, is under construction by The National Center for Supercomputing Applications (NCSA) and the San Diego Supercomputer Center (SDSC), with Argonne National Laboratory (Argonne) and the California Institute of Technology (Caltech), and in partnership with IBM, Intel, Qwest, Oracle and SUN. Based on multiple Linux clusters, DTF will link four sites through high-performance networks to create a very high-performance, distributed facility that allows advanced data handling, remote site interaction, and large-scale storage. Initial operation of the Distributed Terascale Facility will begin in January 2004.

In 2002 NSF provided enhancements to the existing Terascale Facilities and initiated the creation of an Extensible Terascale Facility (ETF) by extending the DTF "backbone network" to TCS, and by placing extensible hubs in Chicago and Los Angeles that will permit further expansion of this distributed facility. This ETF "backplane network" will enable science and engineering researchers to conduct analyses at unprecedented scale, to merge multiple data resources seamlessly, and to advance discovery at the frontiers of science and engineering. This Extensible Terascale Facility, called the Teragrid, will provide the national community with at least 10 teraflops of capability in a single system (NCSA) and over 20 teraflops across the ETF including the 6 teraflop TCS system in an integrated facility. Users will have access to at least 500 terabyte of storage at a single site (SDSC) and nearly 1 petabyte across the ETF. The full ETF is expected to be fully operational by September 2004.



The National Science Foundation (NSF) has announced the first steps it is taking to develop a state-of-the-art cyberinfrastructure likely to revolutionize the conduct of science and engineering research and education. These steps leverage the agency's recent investments in the Extensible Terascale Facility and its six-year investments in the Partnerships for Advanced Computational Infrastructure. *Credit: the Directorate for Computer and Information Science and Engineering, NSF.*

In FY 2003, NSF made awards to extend the ETF to three new sites: Indiana University and Purdue University, Oak Ridge National Laboratory (ORNL), and the University of Texas. These extensions enhance the capabilities of NSF's Extensible Terascale Facility by providing computing resources integrated with scientific instruments and data collections. The new awards will connect neutron scattering instruments at ORNL and other unique computational and data resources in Indiana and Texas to the ETF backbone network for use by the nation's research and education community. The awards funded the high-speed connections required to share local resources across the Teragrid.

In FY 2004, NSF will upgrade the Pittsburgh facility for higher performance. In FY 2005 and beyond, the Terascale facilities will be managed as part of NSF Cyberinfrastructure plans to create an integrated

system of state-of-the-art computing, communications and information resources, tools and services. The plans for Cyberinfrastructure are described in the Tools chapter.

Principal Scientific Goals: To provide state-of-the-art capabilities for simulation and modeling for a vast array of scientific, engineering and mathematical problems in traditional disciplines like physics, chemistry, geosciences, and engineering, as well as in disciplines such as biology and the social and economic sciences, where computing is emerging as a critical new tool. A secondary goal made possible by the distributed architecture of ETF is to seamlessly link large, managed scientific data archives and the high-performance computational resources that can be used to mine, analyze, visualize, and perform related simulations on the data.

Principal Education Goals: To provide access and training to U.S. students, graduate students, and postdoctoral fellows in the use and applications of high-performance computing hardware and software, and to insure that there is a highly-trained scientific workforce with experience in applying state-of-the-art supercomputer technology to basic research problems of national importance in all areas of science and engineering.

Partnerships and Connections to Industry: Several industries are partners in the construction of TCS, DTF, and ETF. Primary industrial partners include Hewlett Packard, IBM, Intel, Juniper, Force 10, Qwest, SUN, and Oracle.

Management and Oversight: Oversight of this project is provided through a Program Manager in the Shared Cyberinfrastructure Subactivity in the Computer and Information Science and Engineering (CISE) Activity. Oversight is supported by the NSF Project Advisory Team consisting of representatives from the Office of General Counsel, the Office of Budget, Finance and Award Management, CISE, Education and Human Resources, Biological Sciences, Geosciences, Mathematical and Physical Sciences, and Engineering Activities. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance. An external Technical Advisory Panel makes periodic site visits to the Terascale facility institutions to review construction progress and provide technical advice to the Program Manager. The Technical Advisory Panel participates in resolution of major technical, managerial, or scheduling concerns; provides technical guidance/advice, especially with regard to the integration and coordination with other NSF Partnerships for Advanced Computational Infrastructure (PACI) program activities; and reviews and, where required, approves technical reports and information to be delivered by the Awardees.

The DTF and ETF Terascale Activities have a centralized management organization with a single Project Director. An executive committee, comprised of the Principal Investigators who participated in the Terascale awards, advises the Project Director on the construction, management and operation of the Terascale facilities. Also reporting to the Project Director are an External Advisory Committee, an Institutional Oversight Committee, and a User Advisory Committee.

Current Project Status: TCS was dedicated on October 29, 2001. It began allocated usage in April 2002. The first stage of DTF is complete and in testing with "friendly" users; it will begin allocated usage in early 2004. ETF will begin allocated usage in October of 2004.

Milestones for the Terascale Computing Systems are outlined below:

FY 2002 Milestones (Completed except as noted):

Terascale Computing System

Begin full operations of TCS (initial site – 2nd quarter).

Distributed Terascale Facility:

Begin construction of DTF (second site – 1st quarter);

Complete infrastructure preparation at four DTF sites (power, cabinets, air conditioning – 2nd quarter);

Contract for High Performance Network connections between Chicago and Los Angeles (2nd quarter);

Take delivery of backplane networks (3rd quarter); and

Take delivery of initial DTF cluster computers (4th quarter – Completed in 1st quarter FY 2003).

Extensible Terascale Facility:

Review and award supplements to TCS and DTF awardees for hardware and networking upgrades to fully integrate them with DTF backplane, and to create an Extensible Terascale Facility (ETF); (4th quarter) and

Hold workshop for additional sites that are interested in connecting to ETF.

FY 2003 Milestones:

Terascale Computing System:

Install TCS computing, storage and networking upgrades awarded for integration of TCS into ETF (2nd quarter).

Distributed Terascale Facility:

Complete installation and testing of initial clusters and DTF backplane networks (1st quarter);

Installation and testing of High Performance Network connections (1st quarter);

Complete installation and testing of operating software (OS, middleware, Globus) (2nd quarter);

Complete construction and integration of all DTF clusters (3rd quarter); and

Conduct performance testing on DTF (4th quarter).

Extensible Terascale Facility:

Install Hub Routers in Chicago and Los Angeles (1st quarter);

Competition to extend ETF to additional sites (2nd quarter).

Install computing and storage upgrades at all 5 ETF sites (3rd quarter);

Complete integration of TCS with DTF (4th quarter); and

Complete high speed connection between Chicago and the Pittsburgh Supercomputing Center (4th quarter);

FY 2004 Milestones:

Terascale Computing System:

Continue full operations.

Make award for upgrade of Terascale Computing System.

Distributed Terascale Facility:

DTF construction completed; acceptance and friendly user testing starts (1st quarter); and

DTF enters production use (2nd quarter).

Extensible Terascale Facility:

Full integration of all 5 sites into ETF including ETF hardware upgrades (3rd quarter);

Begin Allocated usage of ETF (4th quarter);

Begin integration of additional sites into ETF (2ndquarter), and

Complete integration of extensions sites (4th quarter).

Funding Profile: The recommendation to fund ETF in FY 2002 was presented at the National Science Board meeting in August 2002. In order to make certain that all questions raised during the review had been addressed and responded to in writing, the NSB postponed approval of the award to the next

meeting, scheduled for October, 2002, which resulted in a carryover of funds into FY 2003. The NSB approved the award at their October meeting, and the funds have subsequently been obligated. The FY 2003 Request included $20.0 million to extend ETF to additional resource sites that included: additional computational resources; large data archives; large instrumentation facilities; or large sensor networks.

