NSF MAJOR RESEARCH EQUIPMENT AND FACILITIES MANAGEMENT: ENSURING FISCAL RESPONSIBILITY AND ACCOUNTABILITY

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

THURSDAY, MARCH 8, 2012

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Thursday, March 8, 2012

NSF MAJOR RESEARCH EQUIPMENT AND FACILITIES MANAGEMENT: ENSURING FISCAL RESPONSIBILITY AND ACCOUNTABILITY

THURSDAY, MARCH 8, 2012

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, DC.

The Subcommittee met, pursuant to call, at 10:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Mo Brooks [Chairman of the Subcommittee] presiding.

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U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

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Subcommittee on Research & Science Education Hearing

NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

Thursday, March 8, 2012
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. Cora Marrett, Deputy Director, National Science Foundation

Dr. José-Marie Griffiths, Chairman, Subcommittee on Facilities, National Science Board; Vice President of Academic Affairs, Bryant University

Mr. James H. Yeck, IceCube Project Director, University of Wisconsin-Madison

Dr. Tony Beasley, COO/Project Manager, Neon, Inc.

Dr. Tim Cowles, Vice President and Director, Ocean Observing, Consortium for Ocean Leadership

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

HEARING CHARTER

NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

Thursday, March 8, 2012
10:00 a.m. - 12:00 p.m.
2318 Rayburn House Office Building

1. Purpose

On Thursday, March 8, 2012, the Committee on Science, Space, and Technology Subcommittee on Research and Science Education will hold a hearing to examine the management and operations of Major Research Equipment and Facilities Construction (MREFC) projects at the National Science Foundation.

2. Witnesses

Dr. Cora Marrett, Deputy Director, National Science Foundation

Dr. José-Marie Griffiths, Chairman, Subcommittee on Facilities, National Science Board; Vice President of Academic Affairs, Bryant University

Mr. James H. Yeck, IceCube Project Director, University of Wisconsin-Madison

Dr. Tony Beasley, COO/Project Manager, Neon, Inc.

Dr. Tim Cowles, Vice President and Director, Ocean Observing, Consortium for Ocean Leadership

3. Overview

- Providing support for major research equipment and facilities is a component of support for basic research.
- The National Science Foundation (NSF) supports basic scientific research in a number of ways, including through agency-wide capital investments in "major science and engineering infrastructure projects that cost more than one program's budget could support."[1]

[1] Congressional Research Service, *U.S. National Science Foundation: Major Research Equipment and Facility Construction*, p. 2.

- According to the most recent NSF strategic plan for 2011 through 2016, "The Foundation aims to develop and maintain infrastructure that enhances researchers' and educators' capabilities and productivity through management that accounts for and demonstrates best practices."[2]

- NSF funds large research infrastructure projects through the Major Research Equipment and Facilities Construction (MREFC) account. "...[T]he facility projects supported through the MREFC account are highly visible because of their large project budgets, their potential to shape the course of future research in one or more fields, their potential economic benefits for particular regions, their effects on international cooperation research, and their prominence in an increasing number of research fields."[3]

- The Fiscal Year 2013 (FY13) NSF budget request highlights six MREFC projects:
  - ➢ The Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO) is an upgrade of the existing Laser Interferometer Gravitational-Wave Observatory (LIGO) that will allow the Observatory to approach the ground-based limit of gravitational-wave detection.
  - ➢ The Atacama Large Millimeter Array (ALMA) is an aperture-synthesis radio telescope.
  - ➢ The Advanced Technology Solar Telescope (ATST) will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromospheres, and corona.
  - ➢ The IceCube Neutrino Observatory (IceCube) is the world's first high-energy neutrino observatory.
  - ➢ The National Ecological Observatory Network (NEON) will result in an integrated research platform consisting of geographically distributed field and lab infrastructure.
  - ➢ The Ocean Observatories Initiative (OOI) will be an integrated network of ocean observatories.

4. Background

In order to conduct basic research in every field of science and engineering, students, teachers and researchers must have access to powerful, cutting-edge infrastructure, infrastructure that has a major impact on broad segments of scientific and engineering disciplines. Large and up-to-date research equipment and facilities are essential to the fundamental process of basic research. These equipment and facilities may consist of multi-user facilities, large-scale computational infrastructures, or networked instrumentation and equipment. "Many fields of scientific inquiry require capital intensive investments in major research infrastructure to maintain or advance their capabilities to explore the frontiers of their respective disciplines."[4] Telescopes, particle accelerators, gravitational wave observatories, and research vessels are only a handful of examples of major research infrastructure projects.

