



# U.S. National Science Foundation: Major Research Equipment and Facility Construction

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## Summary

The Major Research Equipment and Facilities Construction (MREFC) account of the National Science Foundation (NSF) supports the acquisition and construction of major research facilities and equipment that are to extend the boundaries of science, engineering, and technology. The facilities include telescopes, earth simulators, astronomical observatories, and mobile research platforms. Currently, the NSF provides approximately \$1.0 billion annually in support of facilities and other infrastructure projects. While the NSF does not directly design or operate research facilities, it does have final responsibility for oversight and management. Questions have been raised by many in the scientific community and in Congress concerning the adequacy of the planning and management of NSF facilities. In addition, there has been debate related to the criteria used to select projects for MREFC support.

The FY2011 request for the NSF is \$7,424.4 million, approximately \$551.9 million above the FY2010 estimate. Included in the requested funding is \$165.2 million for MREFC, a 40.8% increase above the FY2010 estimate of \$117.3 million. In FY2011, NSF anticipates construction of the National Ecological Observatory Network (NEON), at a cost of \$20.0 million. The NEON will compile data on the effects of climate changes, land use changes, invasive species on natural resources, and biodiversity. In addition to the support of NEON, NSF will continue its support of four ongoing major construction projects—the Advanced Laser Interferometer Gravitational Wave Observatory (\$23.6 million), the Atacama Large Millimeter Array (\$13.9 million), the Advanced Technology Solar Telescope (\$17.0 million), and the Ocean Observatories Initiative (\$90.7 million).

On July 22, 2010, the Senate Committee on Appropriations approved S. 3636, Commerce, Justice, and Science Appropriations Bill, FY2011 (S.Rept. 111-229). The Senate bill requests a total of \$7,353.4 million for the NSF in FY2011, approximately \$71.0 million below the Administration's FY2011 request and \$480.9 million above the FY2010 estimate. Included in the support for NSF is \$155.2 million for MREFC, a 32.3% increase (\$37.9 million) over the FY2010 estimate.

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## Background

The Major Research Equipment and Facilities Construction (MREFC) account of the National Science Foundation (NSF) was established in FY1995 and supports the acquisition, construction and commissioning of major research facilities and equipment that are to extend the boundaries of science and engineering. Major research facilities are complex in their design, construction, and operation and require a large investment over a limited period of time. Examples of some of the funded projects include telescopes, research vessels, accelerators, networked high-tech research platforms, advanced computing resources, astronomical observatories, and earthquake simulators. These complex projects sometime involve the participation of international partners. Currently, the NSF provides approximately \$1.0 billion annually in support of facilities and other infrastructure projects. The funding for construction of individual facilities ranges from several tens of millions to hundreds of millions of dollars. Additional funding is required annually for operation, maintenance, upgrades and retooling of the facilities.

With the significant exception of research facilities in the Antarctic, the NSF does not directly design or operate research facilities. Rather, it makes awards to other organizations such as universities, consortia of universities, or nonprofit organizations which have the responsibility of construction, operation and management. The NSF enters into cooperative agreements with these external entities, and has the final responsibility for oversight of the development, management and performance of the facilities.

During the past few years, NSF's portfolio of facilities has expanded and diversified to include complex multidisciplinary projects and distributed projects. Because these major facility projects are multi-year, their accounting, management and oversight require more complexity and detail than the traditional average grant award. There are concerns from Congress and from some in the academic and scientific community about the adequacy of the planning and management of NSF facilities. Discussions have focused on how major facility projects are selected for funding. Other questions have centered on the types of costs to be funded through the MREFC account and NSF personnel involved in major facility projects. In the FY2002 budget submission, President Bush directed the NSF to develop clearer policies and procedures for managing all aspects of large facility projects, including funding controls and effective project management.<sup>1</sup> The FY2002 budget document, *A Blue Print for New Beginnings: A Responsible Budget for America's Priorities*, directed that "NSF will develop a plan to enhance its capability to estimate costs and provide oversight of project management and construction. This plan should help ensure that NSF is able to meet and stick to cost and schedule commitments for major facility projects."<sup>2</sup>

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<sup>1</sup> In December 2000, the Office of Inspector General (OIG) of the NSF released an audit of the Gemini Project, reporting that the Gemini Project had cost overruns exceeding its approved construction level of \$184 million. The OIG further stated that the NSF had used or was planning to use approximately \$52.8 million from the Research and Related Activities Account (RRA) to cover the excess construction and commission costs. NSF management refuted the conclusions of the OIG, maintaining that the excess costs were operational in nature and as a result, properly supported through the RRA as opposed to the MREFC account.