MREFC Appropriations for Terascale Computing Systems
(Dollars in Millions)

FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Total
$36.00	$44.90	$35.00	$9.94	$9.94	$135.78

Terascale Computing Systems Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance[3]		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 1998	0.06						$0.06		0.06
FY 1999									
FY 2000				36.00				$36.00	36.00
FY 2001				44.90	2.37		$2.37	$44.90	47.27
FY 2002[1]					7.06		$7.06		7.06
FY 2003				44.83	11.17		$11.17	$44.83	56.00
FY 2004 Estimate[2]				10.05	10.00		$10.00	$10.05	20.05
FY 2005 Request					97.90		$97.90		97.90
FY 2006 Estimate					99.56		$99.56		99.56
FY 2007 Estimate					101.56		$101.56		101.56
FY 2008 Estimate					103.89		103.89		103.89
FY 2009 Estimate					106.49		106.49		106.49
Subtotal, R&RA	$0.06				$540.00		$540.06		$540.06
Subtotal, MREFC				$135.78				$135.78	$135.78
Total, Each Phase		**$0.06**		**$135.78**		**$540.00**			**$675.84**

NOTE: A strategic plan for the long-term support of NSF's Terascale Facility as part of the Cyberinfrastructure effort is under development at the time of this request. See the Cyberinfrastructure section under Tools for detailed information.
[1]FY 2002 MREFC funding for Terascale was carried over into FY 2003 due to the NSB meeting schedule. The award was approved in October, 2002 and the funds were subsequently obligated.
[2]The FY 2004 Estimate includes implementation funds totaling $110,000 carried over from FY 2003.
[3]Operations funding in FY 2005 and beyond represents operations and maintenance support for Widely-shared Cyberinfrastructure, of which support for the operation and maintenance of the Terascale Computing Systems is about $10.0 million in FY 2005. Terascale will be fully integrated with Cyberinfrastructure in future years. Operations estimates for FY 2006 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available. For further information on Widely-shared Cyberinfrastructure, please refer to the Tools chapter.

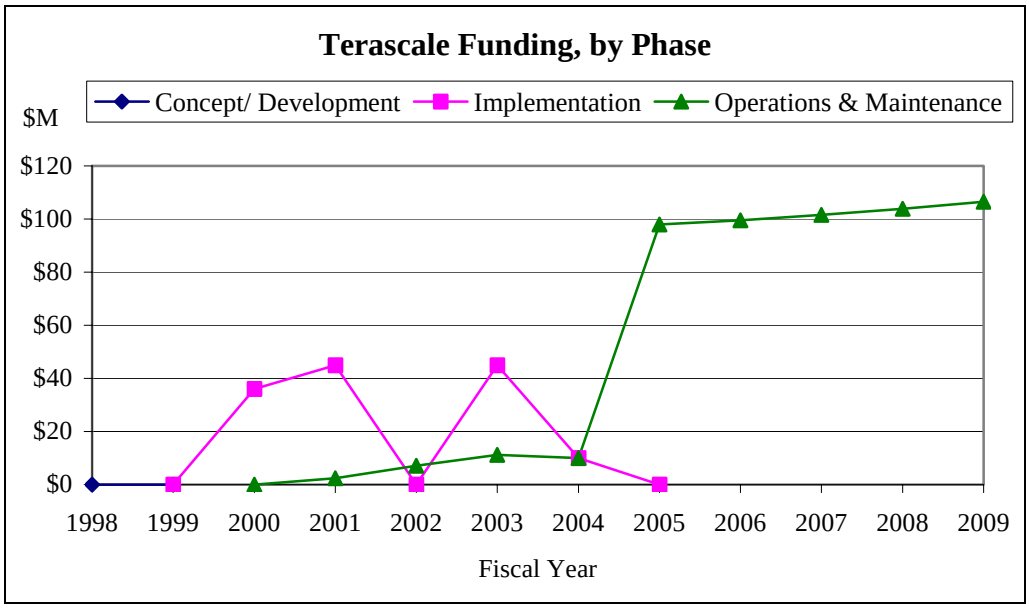
Information pertaining to the data in the table is provided below.

- Concept/Development: Planning for Terascale Computing Systems began in 1998, with a series of 3 workshops held at NSF to assess the need within the academic research community for computational resources with multi-teraflop capability. Because it was anticipated that Terascale Computing Systems would be constructed by partnerships involving academic institutions and commodity

hardware vendors, NSF employed a peer-reviewed, competitive solicitation process in FY 2000 and 2001 to select the best designed systems for funding. In FY 2002 the original systems have been upgraded, and funding for the extension of DTF to form the ETF was provided. In FY 2003 ETF was extended with additional awards integrating additional sites into it. In FY 2004, $9.94 million from MREFC funds will be used to upgrade the Pittsburgh Terascale facility.

- Implementation: TCS was funded at Pittsburgh Supercomputer Center in FY 2000. It was fully operational in first quarter of 2002. DTF was funded at UCSD and NCSA in FY 2001. Construction continued through FY 2003. Funds in FY 2002 enhanced and augmented TCS and DTF, fully integrated TCS and DTF into a single grid-enabled facility, and enabled the DTF to extend beyond the five initial sites. Funds in FY 2003 supported connections of new nodes. In FY 2004, upgrades as called for by rapid advances in computing technologies and systems will be funded at the Pittsburgh Terascale facility.

- Management and Operations: The Terascale facilities incurred operations costs of approximately $7.06 million in FY 2002. Operations costs were $11.17 million in FY 2003. Operations for FY 2004 are estimated at $10.0 million. Operations funding in FY 2005 and beyond represents operations and maintenance support for Widely-shared Cyberinfrastructure, of which support for the operation and maintenance of the Terascale Computing Systems is about $10.0 million in FY 2005. Terascale will be fully integrated with Cyberinfrastructure in future years. Operations estimates for FY 2006 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available. For further information on Widely-shared Cyberinfrastructure, please refer to the Tools chapter.



Future Science Support: Along with the direct operations and maintenance support for Terascale Computing Systems facilities, NSF will support science and engineering research performed at the facilities, through ongoing research and education programs. Terascale Facilities provide support for scientists and engineers funded through all programs supported by the NSF. The annual support for research and education using the Terascale facilities is estimated to be about $160.0 million.

SECOND PRIORITY: NEW STARTS IN FY 2005 AND FY 2006

National Ecological Observatory Network (NEON)

Project Description: NEON will be a continental scale research instrument consisting of geographically distributed infrastructure, 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 comprise 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.

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.*

Principal Education Goals: The 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).

Partnerships and Connections to Industry: Potential federal partners have expressed interest in NEON, including National Park Service, National Forest Service, NASA, USGS, EPA, National Marine Sanctuaries and 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 Director 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 includes 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 Director for Large Facility

Projects is a member of the PAT and will provide 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. 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 CENR.

Current Project Status:

Planning Activities over the past year: There were three activities to further refine NEON science and infrastructure requirements and NEON governance and management. Two NEON Coordination and Implementation Conferences provided open fora for the scientific community to define how to form, manage, and govern NEON. A "scoping" workshop explored how the scientific community would use a network of ecological observation sites to deepen its understanding of the carbon cycle at sub-regional to continental scales. Two publications, the National Research Council (NRC) report and an American Institute of Biological Sciences (AIBS) white paper, were published. The white paper summarized the previous ten NEON workshop reports, synthesized the prior planning efforts, and provided the rationale for a national research platform.

NRC Report: In November 2003, the National Research Council (NRC) released a report entitled "NEON: Addressing the Nation's Environmental Challenges" that strongly endorsed NEON and provided recommendations for its overall implementation. The report identified several major environmental challenges that occur at regional to continental scales, which require nationally distributed infrastructure.