Major Research Infrastructure and the National Science Foundation (NSF)

As the primary federal agency supporting basic scientific research, the National Science Foundation (NSF) plays a key role in the construction and operation of major research equipment

[2] *NSF Strategic Plan FY2011-2016*, p. 9.
[3] The National Academy of Sciences, *Setting Priorities for Large Research Facility Projects Supported fy the National Science Foundation*, p. 9.
[4] National Science Foundation, *2008 Facility Plan*, p. 40.

and facilities. NSF funds a variety of large research projects, from multi-user research facilities to tools for research and education and distributed instrumentation networks. Funding support for these types of projects is coordinated with other agencies, organizations and countries to ensure projects are integrated and complementary.

Major Multi-User Research Facilities Funding[5]

(dollars in millions)

	FY11 Actual	FY12 Estimate	FY13 Request	Change Over FY12 Estimate	
				Amount	Percent
Total, Research and Related Activities	**913.54**	**909.70**	**923/30**	**13.6**	**1.5**
Operations and Maintenance (O&M) of Existing Facilities	*673.63*	*655.37*	*647.35*	*-8.02*	*-1.2*
Federally Funded R&D Centers	*195.25*	*195.85*	*191.71*	*-4.14*	*-2.1*
O&M of Facilities under Construction	*17.49*	*44.73*	*72.49*	*27.76*	*62.1*
R&RA Planning and Concept Devcelopment	*27.17*	*13.75*	*11.75*	*-2.00*	*-14.5*
Major Research Equipment and Facilities Construction	**125.37**	**197.06**	**196.17**	**-0.86**	**-0.5**
Total, Major Multi-User Research Facilities	**1038.91**	**1106.76**	**1119.47**	**12.71**	**1.1**

In 1995, NSF created an agency-wide budgetary account to promote effective planning and management in the Foundation's support for large investments in major research equipment and facilities. The Major Research Equipment and Facilities Construction (MREFC) account supports the acquisition, construction, and commissioning of major research facilities and equipment. "The MREFC account was created to separate the construction funding for a large facility – which can rise and fall dramatically over the course of a few years – from the more continuous funding of facility operations and individual-investigator research."[6]

In order to be considered for MREFC funding, NSF requires that the project not only represent an exceptional opportunity to enable research and education, but also "should be transformative in nature, with the potential to shift the paradigm in scientific understanding."[7]

In the early 2000s, Congress and the scientific community raised concerns over planning, management, and oversight issues within the MREFC account. In response, the NSF worked to establish practices and create additional guidelines for MREFC projects, including the creation of the role of Deputy Director for Large Facilities. The Deputy Director and the Large Facilities Office are "the NSF's primary resource for all policy or process issues related to the development, implementation, and oversight of MREFC projects, and are NSF-wide resource on project management."[8]

In 2004, the National Academies released a report, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*. This report made recommendations about establishing a long term roadmap for major research infrastructure projects and involving the National Science Board (NSB) in the NSF process for identifying and approving the construction and maintenance of these projects. In 2005, the NSB and NSF responded to the

[5] NSF FY13 Budget Request – Facilities, p. 1.

[6] The National Academy of Sciences, *Setting Priorities for Large Research Facility Projects Supportedfy the National Science Foundation*, p. 8.

[7] NSF FY12 Budget Request – MREFC p. 1.

[8] http://www.nsf.gov/bfa/lfo/index.jsp

National Academies report through a complementary joint NSB NSF management report identically titled, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*. The NSB NSF report highlighted the creation of a roadmap through a regularly reported Facility Plan, which would include details on major facilities under construction, the science and objectives that provide the need for the project, and a process for large facility project development. The Facility Plan would be updated regularly and made public.

Today, the evolution of the processes is evident in the dynamic and clearly identified MREFC process:

> MREFC-funded construction projects proceed through a progressive sequence of increasingly detailed development and assessment steps prior to approval for construction funding. Initially, NSF reacts to opportunities articulated and advocated by the research community during the earliest stage of consideration. These ideas are subjected to external merit review, and those ideas or concepts of exceptional merit are further developed into conceptual designs that define the key research questions the proposed facility is intended to address.[9]

(See Appendix A for a visual representation of the NSF MREFC process.)

Since the creation of the MREFC account, NSF has funded 17 projects. In the FY13 budget request, NSF is requesting funding for four facilities: Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO); Advanced Technology Solar Telescope (ATST); National Ecological Observatory Network (NEON); and Ocean Observatories Initiative (OOI). Two other facilities, Atacama Large Millimeter Array (ALMA) and IceCube Neutrino Observatory (IceCube) are transitioning from the MREFC account to the appropriate research directorates for operations and maintenance. At this time, there are no new proposed facilities.

The FY13 budget request for the MREFC account is $196.17 million.