<sup>2</sup> Office of Management and Budget, *A Blueprint for New Beginnings: A Responsible Budget for America's Priorities*, Washington, February 28, 2001, <http://www.whitehouse.gov/news/usbudget/blueprint/budi.htm>, p. 161.

## Definition of a Major Research Facility

The MREFC is an agency-wide capital asset account that funds major science and engineering infrastructure projects that cost more than one program's budget could support.<sup>3</sup> Major research facility projects are defined as those awards made for establishing and/or operating a major tool or facility that will potentially benefit a community of researchers and/or educators. A project should "... offer the possibility of transformative knowledge and the potential to shift existing paradigms in scientific understanding, engineering processes and/or infrastructure technology."

<sup>4</sup>A research facility is considered "major" if its total cost of construction and/or acquisition constitutes an investment that is more than 10% of the annual budget of the sponsoring directorate or office. The majority of large facility projects are funded through the MREFC, but some also receive support through the Research and Related Activities Account (RRA).<sup>5</sup>

## Congressional Hearing on Planning and Management Issues

On September 6, 2001, the House Committee on Science, Subcommittee on Research, held a hearing on planning and management issues associated with major research facilities at the NSF. These hearings resulted from concerns expressed by some in the academic and scientific community and in Congress about the management and oversight of major projects selected for construction and the need for prioritization of potential projects funded in the MREFC. In testimony before the Subcommittee on Research, then NSF Director, Rita R. Colwell, stated that the draft of the *Large Facility Projects Management and Oversight Plan* codifies practices already in place and develops new guidelines for oversight of financial and business functions. She responded to criticism that the lines of authority for project management included in the draft plan were ambiguous and that those with oversight functions for the projects were program officers who may not have the expertise necessary for overseeing a complex project. The *Plan* established a new position—Deputy Director for Large Facility Projects. Under the *Plan*, the Deputy Director would be responsible for implementing and managing guidelines and procedures for facility management and oversight, maintaining lines of authority for facility management, and providing project management training for NSF staff engaged in large facility projects.

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<sup>3</sup> The proposed facilities are too large to fit within the account of any one directorate or program. The concern is that support for such large projects would "disrupt" the budgets of other programs and jeopardize NSF's traditional support of "core" research programs.

<sup>4</sup> National Science Foundation, *Facility Plan*, September 2005, Arlington, VA, p. 6.

<sup>5</sup> Since its establishment, the MREFC has funded the following projects: Atacama Large Millimeter Array (ALMA), IceCube Neutrino Observatory, High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER), Large Hadron Collider, Terascale Computing System and Distributed Terascale Facility, Laser Interferometer Gravitational Wave Observatory (LIGO), George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), Polar Support Aircraft Upgrades, South Pole Safety Project and South Pole Station Modernization (SPSM), EarthScope, National Ecological Observatory Network (NEON), Gemini Observatory, Scientific Ocean Drilling Vessel (SODV), Alaska Region Research Vessel (ARRV), Advanced LIGO, Ocean Observatories Initiative (OOI), and the Advanced Technology Solar Telescope (ATST). For a discussion of these projects, see, for example, National Science Foundation, *NSF-Supported Research Infrastructure: Enabling Discovery, Innovation and Learning*, NSF09-13, February 2009, Arlington, VA, 148 pp.

There has been considerable debate concerning the selection of major research facility projects for funding. In testimony before the Subcommittee on Research, Anita K. Jones, then Vice Chair, National Science Board (NSB), stated that because not all facilities can be built at the time they are considered, the NSB established guidelines for approving major facility projects.<sup>6</sup> She emphasized that there is a prioritization process for selecting major projects, one that involves the NSF and the community, with the NSB actually making the priority decisions. The NSB, she asserted, reviews the need for the facility, the research that will be enabled, the readiness of plans for construction and operation, construction budget estimates, and operations budget estimates before making its decisions. Another issue brought before the Subcommittee was that of maintaining distinct records of spending activities in the MREFC. Subcommittee members questioned the types of costs to be funded through the MREFC account because the differentiation between construction and operation is not always clearly defined.<sup>7</sup> The Subcommittee noted that internal mechanisms needed to be created in order to prevent the combining of MREFC and RRA funds.