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*)

Program Announcement for NEON Coordinating Consortium (NCC) and Project Office: The FY 2004 Estimate level does not fund NEON in the MREFC Account, but encourages NSF to continue planning and development activities. A program announcement will be released in FY 2004 to solicit proposals to refine NEON, which includes: developing the Project Execution Plan, establishing a coordination and governance structure, and setting up the NEON Project Office for administration and management. The NCC will establish a governance board, science and technical advisory committees, membership organization, and the NEON Project Office, and provide the scientific leadership, organizational structure, and overall governance of NEON.

Major milestones for NEON are listed below.

FY 2004 Milestones:

NEON Coordinating Consortium and Project Office awarded (4th quarter)
Refine NEON Project scope, budget, and schedule for research
Preliminary baseline design for NEON networking, informatics, education, training, and outreach

FY 2005 Milestones:

Final baseline design for NEON networking infrastructure, informatics, and education, training, and outreach
Preliminary Project Execution Plan for NEON research infrastructure

FY 2006 Milestones:
Final Project Execution Plan for NEON research infrastructure
Initiate construction of NEON networking infrastructure, informatics, and education, training and outreach
Evaluation of the NCC and Project Office

FY 2007 Milestones:
Installation and construction NEON research infrastructure
Continued construction of NEON networking infrastructure, informatics, and education, training and outreach

FY 2008 – FY 2010 Milestones:
Continued construction NEON research infrastructure
Continued construction of NEON networking infrastructure, informatics, and education, training and outreach

Funding Profile: In FY 2004, NSF requested $12.0 million in the MREFC Account to initiate construction of the first two NEON observatories. While the FY 2004 Estimate level does not provide funding, NSF will consider the recommendations in the NRC report, and continue to refine NEON planning with funds within the Research and Related Activities Account.

In FY 2004 the NEON Coordinating Consortium and Project Office will be established to refine NEON Project scope, budget, and schedule for research infrastructure. The NCC and Project Office will establish the governance and management structure for NEON, mechanisms for obtaining a community-driven definition of the location and types of infrastructure needed to address and prioritize the environmental grand challenges, and develop the preliminary baseline definition for the networking; informatics; and education, training, and outreach infrastructure in NEON.

In FY 2005, the NCC and Project Office will complete the preliminary Project Execution Plan for NEON research infrastructure. The Project Office will prepare the Final baseline design for NEON networking infrastructure, informatics, and education, training, and outreach.

Requested MREFC Funds for NEON
(Dollars in Millions)

FY 2005 Request	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	Total
$12.00	$16.00	$20.00	$20.00	$20.00	$12.00	$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		**$0.01**
FY 1999	0.03						$0.03		**$0.03**
FY 2000	0.17						$0.17		**$0.17**
FY 2001	0.10						$0.10		**$0.10**
FY 2002	1.00						$1.00		**$1.00**
FY 2003	0.92						$0.92		**$0.92**
FY 2004 Estimate	4.00						$4.00		**$4.00**
FY 2005 Request	4.00			12.00			$4.00	$12.00	**$16.00**
FY 2006 Estimate	1.00			16.00	0.25		$1.25	$16.00	**$17.25**
FY 2007 Estimate	1.00			20.00	0.25		$1.25	$20.00	**$21.25**
FY 2008 Estimate	1.00			20.00	3.00		$4.00	$20.00	**$24.00**
FY 2009 Estimate	1.00			20.00	6.00		$7.00	$20.00	**$27.00**
FY 2010 Estimate	1.00			12.00	9.00		$10.00	$12.00	**$22.00**
Subtotal, R&RA	$15.23				$18.50		$33.73		
Subtotal, MREFC				$100.00				$100.00	
Total, each phase	**$15.23**			**$100.00**	**$18.50**				**$133.73**

NOTE: The expected operational lifespan of this project is 30 years after construction is complete in FY 2010. A steady state of $9.0 million in operations support is anticipated by FY 2010. Operations estimates for FY 2006 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

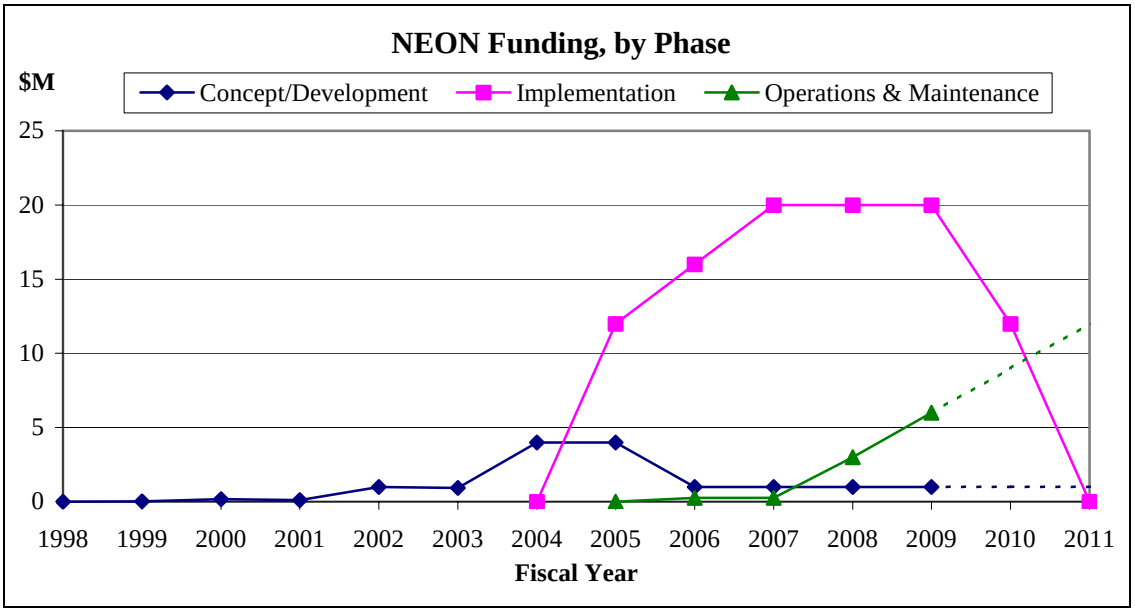
[1]FY 2006-10 implementation funding will be contingent upon the Project Execution Plans for research infrastructure, networking and informatics, and education, outreach, and training.

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

- Concept/Development: In FY 2002-2003 workshops were funded to specifically address the information technology needs, instrument array design and development, and data, information management architectures and synthesis of a regional-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 will be released for a NEON Consortium and Project Office to provide the central management and governance of NEON and to develop the project execution plans for a continental implementation strategy based on nationally significant ecological research challenges. In FY 2005, funding for NEON enabling technologies will be supported.

- Implementation: Total construction costs for NEON will be determined from the project execution plan developed for research, networking, and education infrastructure. In FY 2005-06 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 2006.

- Operations and Maintenance: Initial operations support will commence in FY 2006 as construction is completed on NEON networking, and informatics infrastructure. Operations and maintenance support will increase as the research platform is established.



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.

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.

Scientific Ocean Drilling Vessel (SODV)

Project Description: This project is to support the contracting, conversion, outfitting and acceptance trials of a deep-sea drilling vessel for long-term use in a new international scientific ocean drilling program. Commercial drillships are not routinely configured or equipped to meet the requirements of scientific research. 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. (For more information on the IODP, please refer to the Tools chapter.) The IODP is co-led by the NSF and the Ministry of Education, Culture, Sport, Science and Technology (MEXT) of Japan. European and other Asian nations are also participating in the program.