MREFC Account Funding Request[10]

(dollars in millions)

MREFC Project	FY11 Actual	FY12 Estimate	**FY13 Request**	FY14 Estimate	FY15 Estimate	FY16 Estimate	FY17 Estimate	FY18 Estimate
AdvLIGO	23.58	20.96	**15.17**	14.92				
ALMA	13.92	3.00						
ATST	5.00	10.00	**25.00**	42.00	20.00	20.00	9.93	
IceCube	5.29							
NEON	12.58	60.30	**91.00**	98.20	91.00	80.66		
OOI	65.00	102.80	**65.00**	27.50				

[9] National Science Foundation, *2008 Facility Plan*, p. 40.
[10] NSF FY13 Budget Request – MREFC, p. 1.

Major Research Infrastructure Process at NSF

Funding for projects within the MREFC account ranges from tens of millions to hundreds of millions of dollars. "A research facility is considered 'major' if its total cost of construction and/or acquisition constitutes an investment that is more than 10 percent of the annual budget of the sponsoring directorate or office."[11] Due to the significant costs associated with MREFC projects NSF has established a detailed multi-stage process for each project to complete.

The genesis for an MREFC project begins with Horizon Planning, where the relevant research community presents a compelling case for a scientific tool or facility. Part of this process includes identifying the way in which a potential project is aligned with NSF's strategic plan and its compatibility with the existing MREFC portfolio. The Foundation informs the NSB of projects in the Horizon Planning stage.

In the Conceptual Design stage, project proponents identify specific requirements and risks and begin to define a schedule for the project. At this stage, they draft initial cost estimates, including costs to operate the program once construction is complete. "Early in the Conceptual Design stage, NSF and/or other institutions begin to invest research and development funds in conceptual development and design, and in efforts that promote community building and planning. Investments in fundamental research activities, community building, and initial planning activities may occur over many years."[12] Projects progress from Conceptual Design to Preliminary Design after completing a Conceptual Design Review (CDR). At this stage, the NSF Director approves the continued movement of the project and officially notifies the NSB. Horizon Planning and Conceptual Design stages are supported by NSF program offices from the Research and Related Activities (RRA) account with design and development grants.

During the Preliminary Design stage, the major elements of the project are more defined and detailed, including identifying risk, schedule, partnerships and cost estimates. During Preliminary Design, cost estimates are risk-adjusted total cost estimates. Budget estimates resulting at this stage must be accurate to present to the NSF Director, the NSB, the Office of Management and Budget (OMB) and Congress. The goal of the Preliminary Design stage is to determine project readiness and produce a project baseline. After a Preliminary Design Review (PDR), a project may be approved by the NSB to move forward to Final Design and Construction. It is at this stage that the project can appear as a line-item in the President's Fiscal Year Budget Request.

The Final Design stage is used to advance the project to construction. At this time, project managers are refining cost estimates based on vendor quotes, putting construction teams in place, and finalizing details necessary to begin construction. A Final Design Review (FDR) includes a construction-ready design, the technologies and tools necessary for construction, a project management plan, and an updated budget and contingency.

The Construction stage begins after Congress appropriates the funding and NSF is able to award the contract for construction. Contract awardees are required to provide periodic financial and technical reports to NSF, the terms of which are established by cooperative agreements. During

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[11] Congressional Research Service, *U.S. National Science Foundation: Major Research Equipment and Facility Construction*, p. 2.

[12] *National Science Foundation Large Facilities Manual*, March 31, 2011, p. 11.

the Construction stage, the project manager must adhere to the project baseline. If the baseline is not being met, a project may need to be re-baselined or have its scope readjusted.

The life-cycle of a MREFC project takes into account the steps from Horizon Planning to construction and beyond. The completion of construction does not mean that NSF has completed the scientific endeavor. The Foundation accounts for the operations and maintenance (O&M) of the equipment or facility from project inception. A program officer from the appropriate RRA Directorate is assigned to carry through the life of the project. In the 2002 NSF Authorization Act, Congress codified that this program manager must be a permanent NSF employee. Maintaining a permanent science based program officer helps to smooth the transition from inception of the project through construction and to post-construction O&M. Often the operations of the project begin before construction is complete. Like the pre-construction activities, post-construction O&M are funded through the RRA or the Education and Human Resources (EHR) accounts.

Contingencies

In an effort to keep MREFC project costs from escalating during construction, NSF has instituted a "no cost overrun policy" on any new MREFC-funded construction projects. "This policy requires that the total project cost estimate developed at the Preliminary Design Stage have adequate contingency to cover all forseeable risks, and that any cost increases not covered by contingency be accommodated by reductions in scope."[13]

The use of contingency funding relative to MREFC projects has recently been under review by the NSF Inspector General (IG). In the September 2010, March 2011 and September 2011 Seminanual Reports to Congress, the IG highlighted audits of MREFC projects focused on "unallowable contingency costs." "The audit did not find any controls or technical barriers to prevent the organization from drawing down contingency funds and spending them without NSF approval."[14] According to NSF, the construction contingency policies are consistent with the GAO Cost Estimating and Assessment Guide and the OMB Capital Programming Guide and are part of the budget to be maintained by the project manager.