## **Audit of Funding for Major Research Equipment and Facilities**

In May 2002, the NSF's Office of Inspector General (OIG) released a draft report, *Audit of Funding for Major Research Equipment and Facilities*.<sup>8</sup> The report noted that the current policy for major research equipment and facilities projects is limited to only the MREFC and does not include major facilities for other programs in NSF. In addition, the existing guidelines stipulate a single financial review and do not offer directives on how the review should be conducted. Also, according to the audit, the current policies did not provide direction to NSF program managers on how to address the problem of potential cost overruns. While federal guidelines require that the total cost of major research facilities be tracked through all stages of a project, NSF's policies and procedures did not provide full accounting costs in its financial reports in accordance with federal standards.

Because of NSF's inconsistencies in tracking costs and funding sources of its major research facilities, the OIG recommended that NSF revise its policies and procedures by complying with the directives that were detailed in the FY2002 appropriation bill.

## **Congressional Activity**

In June 2002, Congress requested the National Academy of Sciences (NAS) to review NSF's management of its large facility projects.<sup>9</sup> The study began in February and examined how the

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<sup>6</sup> National Science Board, *Guidelines for Setting Priority for Major Research Facilities*, NSB01-204, Arlington, VA, November 15, 2001, 2 pp.

<sup>7</sup> Acquisition, construction and commissioning are funded through the MREFC. Planning, design, and development are supported through the R&RA, in addition to operations and maintenance upon completion of the project.

<sup>8</sup> National Science Foundation, Office of Inspector General, *Audit of Funding for Major Research Equipment and Facilities*, OIG02-2007, May 1, 2002, Arlington, VA, 17 pp.

<sup>9</sup> The NSF Authorization Act of 2002 (P.L. 107-368, H.R. 4664) contained language directing the NAS to conduct the study of NSF's priority-setting process of its large facility projects.

NSF sets priorities in determining which competing projects to fund, and offered recommendations on how to strengthen the process. The recommendations are contained in a January 2004 report prepared jointly by the NSB and the NSF—*Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*.<sup>10</sup> At an October 2004 meeting of the NSB, the NSF was directed to begin implementation of the proposed large facility project review and prioritization process outlined in the report. The report revealed that in addition to there being a backlog of approved but unfunded projects, there was a lack of support for disciplines conducting idea-generating activities, and lack of funding for conceptual development, planning, and design.

## Planning and Management Issues

The May 2007 report, *Large Facilities Manual*, details the procedures by which large facility research projects advance through a multi-phase internal and external review and approval process.<sup>11</sup> According to the *Guidelines*, a MREFC Panel evaluates the projects based on, among other things, project definition, intellectual justification, connection to NSF strategic goals and priorities, life-cycle cost profile, partnerships, and project management plans, schedules, and reviews. Based on the review, the MREFC Panel submits to the NSF Director its recommendation on the project's relative importance, eligibility, and readiness, with readiness defined as its ability to be included in the upcoming budget request. The Director then makes the selection of projects based on: (1) strength and substance of the information; (2) the appropriate balance among various fields, disciplines, or directorates; and (3) opportunities to leverage MREFC funds. The Director submits his selections to the NSB for project approval. After the NSB approves a project for future budget cycle funding, it prioritizes among the projects.<sup>12</sup> On an annual basis, the NSB reviews all NSB-approved projects that have not been funded as yet to determine if any changes are necessary to the priority order of the projects.<sup>13</sup> If a project is not approved, or if a project's plans are no longer determined to be "clearly and fully construction ready," the project will be returned to the preliminary design/readiness phase for additional work. A project can be resubmitted to the NSB the following year. While the NSB may approve a project for inclusion in a future budget request, it does not necessarily mean that it will receive funding in the upcoming budget request. It does indicate that the project is to be considered for inclusion, depending on current budget levels and constraints.