Pictured above is the JOIDES *Resolution*, the current drillship of the Ocean Drilling Program. MREFC funds are requested in FY 2005 to modify this or a similar ship to provide the Integrated Ocean Drilling Program with light drillship capability. *Credit: Joint Oceanographic Institutions (JOI).*

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

Principal Education Goals: To engage students and the public in geoscience discovery through distance learning initiatives, preparation of classroom modules on IODP research initiatives, and outreach displays at museums and educational/teaching institutions.

NSF Management and Oversight: The project is managed and overseen by a project manager in the Division of Ocean Sciences in the Directorate for Geosciences. The project director receives advice and oversight support from a NSF Project Advisory Team, which consists of representatives from the Geosciences Activity, the Office of Polar Programs, the Office of Budget, Finance and Award Management, and the Office of General Counsel. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide advice and assistance. A scientific-user-community advisory committee has been established to provide recommendations and advice on vessel conversion planning.

Current Project Status: Following proposal review and evaluation, NSF signed a contract with JOINT Oceanographic Institutions, Inc. (JOI) in September 2003 to provide drillship and science services for the IODP. JOI has contracted for drilling services in 2004 and 2005 on the *JOIDES Resolution*, which was used in ODP and is capable of addressing some IODP objectives. A separate task of the NSF-JOI contract is to plan and implement the SODV MREFC project, which will provide an enhanced vessel for long-term IODP use. Initial conceptual planning has been completed for the SODV within the U.S. scientific community, including vessel, drilling and laboratory requirements. Detailed planning by JOI will continue in FY 2004 under R&RA funding in the Geosciences Directorate, with project implementation (MREFC funding) beginning in FY 2005 with vessel contracting. The project schedule is outlined below:

FY 2004 Milestones:
- Solicit drilling contractor capabilities, recommendations and interest (1st-2nd quarter)
- Prepare initial MREFC Project Execution plan for approval (1st – 2nd quarter)
- Prepare RFP for drilling contractor (2nd and 3rd quarter)
- Refine laboratory requirements (2nd and 3rd quarter)
- Release RFP and evaluate responses (3rd and 4th quarter)

FY 2005 Milestones:
- Inspect vessels (1st quarter)
- Vessel decision and contracting – initiate SODV MREFC project (1st quarter)
- Initiate equipment procurement – (2nd quarter)
- Sign shipyard contract – (3rd quarter)
- Begin shipyard conversion of drillship (4th quarter)

FY 2006 Milestones:
- Complete shipyard conversion (1st quarter)
- Outfit laboratories (1st quarter)
- Vessel acceptance trials (1st and 2nd quarters)
- Vessel commissioning and acceptance – terminate SODV MREFC project (3rd quarter)
- Vessel scientific operations begin (3rd quarter)

Funding Profile: Planning through FY 2003 cost approximately $2.70 million. In 2004, approximately $2.1 million will be provided to initiate contract activity, planning and design. In FY 2005 and FY 2006, $40.85 million and $59.94 million is requested through the MREFC Account respectively, for a total MREFC request of $100.79 million for conversion/equipping/testing of the drillship.

Requested Funds for the SODV
(Dollars in Millions)

FY 2005 Request	FY 2006	Total
$40.85	$59.94	$100.79

SODV Funding Profile
(Dollars in Millions)

	Concept/ Development		Implementation		Operations & Maintenance[1]		Totals		**Grand**
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	**Total**
FY 2000	0.10						$0.10		**$0.10**
FY 2001	0.20						$0.20		**$0.20**
FY 2002	0.30						$0.30		**$0.30**
FY 2003	2.10						$2.10		**$2.10**
FY 2004 Estimate	2.10				35.60		$37.70		**$37.70**
FY 2005 Request	0.50	4.00		36.85	31.60		$32.10	$40.85	**$72.95**
FY 2006 Estimate		1.00		58.94	37.00		$37.00	$59.94	**$96.94**
FY 2007 Estimate					65.00		$65.00		**$65.00**
FY 2008 Estimate					67.00		$67.00		**$67.00**
FY 2009 Estimate					69.00		$69.00		**$69.00**
FY 2010 Estimate					70.73		$70.73		**$70.73**
FY 2011 Estimate					72.49		$72.49		**$72.49**
FY 2012 Estimate					74.31		$74.31		**$74.31**
Subtotal, R&RA	$5.30				$522.72		$528.02		
Subtotal, MREFC		$5.00		$95.79				$100.79	
Total, each phase		**$10.30**		**$95.79**		**$522.72**			**$628.81**

NOTE: The expected operational lifespan of this project is 15 years, beginning in FY 2006. A steady state of about $53 million in operations support is expected to occur in or about FY 2006 as the SODV vessel begins full operations. Operations estimates for FY 2008 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

[1]R&RA operations and maintenance funds in FY 2004 will support ODP drilling operations on the *JOIDES Resolution.* Operations and maintenance support for FY 2005 and beyond represents funding for the Integrated Ocean Drilling Program (IODP), of which the SODV is the largest part. For further information on the IODP, please refer to the Tools chapter.

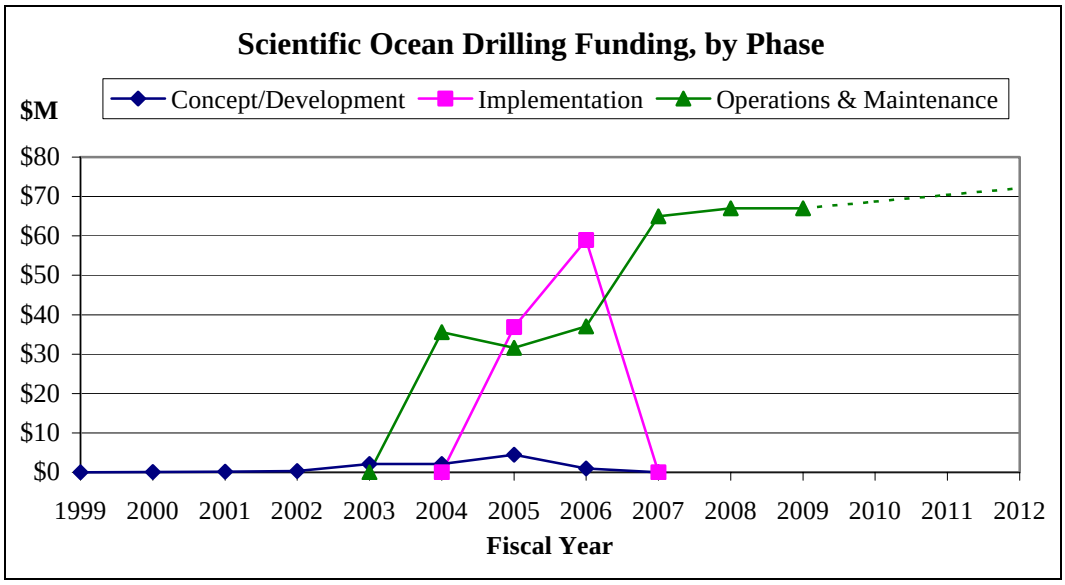
Information pertaining to the data in the table is provided below.

- Concept/Development: Activities supported by the R&RA Account began immediately upon contract award in September 2003. This includes: efforts necessary to begin IODP planning in FY 2003 with Japanese partners and the scientific user community; planning and initiating IODP drilling operations from the *JOIDES Resolution*, development of the SODV Project Execution Plan by the contractor; development of the Environmental Impact Statement for the non-riser drilling vessel; initiation of

planning for shore based support of the program, including core storage, data management systems, and logistics.

- Implementation: The MREFC funds in FY 2005-06 are requested 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 requested for vessel lease during modification and for sea-trial operations of approximately four months duration in FY 2006.

- 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 will be required 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 $31.0 million.