The FY12 Commerce, Justice, and Science Appropriations Conference Report addressed the contingency issue:

> The conferees remain concerned about how NSF and its grantees are defining, estimating and managing construction funding, particularly contingency funds. Stronger management and oversight of these funds could result in improved project efficiencies and, ultimately, cost savings. NSF is directed to report to the Committees on Appropriations on the steps it is taking to impose tighter controls on the drawdown and use of contingencies, as well as steps intended to incentivize grantees to complete construction under budget, for projects managed through the MREFC appropriation and for other large facility projects.[15]

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[13] Ibid, p. 18.
[14] *NSF OIG Semiannual Report to Congress*, September 2010, p. 5.
[15] Conference Report 112-284 to accompany H.R. 2112, p. 264.

IceCube Neutrino Observatory (IceCube)[16]

The IceCube Neutrino Observatory (IceCube) is the world's first high-energy neutrino observatory, located deep within the ice cap under the South Pole in Antarctica. It provides 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.

NSF requested construction funding for IceCube in the FY04 budget request, and the total cost of the project (including start-up activities) was estimated to be $271.77 million at that time, $242.07 from NSF and the balance from the international partners. IceCube construction was carried out by the IceCube Collaboration, led by the University of Wisconsin and consisting of 11 other U.S. institutions and institutions in Belgium, Germany, and Sweden. NSF's foreign partners are contributing approximately $37.40 million to the project, as well as a pro rata share of IceCube operations and maintenance costs based on the number of PhD-level researchers involved.

Oversight responsibility for IceCube construction was the responsibility of the Office of Polar Programs (OPP). Support for operations and maintenance, research, education, and outreach will be shared by OPP and the Directorate for Mathematical and Physical Sciences (MPS), as well as other organizations and international partners. NSF expects to support evaluation and measurement-based education and outreach programs under separate RRA grants to universities and other organizations that are selected following standard NSF merit review.

IceCube construction was successfully completed at the South Pole on December 18, 2010. The Observatory consists of 5,160 optical sensors installed at a depth between 1.5 and 2.5 kilometers on 86 cables and 324 optical sensors placed in 162 surface tanks. All cables are routed into the IceCube laboratory located in the center of the surface array.

O&M in support of scientific research began in FY07 and cost approximately $5 million per year. Full science operations began in FY11. The associated costs are and will continue to be shared by the partner funding agencies – U.S. (NSF) and non-U.S. – proportional to the number of PhD researchers involved (currently about 55:45). Starting in FY12, the U.S. share of full science operations and maintenance is $6.90 million annually. In FY12, the U.S. share of data analysis and modeling costs is estimated at $5.50 million. The expected operational lifespan of this project is 25 years beginning in FY11.

The FY13 MREFC budget request does not include funding for IceCube as the program will close out all construction activities in 2012.

The National Ecological Observatory Network (NEON)[17]

In 2004, the National Research Council (NRC) evaluated the original National Ecological Observatory Network (NEON) design of loosely confederated observatories and recommended that it be reshaped into a single integrated platform for regional to continental scale ecological

[16] NSF FY12 Budget Request – MREFC p. 23-27.
[17] NSF FY13 Budget Request – MREFC, p. 18-24.

research. Congress originally appropriated a total of $7 million for NEON in FY07 and FY08, $4 million of which was rescinded in FY08. A PDR was completed in June 2009 and a FDR was completed in November 2009. In November 2009, the final design, scope, schedule, and risk-adjusted costs were reviewed and the project's baseline scope, budget, and schedule were found to be credible. The review panel endorsed the pre-construction planning activities in 2011 that enabled the project to commence construction in FY11. Contingency was increased to cover known risks per panel recommendations.

NEON will consist of geographically distributed field and lab infrastructure networked via cybertechnology into an integrated research platform for regional to continental scale ecological research. Cutting-edge sensor networks, instrumentation, experimental infrastructure, natural history archive facilities, and remote sensing will be linked via the internet to computational, analytical, and modeling capabilities to create NEON's integrated infrastructure.

NEON is funded through cooperative agreements with NEON, Inc., a non-profit, membership-governed consortium established to oversee the design, construction, management, and operation of NEON for the scientific community. NSF and NEON, Inc. coordinate with other federal agencies (National Aeronautics and Space Administration, Department of Energy, U.S. Department of Agriculture, U.S. Geological Survey, Environmental Protection Agency, and the National Oceanic and Atmospheric Administration) through the NEON Federal Agency Coordinating Committee. Areas of coordination include planning, design, construction, deployment, environmental assessment, data management, geospatial data exchange, cyberinfrastructure, research, and modeling.