In February 2008, NSF released its third annual *Facility Plan*.<sup>14</sup> The *Plan* covers readiness stage projects through those projects that are in the process of completion. In addition, the report includes NSF's support for major research infrastructure and operational facilities that have

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<sup>10</sup>National Academy of Sciences, Committee on Science, Engineering, and Public Policy, and Global Affairs Division, Board on Physics and Astronomy, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*, Washington, DC, January 14, 2004, 215 pp.

<sup>11</sup>National Science Foundation, *Large Facilities Manual*, NSF07-38, Arlington, VA, May 2007, 58 pp. NOTE: The *Large Facilities Manual* supersedes and incorporates the former *Facilities Management and Oversight Guide* and the *Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction Account*.

<sup>12</sup> First priority is given to projects under construction. Second priority is for NSB-approved new starts. There are projects that are classified as being in the readiness stage or recommended for advancement to the readiness stage. Also, there are projects classified as being under exploration.

<sup>13</sup>The Office of Management and Budget (OMB) may reject or change the NSF's prioritizations.

<sup>14</sup>National Science Foundation, *2008 Facility Plan*, NSF08-24, February 2008, Arlington, VA, 44 pp.



received new or renewed awards within the past two years. The *2008 Facility Plan* describes NSF's goals and strategies for incorporating the existing approaches and practices into a system for selecting, managing, and overseeing large facility projects to make certain that a large facility is both constructed properly and is the appropriate facility to build. The *Facility Plan* is consistent with the vision detailed in the *NSF Strategic Plan, Investing in America's Future, FY2006-FY2011*.<sup>15</sup> The projects under construction and those being considered for construction are indicative of NSF's long-term investment priorities for new capabilities and next-generation facilities that will "transform research in science and engineering." The NSF states that:

As in any sort of exploration, the horizon keeps moving. Every year new opportunities will arise and new priorities will assert themselves. As a result, no roster of potential projects is ever final.... This process of identification and selection is, and must be, continuously repeated.<sup>16</sup>

The *2008 Facility Plan* describes a team approach and details the cooperation between the scientific and technical staff and the business operations staff. All projects seeking funding in the MREFC move through a "progressive sequence of increasingly detailed development and assessment steps" in order to be considered for construction support.<sup>17</sup> The lines of authority and responsibility are defined for the NSF Director, the participating Division Director, the NSF Program Manager, and the awardees' project director. In every large facility project, the NSF Program Manager, with the support of the participating Division Director, has primary responsibility for all aspects of management. In addition, the NSF Program Manager is responsible for determining whether the project director and project management staff have the necessary training and skills for working on the project.

## Termination of a Major Research Project

The Rare Symmetry Violating Processes Project (RSVP) was initially NSB-approved for funding in October 2000, and was included in the FY2005 budget request as a new construction project. While the RSVP was in the design phase, an analysis revealed that there could be significant increases in construction and operating costs. The cost overruns generated interest from Congress and the international scientific community. An evaluation was conducted by scientific personnel internal and external to NSF in an attempt to resolve the cost increases in various elements of the project. In August 2005, on the recommendation from NSF management, the NSB terminated the RSVP. NSF determined that continued support for the RSVP would cause "unacceptable loss of research opportunities in elementary particle physics and other areas of science."<sup>18</sup> The RSVP underwent a series of phase-out activities.

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<sup>15</sup>National Science Foundation, *Investing in America's Future - Strategic Plan FY2006-2011*, NSF06-48, September 2006, Arlington, VA, 20 pp.

<sup>16</sup>National Science Foundation, *2007 Facility Plan*, NSF07-22, February 2007, Arlington, VA, p. 4.

<sup>17</sup>*2008 Facility Plan*, p. 40

<sup>18</sup>National Science Foundation, "NSF Terminates Rare Symmetry Violating Processes (RSVP) Project," Press Release 05-138, Arlington, VA, August 11, 2005.



## MREFC Support in the FY2011 Budget Request

The MREFC account is funded at \$165.2 million in the FY2011 request, an increase of 40.8% (\$47.9 million) over the FY2010 estimate of \$117.3 million. NSF has required that in order for a project to receive support, it must have the “the potential to shift the paradigm in scientific understanding and/or infrastructure technology.” The FY2011 request supports four ongoing projects—Advanced Laser Interferometer Gravitational Wave Observatory (\$23.6 million), Atacama Large Millimeter Array (\$13.9 million), the Ocean Observatories Initiative (\$90.7 million), and the Advanced Technology Solar Telescope (\$17.0 million). The FY2011 request also provides \$20.0 million for the initial construction of the National Ecological Observatory Network.