Rare Symmetry Violating Processes (RSVP)

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 extraordinary opportunity to empower a large and growing community led by university-based groups to make major discoveries. Two major experiments are to be pursued through this proposal: MECO (Muon to Electron Conversion) and KOPIO ($K^{o}_{L} \rightarrow \pi^{o}$ ν ν-bar).

At the sensitivity frontier, reactions occur very rarely and when they occur, they are accompanied by "noise" much larger than the sought after signal. Both of these challenges must be addressed by the

experiments, and if successful, they will push this frontier by many orders of magnitude. The scale of these experiments, both in cost and technical complexity, is set by the extraordinary sensitivity required to do this science.

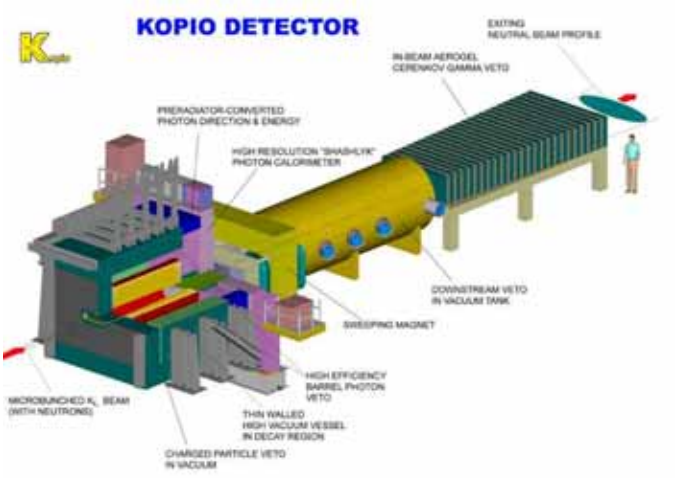
These experiments address two great mysteries, so that if the challenges are met, the rewards are great. Each of the reactions above has special properties that allow these experiments to uncover fundamental new physics relating to the unexplained absence of anti-matter in the universe, and to the postulated existence of "supersymmetric particles" that existed in the early universe and may be responsible for "dark matter." Most of the universe is known to be made of this mysterious dark matter. And anti-matter, thought to be approximately 50 percent of the universe at its birth, has mysteriously disappeared.

These 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 for these experiments. 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. MECO and KOPIO will extend the sensitivity of probes of rare symmetry violating processes by many orders of magnitude.

Principal Scientific Goals: RSVP consists of two complementary experiments:

- MECO is a search for the conversion of muons to electrons and would be able to detect this process even if it is as rare as 1 event for 10^{17} detected muons. Electrons and muons are a part of a family of elementary particles called leptons, and the family relationship is not understood at a fundamental level. Supersymmetry is thought to underlie this relationship.
- KOPIO is a search for the decay of a neutral kaon (K^{o}_{L}) to a neutral pion, a neutrino and an anti-neutrino. The goal is to understand better a process called CP violation. This process needs to be understood in this universe, which contains matter rather than a mixture of matter and anti-matter.

Principal Education Goals: RSVP is planning the PRINCIPLES Project, a mathematics, science and technology educational enrichment program for fourth grade teachers and students. BNL, SUNY/Stony Brook and other partners will establish an Elementary Teachers Academy at BNL. The keystone of the Academy will be an in-service seminar course at BNL for elementary school teachers that will address the teaching of Mathematics, Science and Technology through investigations or projects by elementary students - focusing on the fourth grade level. Objectives are to show teachers first-hand (1) how and what general principles underlie specific inquiry-based learning activities, and (2) how recourse to such principles can support use of observation and reasoning by their students as they learn. The ultimate goal is to improve student performance in assessments requiring use of these skills. In addition, the strong university makeup of the RSVP collaborations lends itself well to student and postdoctoral educational opportunities. Each of the institutions will train undergraduate and graduate students and postdoctoral associates. They will receive a broad education in detector construction and operation and in data analysis and the interpretation of results.



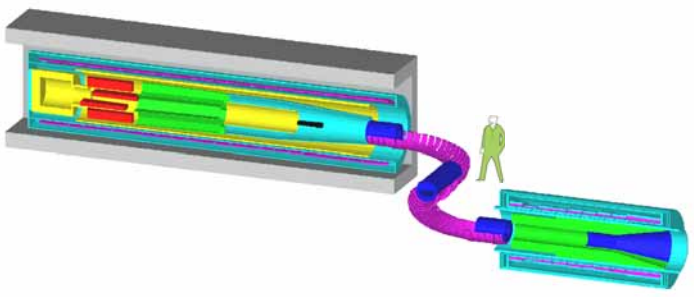
RSVP will address new physics at the cutting edge of the sensitivity frontier, and represents an extraordinary opportunity to empower a large and growing community to make major discoveries. Two major experiments are to be pursued through this proposal: MECO and KOPIO. A diagram of KOPIO is pictured above. *Credit: R. Ruggiero and E. Garber, Brookhaven National Laboratory.*

This opportunity is increasingly rare in particle physics, as most experiments are carried out by much larger collaborations.

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

Management and Oversight: RSVP will, through an NSF/DOE memorandum of understanding currently under development, be a university-led, NSF-supported activity, running concurrently with RHIC. NSF funding includes only incremental AGS operating costs. AGS "landlord responsibilities" rest with the DOE Nuclear Physics program. This sensitivity frontier program is an excellent example of the effective use of governmental facilities.

Management and oversight of RSVP will be provided through the Physics (PHY) Subactivity in the Mathematical and Physical Sciences (MPS) Activity. A designated Program Officer in PHY will maintain primary oversight responsibility, with assistance from an internal Project Advisory Team (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 Director for Large Facility Projects is a member of the PAT and will provide advice and assistance. Additional staff may be required during construction, particularly staff trained in large project management principles.



A diagram of the Muon to Electron Conversion (MECO) Experiment, one of two experiments proposed as part of the Rare Symmetry Violating Processes project. MECO is a search for the conversion of muons to electrons. *Credit:*

A comprehensive Project Execution Plan (PEP) has been drafted and has been reviewed favorably, with minor improvements suggested. The collaboration has benefited from BNL's tested methodology for the development, management and oversight of large projects, with major university participation, at national laboratories. The successful experience of the U.S. Large Hadron Collider (LHC) detector project, now nearing completion, provides confidence in this methodology. The draft version of the PEP includes project-tracking elements such as detailed costs and schedules (Work Breakdown Structure format), milestones, oversight and reporting responsibilities and change controls. The plan includes experienced university-based project managers, a host laboratory role for BNL that involves Environment, Health and Safety responsibilities for the entire project, and review procedures by the experimenters, by BNL, and by the NSF. A direct reporting path from the Project Manager to the NSF Program Officer is part of this plan. NSF management and oversight includes periodic baseline, cost, schedule, and technical reviews for the project and subproject throughout its lifecycle.

Current Project Status: R&D is continuing on critical project components and is expected to continue through FY 2004. RSVP's construction schedule is still under review and discussion. From 2000 through 2003, NSF conducted cost, management, and scientific and technical reviews of RSVP. Each panel consisted of external reviewers, and each rated the project highly. The management reviews indicated areas of potential improvement, which have since been implemented by the collaborators. The last review of RSVP occurred on 20-21 January 2003. At this review, each experiment presented to the NSF review panel a detailed plan for achieving construction readiness. The panel strongly endorsed the plans and recommended that the NSF fund the R&D proposals of both KOPIO and MECO. The review panel

concluded that the roadmaps to construction readiness were well thought out and provided a basis for applying resources to bring the RSVP experiments to construction readiness in a timely way. The review panel recommended starting construction of RSVP as soon as possible after baseline reviews are conducted. The baseline reviews that establish the Work Breakdown Structures are expected to take place in Spring 2004.