The NEON program is managed through the Directorate for Biological Sciences (BIO) as part of Emerging Frontiers. BIO provides overall policy guidance and oversight. The NEON program is managed by a dedicated program officer. An NSF/NEON project manager was added in FY11 to oversee construction and participate in planning, development, and oversight of management and operations.

The projected length of the project is six fiscal years, with a six-month schedule contingency. The risk-adjusted cost of $433.72 million includes a contingency budget of 19 percent. The first NEON Airborne Observatory platform is expected to be completed, fully instrumented, and flight-tested in preparation for delivery to Observatory operations in FY14.

The FY13 budget request for NEON is $91 million, which represents the third year of the six-year construction project. The FY13 request also includes $30.39 million from the RRA account for O&M of the five domains commissioned, including related management and technical support, seasonal biological sampling, and domain facilities costs. The current request incorporates a three year initial operations request to allow NEON to gain operational experience and explore opportunities for schedule and cost efficiencies. For the outyears, the costs are held constant at the projected operations ceiling reviewed at both the PDR and FDR. After gaining operational experience, NEON, Inc. will submit a plan for the remaining five years.

Ocean Observatories Initiative (OOI)[18]

The Ocean Observatories Initiative (OOI) will provide the oceanographic research and education communities with continuous, interactive access to the ocean through an integrated network of observatories. Deployed in critical parts of the global and U.S. coastal ocean, OOI's 24/7 telepresence will capture climate, carbon, ecosystem, and geodynamic changes on the time scales at which they occur. Data streams from the air-sea interface through the water column to the seafloor will be openly available to educators and researchers in any discipline, making oceanography available to citizens and scholars who might never go to sea.

OOI has three elements: 1) deep-sea buoys with designs capable of deployment in harsh environments such as the Southern Ocean; 2) regional cabled nodes on the seafloor spanning several geological and oceanographic features and processes; and 3) an expanded network of coastal observatories. A cutting-edge, user-enabling cyberinfrastructure will link the three components of OOI and facilitate experimentation using assets from the entire network. Data from the network will be made publicly available via the Internet.

NSF first requested construction funding for OOI through the MREFC account in FY07 and received an initial appropriation of $5.12 million in that year. The OOI has undergone a series of technical reviews, with the FDR conducted in November 2008.

The project is managed and overseen by a program director in the Division of Ocean Sciences (OCE) in the Directorate for Geosciences (GEO). NSF established an Ocean Observing Science Committee (OOSC) via the University National Oceanographic Laboratory System (UNOLS). The Committee is made up of ocean science community representatives and is charged with providing guidance on decisions and plans from the science perspective related to all NSF observing systems.

NSF established a cooperative agreement with the Consortium for Ocean Leadership for the construction and initial operation of the OOI in September 2009. NSF conducts a weekly meeting, attends weekly calls, convenes external panels, and reviews monthly Earned Value Management reports from the project team. NSF attends internal project reviews, critical design reviews, and conducts vendor site visits as required.

The FY13 budget request for OOI is $65 million, which represents the fourth year of a six-year construction project totaling $386.42 million. The project is currently in year three of the construction and transition to O&M efforts. Major construction milestones were achieved on time and within budget. OOI transition to O&M was funded in FY11 and FY12. The request for O&M funding for FY13 is $40.1 million. Full O&M is planned for FY15. The expected operational lifespan of this project is 25 years.

Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO)

The Advanced Laser Interferometer Gravitational-Wave Observatory (AdvLIGO) is the planned upgrade of the Laser Interferometer Gravitational-Wave Observatory (LIGO) that will allow LIGO to approach the ground-based limit of gravitational-wave detection. LIGO consists of the

[18] NSF FY13 Budget Request – MREFC, p. 25-29.

world's most sophisticated optical interferometers, operating at two sites 3,000 km apart: Hanford, WA and Livingston, LA. The interferometers measure minute changes in arm lengths resulting from the passing of wave-like distortions of spacetime called gravitational waves, caused by cataclysmic processes in the universe such as the coalescence of two black holes or neutron stars. LIGO is sensitive to changes as small as one one-thousandth the diameter of a proton over the 4-km arm length; AdvLIGO is expected to be at least 10 times more sensitive.

NSF first requested FY08 construction funds for AdvLIGO through the MREFC account in the FY06 budget request to Congress. The original proposal, received in 2003, estimated a total construction cost of $184.35 million. A baseline review in June 2006 established the project cost at $205.12 million, based upon known budget inflators at the time and a presumed start date of January 1, 2008. A second baseline review held in June 2007 confirmed this cost, subject to changes in inflators. An FDR in November 2007 recommended that construction begin in FY08. The NSB approved the project at a cost of $205.12 million in March 2008, and the project began in April 2008.