The NSF has instituted tighter standards and requirements for receiving funding in this account. Included in the more stringent procedures was the implementation of a “no cost overrun” policy for major projects. All projects seeking funding in the MREFC must move through a “progressive sequence of increasingly detailed development and assessment steps” in order to be considered for construction support.<sup>19</sup> The cost estimates for projects developed at the preliminary design phase must include adequate contingencies. In the absence of such contingencies, any cost increase would result in reduction in scope for the project. Three projects that appeared in the FY2008 request (Alaskan Regional Research Vessel, Ocean Observatories Initiative, and the National Ecological Observatory Network) have to undergo a revised baseline budget and risk management plan. These projects are still supported by NSF, and will be considered for inclusion in the next budget cycle following submission of their final design review. The following table provides funding levels for current and out-years for projects in the MREFC account.

**Table I. MREFC Account Funding, by Project**  
(Dollars in Millions)

	FY2009 Omnibus <sup>a</sup>	FY2009 ARRA <sup>a</sup>	FY2010 <sup>b</sup>	FY2011 Request	FY2012 <sup>b</sup>	FY2013 <sup>b</sup>	FY2014 <sup>b</sup>	FY2015 <sup>b</sup>	FY2016 <sup>b</sup>
AdvLIGO	\$51.43	—	\$46.30	\$23.58	\$20.96	\$15.17	\$14.92	—	—
ATST <sup>c</sup>	—	—	13.00	17.00	20.00	20.00	20.00	20.00	20.00
ARRV <sup>d</sup>	14.13	148.07	—	—	—	—	—	—	—
ALMA	82.25	—	42.76	13.91	3.00	—	—	—	—
IceCube	11.85	—	0.95	—	—	—	—	—	—
NEON	—	—	—	20.00	87.92	101.07	103.43	86.23	32.07
OOI	—	105.93	14.28	90.70	102.80	46.80	20.00	—	—
SPSM <sup>e</sup>	1.10	—	—	—	—	—	—	—	—
MREFC Account Total	\$148.076	\$254.00	\$117.29	\$165.19	\$234.68	\$183.04	\$158.35 \$158.35	\$106.23	\$52.07

**Source:** U.S. National Science Foundation, *FY2011 Budget Request to Congress*, Arlington, VA, February 1, 2010. p. MREFC-I.

<sup>19</sup> National Science Foundation, *2008 Facility Plan*, p. 40.

**Notes:** Totals may not add due to rounding.

- a. Actual.
- b. Estimate.
- c. Funds appropriated for ATST through the American Recovery and Reinvestment Act (ARRA), FY2009, totaling \$146.0 million, were obligated in January 2010.
- d. ARR, Alaska Regional Research Vessel.
- e. SPSM, South Pole Station Modernization.

NSF's FY2011 request proposes \$165.2 million for the MREFC, a 40.8% increase above the FY2010 estimate of \$117.3 million.<sup>20</sup> In FY2011, NSF anticipates construction of the National Ecological Observatory Network (NEON) at a cost of \$20.0 million. The NEON will compile data on the effects of climate changes, land use changes, invasive species on natural resources, and biodiversity. Data from NEON is expected to have local, regional, and national uses. In addition to the support of NEON, NSF will continue its support of four ongoing construction projects—the Advanced Laser Interferometer Gravitational Wave Observatory (AdvLIGO, \$23.6 million), the Atacama Large Millimeter Array (ALMA, \$13.9 million), the Advanced Technology Solar Telescope (ATST, \$17.0 million), and the Ocean Observatories Initiative (OOI, \$90.7 million).

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<sup>20</sup> On February 17, 2009, President Barack Obama signed into law the American Recovery and Reinvestment Act (ARRA), FY2009, P.L. 111-5 (H.R. 1). The legislation provided slightly more than \$3.0 billion for the NSF—\$400.0 million for MREFC, \$2.5 billion for Research and Related Activities Account, \$100.0 million for the Education and Human Resources, and \$2.0 million for the Office of Inspector General.