The milestones listed below are preliminary and will likely be revised as the project's schedule is finalized.

FY 2004 Milestones:
- Complete MECO magnet acquisition plan.
- Begin KOPIO beam studies at AGS.
- Begin MECO detector studies

FY 2005 Milestones (Requested Construction Start):
- Complete KOPIO and MECO AGS and beam design modifications.
- Begin KOPIO detector construction.
- Begin MECO detector design and construction.
- Complete MECO magnet engineering design and start construction

FY 2006 Milestones:
- Begin KOPIO delivery of modules
- Begin MECO trigger and data acquisition design
- Begin MECO magnet coil production.

FY 2007 Milestones:
- Complete construction of AGS beams for KOPIO and MECO
- Begin KOPIO and MECO detector installation
- Complete design of the KOPIO and MECO data acquisition and trigger systems

FY 2008 Milestones:
- Complete data acquisition system and trigger construction and installation.
- Complete delivery and installation of MECO magnet coils.
- MECO Magnet acceptance tests
- KOPIO Trigger and data acquisition tests

FY 2009 Milestones:
- Complete construction and installation
- Perform engineering runs

FY 2010 Milestones:
- First data runs

Funding Profile: Through FY 2003, $4.0 million has been spent for concept and development of RSVP through the R&RA Account. The total construction cost of the project is estimated at $144.91 million over five years. The current funding plan is presented below.

Requested MREFC Funding for RSVP
(Dollars in Millions)

FY 2005 Request	FY 2006	FY 2007	FY 2008	FY 2009	Total
$30.00	$42.66	$44.00	$20.25	$8.00	$144.91

RSVP 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	0.90						$0.90		**$0.90**
FY 2002	1.20						$1.20		**$1.20**
FY 2003	1.90						$1.90		**$1.90**
FY 2004 Estimate	6.00						$6.00		**$6.00**
FY 2005 Request				30.00				$30.00	**$30.00**
FY 2006 Estimate				42.66				$42.66	**$42.66**
FY 2007 Estimate				44.00				$44.00	**$44.00**
FY 2008 Estimate				20.25	5.30		$5.30	$20.25	**$25.55**
FY 2009 Estimate				8.00	8.50		$8.50	$8.00	**$16.50**
FY 2010 Estimate					8.50		$8.50		**$8.50**
FY 2011 Estimate					13.50		$13.50		**$13.50**
FY 2012 Estimate					15.00		$15.00		**$15.00**
Subtotal, R&RA	$10.00				$50.80		$60.80		
Subtotal, MREFC				$144.91				$144.91	
Total, each phase		**$10.00**		**$144.91**		**$50.80**			**$205.71**

NOTE:. The estimated operational lifetime of the experiments will be least 10 years after the end of construction. A steady state of about $15.0 million in operations support is expected to occur on or about FY 2012. Operations estimates for FY 2008 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

[1]The total project cost for RSVP has had several reviews. However, the total shown is still an estimate, and the funding stream has not yet been baselined. A baseline review is scheduled for June 2004.

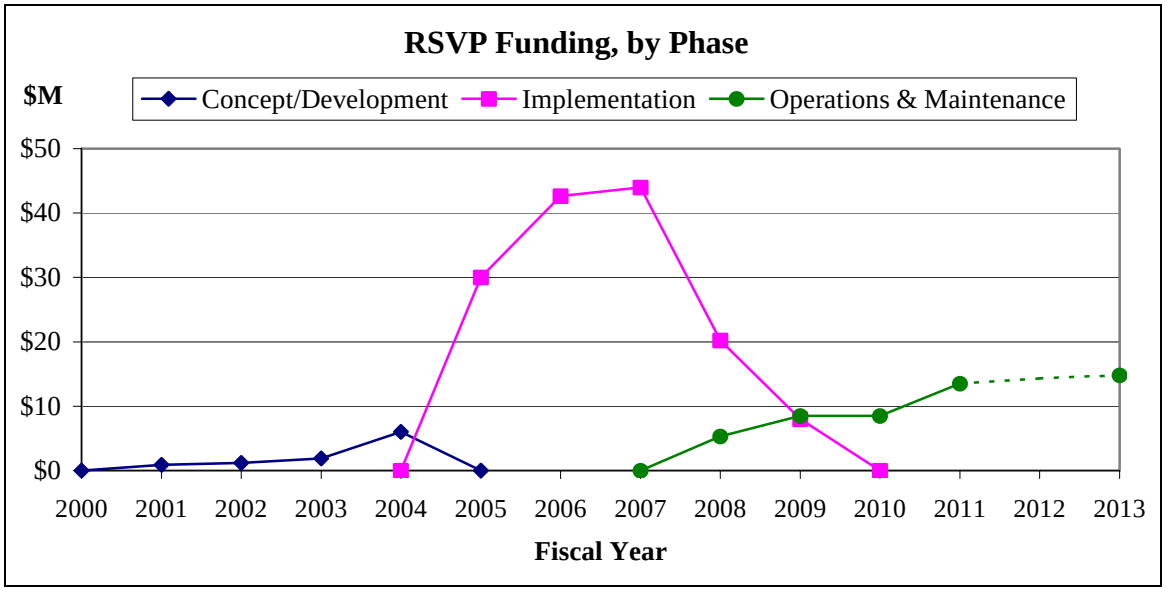
Information on the data in the table is provided below.

- Concept/Development: The technical needs of RSVP require a strong R&D program that is now in progress. R&D teams have been formed, and prototype detector elements have been built and tested. In addition to R&D on all KOPIO and MECO components, a major component of MECO is a sequence of high-field, superconducting solenoids appropriately instrumented for particle detection and readout. These solenoids have very tight and challenging field requirements, and the MECO collaboration, with a group at the MIT Plasma Science and Fusion Center, has completed a detailed conceptual design of the magnet system that proves its feasibility and lays the groundwork for industrial production. KOPIO requires a low-energy, time-structured K^o beam, which allows a precise determination of the incident kaon momentum on an event-by-event basis using time-of-flight techniques. R&D is underway on the KOPIO Alternating Gradient Synchrotron (AGS) modifications. All R&D is under periodic review by technical panels.

- 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. This work will be

performed by BNL personnel. For the KOPIO detector, universities will construct the critical beam, catcher, radiator and veto counter assemblies. The MECO superconducting magnets will be constructed by industry after a conceptual design is complete, but MECO collimators, targets, beam stops, and calorimeters will be constructed at universities.

- Operations and Maintenance: Support for operations and management will phase in as the project is under construction. Initial funds provided through R&RA will support project managers for MECO and KOPIO and a project management office. Test beam operations can begin in FY 2008 and will ramp up as detector elements are completed. Full operations costs are expected to be approximately $15.0 million beginning in about FY 2012.



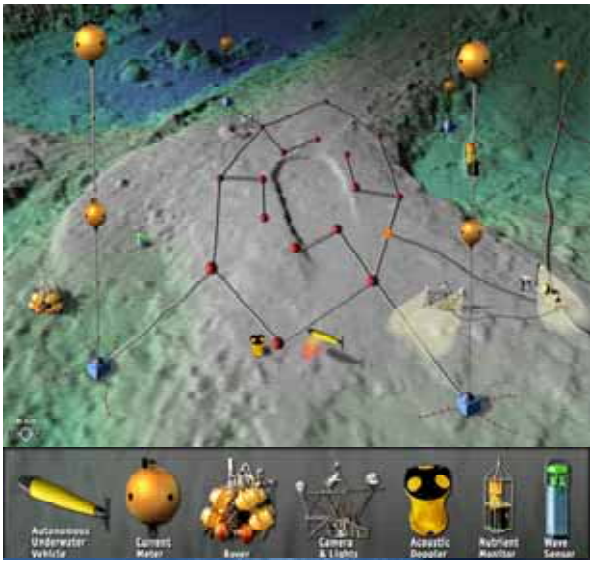
Future Science Support: Along with direct support for operations and maintenance, NSF will also support physics research performed at this facility, through ongoing physics research and education grants. Support for such activities is presently estimated to be about $4.0 million per year from NSF, once the facility reaches full operations.