NSF oversight is coordinated internally by a dedicated LIGO program director in the Division of Physics (PHY) in the Directorate for Mathematics and Physical Sciences (MPS). LIGO is managed by the California Institute of Technology under a cooperative agreement with NSF. An Executive Director has overall responsibility for the LIGO Laboratory. Substantial connections with industry have been required for the construction and measurements involved in the LIGO projects.

On October 20, 2010, the final LIGO science run ended and the facility was turned over to the AdvLIGO project for the installation of the advanced components. The project has pushed back completion of installation at Livingston and at Hanford by three months due to procurement difficulties, but no effect on the project completion date is expected. The removal of initial LIGO instruments is nearing completion with the end of a highly successful quantum-squeezing experiment and the decommissioning of the final initial LIGO interferometer. The major current project activity is the assembly and installation of large subsystem components, testing of which will begin this year. The current project performance is consistent with ending on time and on budget. Total project contingency usage as of November 2011 is $23 million of an initial $39.1 million, or 59 percent of initial contingency for 64 percent of the project completed.

The FY13 budget request for AdvLIGO is $15.17 million, which represents the sixth year of a seven-year project totaling an estimated $205.12 million. The projected length of the project is seven years, with an 11-month schedule contingency. The risk-adjusted cost of $205.12 million included a contingency budget of 23.7 percent at the time of the award. Future O&M costs will be approximately $39 million per year funded through PHY.

Atacama Large Millimeter Array (ALMA)

The origin of the Atacama Large Millimeter Array (ALMA) began as a $26.0 million, three-year design and development phase plan for a U.S.-only project, the Millimeter Array. NSF first requested funding for design and development of this project in FY98. In June 1999, the U.S. entered into a partnership via a Memorandum of Understanding (MOU) with the European Southern Observatory (ESO), a consortium of European funding agencies and institutions. The MOU committed the partners to construct a 64 element array of 12-meter antennas. NSF received $26 million in appropriations between FY98 and FY00. Because of the expanded managerial and technical complexity of the joint US/ESO project, now called ALMA, Congress provided $5.99 million in FY01 for an additional year of design and development. In FY02, $12.5 million was appropriated to initiate construction. The U.S. total share of the cost was estimated to be $344 million.

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

The ALMA Board initiated rebaselining in the fall of 2004 under the direction and oversight of the Joint ALMA Office (JAO) Project Manager. At that point, the project was sufficiently mature that the baseline budget and schedule established in 2002, prior to the formation of the partnership, could be refined. The new baseline plan developed by the JAO assumed a 50-antenna array as opposed to the original number of 64, extended the project schedule by 24 months, and established a new U.S. total project cost of $499.26 million. The FY09 request was increased by $7.50 million relative to the rebaselined profile in order to allow more strategic use of project contingency to buy down near-term risk, as recommended by the 2007 annual external review. The increase in FY09 was offset by a matching decrease in the FY11 budget request.

Construction continues in FY12, both at the site in Chile and within the ALMA partner countries. In FY11, delivery of North American production antennas continued at the planned rate of one every two months, and a total of twenty antennas were accepted or assembled and tested in Chile. Following assembly and testing, antennas were transported to the final, high-altitude site. Early science operations began in late FY11 and completion of the construction project and the start of full science operations are forecast to occur in FY13.

Programmatic management is the responsibility of the ALMA program manager in the Division of Astronomical Sciences (AST). North America and Europe are equal partners in the core ALMA instrument. Japan joined ALMA as a third major partner in 2004, and will deliver a number of enhancements to the baseline instrument. The North American side of the project (including Taiwan) is led by the Associated Universities Incorporated/National Radio Astronomy Observatory (AUI/NRAO).

The current schedule performance is slightly behind plan due to equipment delivery delays, specifically delivery of receivers and European antennas. Consequently, the major milestone of full-science is forecast to be delayed by nine to twelve months when compared to the baseline plan. However, early science commenced in September 2011 as predicted a year ago. Cost performance is good at this stage — cost variance is on track with the reference baseline and schedule variance is -6 percent relative to the reference — with about 25 percent contingency remaining in the uncommitted budget.

No additional MREFC funds are requested for the Atacama Large Millimeter Array (ALMA) in the FY13 budget request. The FY12 appropriation provided $3 million, which represents the final amount necessary to complete funding for the eleven-year project, totaling $499.26 million. O&M funding will phase-in as initial site construction is completed and antennas are delivered. Funds will be used to manage and support site and instrument maintenance, array operations in Chile, early- and eventually full-science operations, as well as support ALMA observations by the U.S. science community. Full ALMA science operations are forecast to begin in 2013. The anticipated operational lifespan of this project is at least 30 years.

Advanced Technology Solar Telescope (ATST)

To be constructed at the Haleakala High Altitude Observatory on the island of Maui in Hawaii, the Advanced Technology Solar Telescope (ATST) will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere, and corona. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity, including flares and coronal mass ejections. These can affect civil life on Earth through the phenomena generally described as "space weather" and may have impact on the terrestrial climate.

The project is a collaboration of scientists and engineers at more than 20 U.S. and international organizations. Other potential partners include the Air Force Office of Scientific Research and international groups in Germany, the United Kingdom, and Italy.

The current design, cost, schedule, and risk were scrutinized in an NSF-conducted PDR in October-November 2006. The FDR held in May 2009 determined that the project was fully-prepared to begin construction. In FY09, $6.67 million was provided through the RRA account. Of this total, $3.57 million in regular RRA funds supported design activities to complete a construction-ready design, and $3.1 million through the American Recovery and Reinvestment Act of 2009 (ARRA) supported risk reduction, prototyping, design feasibility, and cost analyses in areas identified at preliminary and systems design reviews. ARRA funding also provided for several new positions to complete preparation for the start of construction. Also in FY09, $153 million was provided through MREFC account to initiate construction. Of these MREFC funds, $146 million was appropriated through ARRA. Given the timing of the receipt of budget authority and the complexity of project contracting, the entire $153 million was carried over from FY09 and subsequently obligated in FY10.

Oversight from NSF is handled by a program manager in AST. The project is managed by the National Solar Observatory (NSO). NSF funds NSO operation and maintenance and ATST design and development via a cooperative agreement with the Association of Universities for Research in Astronomy, Inc. (AURA).

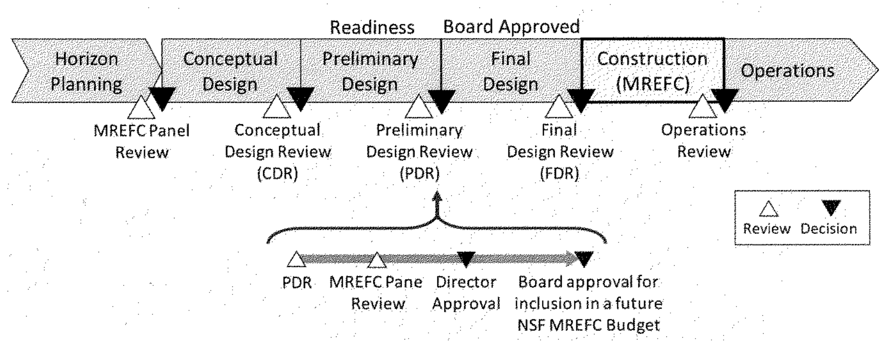
The baseline not-to-exceed cost was established following the FDR. Funding is derived from ARRA ($146 million) and annual appropriations in the MREFC account ($151.93 million). In order to clearly separate funds from the two sources, the project developed two statements of work, dividing their resource-loaded Work Breakdown Structure between large contracts to be funded early in the project by ARRA, and smaller procurements and project costs, such as labor and rent, to be funded by future annual MREFC appropriations.

The FY13 budget request for ATST is $25 million. The total project cost to NSF, $297.93 million, was finalized after a FDR in May 2009. The NSB approved an award for this amount at the NSF Director's discretion, contingent upon completion of compliance with relevant environmental and cultural/historic statutes. The environmental compliance requirements were completed on November 20, 2009, and the Record of Decision authorizing the construction was signed by the NSF Director on December 3, 2009. The Board on Land and Natural Resources (BLNR) approved the project's application for a Conservation District Use Permit (CDUP) on December 1, 2010. After a lengthy challenge to the CDUP by a Native Hawaiian organization, a hearing officer overturned the challenge on February 24, 2012, clearing the way for site preparation and construction to begin.

The estimated annual operations cost is projected to be $18 million in FY18, including $2 million annually for cultural mitigation. Approximately $5-$7 million per year of NSO costs will be recovered from the closure or divestment of redundant facilities. NSO has a preliminary transition plan that will be revised and externally reviewed after construction begins.