Ocean Observatories Initiative (OOI)

Project Description: This project will construct an integrated observatory network that will provide the oceanographic research and education communities with continuous access to the ocean. The OOI will have three elements: 1) a regional cabled network consisting of interconnected sites on the seafloor spanning several geological and oceanographic features and processes, 2) relocatable deep-sea buoys, 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.

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 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 observation 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; an ability to operate during storms and in harsh conditions; an ability to accommodate plug and play 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 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.



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.*

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 the Ocean Sciences Subactivity (OCE) in the Geosciences Activity (GEO). The program manager will receive advice and oversight support from an NSF Project Advisory Team that includes representatives from GEO, the Office of Budget, Finance and Award Management, the Office of International Science and Engineering, the Office of General Counsel, and the Office of Legislative and Public Affairs. The NSF Deputy Director for Large Facility Projects is a member of the PAT and will provide 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 to be established through a cooperative agreement with NSF. The Director will be accountable to an Executive Committee under which will be established Scientific

and Technical Advisory Committees. The Executive and Advisory Committees will draw their membership from individuals with expertise in ocean observing science and engineering. 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: Current activities are concentrating on the development of implementation plans for the three components of the OOI to facilitate the high priority science developed through community input. For coastal observatories a workshop organized through the Coastal Ocean Processes Program (May 2002) to provide advice on the use of observing infrastructure for advancing coastal science. The report was published in December 2002. This activity was followed in November 2003 by a more focused workshop to address implementation issues related to coastal observing systems of the OOI. For the regional cabled observatory component of the OOI, a workshop was held in August 2002 to document the high priority science requiring the use of submarine cable technology. The report from this workshop was published in April 2003. This activity was followed by a workshop in October 2003 whose goal was to focus on the location and design of a regional cabled observatory. In February 2003 a community activity was held to address deployment issues related to a global network of moored buoy systems to facilitate multi-disciplinary science. The report of this group is to be completed in January 2004. A large, multi-disciplinary workshop was held in January 2004 to develop an initial science plan for the OOI across coastal, regional, and global scales. The report from this workshop is expected in Spring 2004. In addition to these activities, OCE sponsored a National Research Council study to provide recommendations for an overall implementation plan for the OOI. This report was released in July 2003. In early 2004 a cooperative agreement will be established for the Ocean Observatory Project office.

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

FY 2002 Milestone (Completed):
- Establish NSF Program Management Team

FY 2003 Milestones (Completed):
- Project Management
  - Complete Program Solicitation for the Ocean Observatory Project Office
  - Issue Program Solicitation
  - Proposals submitted
  - Proposal evaluation and selection

FY 2004 Milestones:
- Project Management
  - Recommend award for Project Office (Completed)
  - Completion of OOI Internal Management Plan (1^{st} – 2^{nd} quarter)
  - Completion of OOI Initial Science Plan (2^{nd} quarter)

FY 2005 Milestones:
- Project Management
  - Completion of OOI Science Plan
  - Systems engineering review of OOI
  - Complete design of data management and archiving system
  - Completion of OOI Project Execution Plan

FY 2006 Milestones:
- Project Management
  - Submission of Project Execution Plan for review to the Deputy Director, Large Facilities Projects
  - Implementation of data management and archiving system
- Coastal Observatories
  - Issue Program Solicitation for establishment of coastal observing infrastructure
- Deep-Sea Buoys
  - Design and testing of moored buoyed systems
  - Issue Program Solicitation for establishment of moored buoy infrastructure
- Regional Cabled Network
  - Cable-route surveys and planning
  - Design, inspection and testing of cables, connectors, nodes, and shore equipment
  - Purchase of fiber optic cable

FY 2007 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
  - Installation of deep-sea buoys
  - Issue Program Solicitation for establishment of moored buoy infrastructure
- Regional Cabled Network
  - Physical (hardware and software) system integration and testing prior to deployment
  - Preparation of shore facilities and installation of equipment.

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
  - Installation of deep-sea buoys
  - Issue Program Solicitation for establishment of moored buoy infrastructure
- Regional Cabled Network
  - Installation and subsequent inspection of first cable backbone section
  - Installation of science nodes on first backbone section

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
  - Installation of deep-sea buoys
  - Issue Program Solicitation for establishment of moored buoy infrastructure
- Regional Cabled Network
  - Testing and commissioning of first backbone section
  - Installation and subsequent inspection of second cable backbone section
  - Installation of science nodes on second backbone section
  - Installation of initial science experiments on first backbone section

FY 2010 Milestones:

Coastal Observatories

Construction and deployment of coastal observing infrastructure

Deep-Sea Buoys

Installation of deep-sea buoys

Regional Cabled Network

System testing and commissioning

Installation of initial science experiments on second backbone section

Funding Profile: NSF expects to spend approximately $25.20 million in concept and development activities through FY 2005. The total construction cost for OOI is $245.70 million beginning in FY 2006. Management, operations and maintenance will be funded through the R&RA Account.

Requested MREFC Funds for OOI
(Dollars in Millions)

FY 2006 Request	FY 2007	FY 2008	FY 2009	FY 2010	Total
$24.76	$63.44	$65.00	$47.30	$45.20	$245.70

Ocean Observatories Initiative 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	1.60						$1.60		**$1.60**
FY 2002	11.00						$11.00		**$11.00**
FY 2003	4.60						$4.60		**$4.60**
FY 2004 Estimate	5.00						$5.00		**$5.00**
FY 2005 Request	3.00						$3.00		**$3.00**
FY 2006 Estimate				24.76	10.00		$10.00	$24.76	**$34.76**
FY 2007 Estimate				63.44	15.00		$15.00	$63.44	**$78.44**
FY 2008 Estimate				65.00	20.00		$20.00	$65.00	**$85.00**
FY 2009 Estimate				47.30	30.00		$30.00	$47.30	**$77.30**
FY 2010 Estimate				45.20	50.00		$50.00	$45.20	**$95.20**
FY 2011 Estimate					51.25		$51.25		
FY 2012 Estimate					52.53		$52.53		**$52.53**
Subtotal, R&RA	$25.20				$228.78		$253.98		**$253.98**
Subtotal, MREFC				$245.70				$245.70	**$245.70**
Total, Each Phase		**$25.20**		**$245.70**		**$228.78**			**$499.68**

NOTE: The expected operational lifespan of this project is 30 years, beginning in FY 2011. A steady state of about $50 million in operations support is expected to occur in or about FY 2010. Operations estimates for FY 2010 and beyond are developed strictly for planning purposes and are based on current cost profiles. They will be updated as new information becomes available.

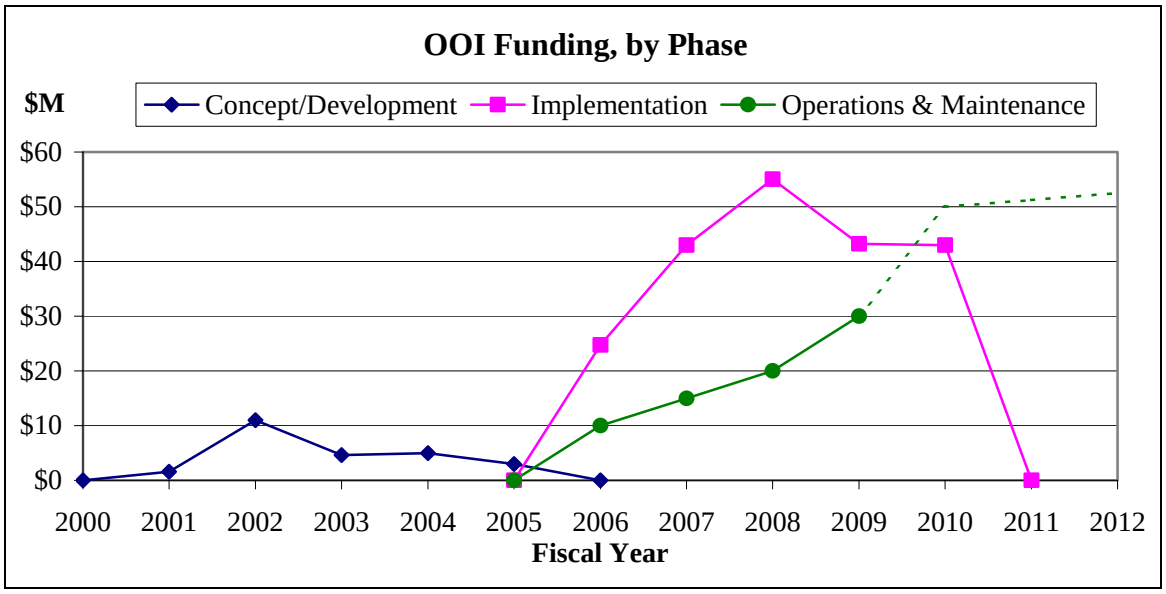
Information pertaining to the data in the table is provided below.

- Concept/Development: R&RA 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 an unsolicited proposal from the Monterey Bay Aquarium Research Institute resulted in a $6.9 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 will also be 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 $50.0 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 38 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* and the oversubscribed schedules of other aging vessels that operate in the region. The ARRV would operate in the challenging

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*

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 ice has become increasingly urgent. The ARRV will provide improved access to the region, enabling further exploration to address these critical issues. With an operating year of 275-300 days per year, the ARRV could support upwards of 500 scientists and students at sea annually.

Principal Scientific Goals: Many cutting edge science projects require an oceanographic platform in the Alaska region to conduct field research ranging from ocean circulation, climate and ecosystem studies to natural hazards and cultural anthropology. Recent climate studies indicate perennial ice in the arctic thinning at 9 percent per decade.

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 the ocean depths, will bring research into the K-12 classroom and to the general public.

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

Management and Oversight: The NSF Coordinator will be the Program Manager for Ship Acquisition and Upgrade Program, Integrative Programs Section/Division of Ocean Sciences/GEO, with other staff in the Integrative Programs Section providing program management assistance. Internal oversight will also be provided by a Project Advisory Team (PAT) including staff from GEO, the Office of Budget, Finance and Award Management (BFA) and the Office of the General Counsel (OGC). 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.

Seakeeping Model Tests of the ARRV. Testing confirmed both excellent sea keeping in the open ocean and the ability to operate effectively in seasonal ice. *Credit: Glosten Associates, Inc.*

Current Project Status: Final model and tank testing and data analysis were successfully completed in 2003. Results from model testing concluded that the current design has excellent seakeeping 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. Currently, the design phase is nearing completion. Documents prepared during this final design phase will be used for developing the shipyard construction contract. 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 (Chaired by the NSF Director).

Milestones for ARRV are outlined below:

FY 2006 Milestones:

Prepare and issue a solicitation to build and operate the ARRV via a cooperative agreement (NSF).
Select the winning proposal through an external merit review process (NSF).
Establish the Systems Integration Office and issue the shipyard construction bid package (awardee).
Adjudicate the construction bids and select the winner (awardee in cooperation with NSF).
Initiate vessel construction (shipyard).
Establish quarterly in depth reviews of construction progress (awardee and NSF).

FY 2007 Milestones:

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

FY2008 Milestones:

Complete construction and scientific outfitting (24 months from award of construction contract).
Undergo sea trials (ship yard, awardee, NSF).
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 funded the concept design, detailed design and model testing for a replacement vessel and is prepared to initiate a two-year construction phase.

Requested Funds for the ARRV
(Dollars in Millions)

FY 2006 Request	FY 2007	Total
$49.32	$32.88	$82.20

ARRV Funding Profile
(Dollars in Millions)

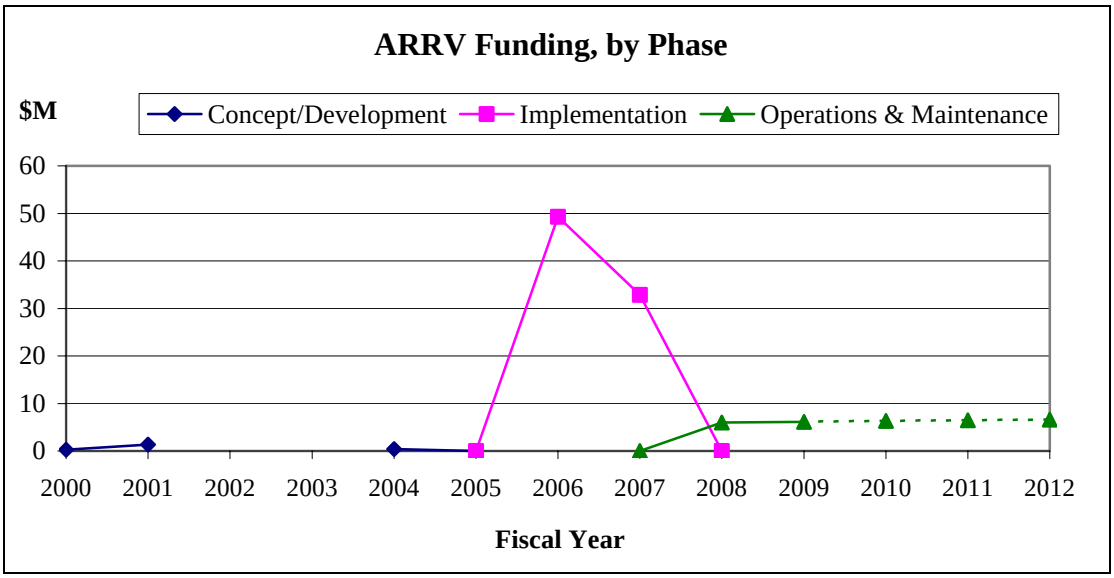
	Concept/ Development		Implementation		Operations & Maintenance		Totals		Grand
	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	R&RA	MREFC	Total
FY 2000 & Earlier	0.25						0.25		**$0.25**
FY 2001	1.36						$1.36		**$1.36**
FY 2002									
FY 2003									
FY 2004 Estimate	0.40						$0.40		**$0.40**
FY 2005 Request									
FY 2006 Estimate				49.32				$49.32	**$49.32**
FY 2007 Estimate				32.88				$32.88	**$32.88**
FY 2008 Estimate					6.00		$6.00		**$6.00**
FY 2009 Estimate					6.15		$6.15		**$6.15**
FY 2010 Estimate					6.30		$6.30		**$6.30**
FY 2011 Estimate					6.46		$6.46		**$6.46**
Subtotal, R&RA	$2.01				$24.92		$26.93		**$26.93**
Subtotal, MREFC				$82.20				$82.20	**$82.20**
Total, Each Phase		**$2.01**		**$82.20**		**$24.92**			**$109.13**

NOTE: The expected operational service life of the ARRV is 30 years after construction is complete. Ship Operations are estimated to be approximately $6.0 million per year. 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.

- 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 Division of Ocean Sciences funds were used in FY 2003 and 2004 to further the design process.

- Implementation: The project will be prepared to go into the construction phase in FY 2006. 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 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 $6.0 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.