APPENDIX A: NSF MREFC Process

NSF's updated large facility project planning process



- **Horizon/Conceptual Design MREFC Panel Review**
  - –Compelling science case, aligned with NSF's strategic plan and compatible with existing facilities portfolio, reasonable development timeline, potentialities for partnership, assessment of any major challenges to NSF
- **Conceptual Design Stage**
  - –Requirements, initial estimates of cost (including operations), risk and schedule
- **Preliminary Design ("Readiness") Stage**
  - –Definition and design of major elements, detailed estimates of cost, risk and schedule, partnerships, siting
- **Final Design ("Board Approved") Stage**
  - –Interconnections and fit-ups of functional elements, refined cost estimates based substantially on vendor quotes, construction team substantially in place

Chairman BROOKS. The Subcommittee on Research and Science Education will come to order.

Welcome to today's hearing entitled "NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability." The purpose of today's hearing is to examine the management and operations of major research equipment and facilities' construction—MREFC is the acronym—projects at the National Science Foundation. I now recognize myself for five minutes for an opening statement.

I am pleased to welcome all of our witnesses to discuss the oversight of NSF's major research equipment and facilities management from basic concept design through post-construction operations and maintenance. I look to my colleague, Mr. Lipinski, and my fellow Subcommittee members on both sides of the aisle to work with me to continue to ensure the Subcommittee performs its legislative, oversight, and investigative duties with due diligence on matters within its jurisdiction throughout the 112th Congress and appreciate their valued experience and insights.

Investments in various multi-user research facilities such as vessels, astronomical observatories, particle accelerators, the United States Antarctic stations, seismic observatories, and many others comprise approximately 15 percent of NSF's portfolio. Additional components of the infrastructure portfolio include large datasets based on NSF-supported surveys, the provision of shared-use equipment for academic researchers, and interdisciplinary centers.

Under the Major Research Equipment and Facilities Construction (MREFC) account, large multi-year projects are funded that would be too expensive for a specific Directorate to take up on its own. MREFC projects focus solely on the construction of major equipment and facilities. The science driving the projects and the operations and maintenance once construction is completed are funded through separate NSF budget accounts.

Over the past ten years, NSF has worked to establish and refine the practices for launching new MREFC projects, overseeing construction, and the transition to managing the operations and maintenance of the equipment and facilities. These practices have lead to greater involvement by the National Science Board and a clear understanding of how MREFC projects are prioritized in difficult economic times. While these major equipment and facilities support NSF's larger goal of ensuring the United States maintains its competitive edge in science by promoting global leadership in advancing research, education, and innovation, it is imperative that appropriate oversight be executed to guarantee the greatest return on taxpayer investments.

I have said this before and will echo the sentiment again today—America faces unsustainable budget deficits that constitute our greatest economic and national security threat. This leaves absolutely no room for government waste, even within America's most prized programs and facilities. I look forward to learning more about what I, and my colleagues on the Research and Science Education Committee, can do to pave a more responsible path for America's future by way of supporting these important endeavors.

The Chair now recognizes Mr. Lipinski from the great State of Illinois for an opening statement.

[The prepared statement of Mr. Brooks follows:]

PREPARED STATEMENT OF CHAIRMAN MO BROOKS

Good morning and welcome. I am pleased to welcome all of our witnesses to discuss the oversight of NSF's major research equipment and facilities management from basic concept design through post-construction operations and maintenance.

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Mr. LIPINSKI. Thank you, Chairman Brooks. Thank you for holding this hearing today.

Ten years is probably too long a period between hearings on the important topic of how NSF manages and oversees its large facilities over their full life cycle, especially given the many changes of the MREFC process in that time. So I am pleased that we are having this hearing this morning and grateful to witnesses who are taking the time to help us understand where we stand with MREFC and what oversight issues remain.

When I was Subcommittee Chair in the last Congress, we held a hearing on the role of NSF in supporting university research infrastructure. That was a somewhat different topic but still part of the larger question of how we balance support for research infrastructure with support for research grants. Remaining a global leader in scientific R&D requires more than intellectual freedom in grant funding. Cutting edge research requires state-of-the-art research facilities and we can no longer take it for granted that the best scientists want to live and work in the United States.

In a 2003 report on science and engineering infrastructure, the National Science Board recommended that the share of the NSF budget dedicated to research infrastructure should fall in the range of 22 to 27 percent but closer to the high end of that range. While I am pleased that the fiscal year 2013 budget request restores funding to MREFC projects after several years of cuts as a percentage of the budget, funding for it still remains at the bottom end of that range. This can at least in part be explained by the blip in ARRA funding in 2009 that reduced pressure on out-year budgets for MREFC and the fact that there is no new proposals for fiscal year 2013. However, this remains an area of concern for me and one I will continue to closely—follow closely in my leadership role on this Subcommittee.

Returning to the specific topic of this hearing, major research facilities management, there are a couple of issues I am hoping to learn more about. First, I would like to understand how MREFC policies have evolved in the last few years, including the role of the National Science Board and what instigated these changes. In particular, I would like to know what we have learned from the Deep Underground Science and Engineering Laboratory, or DUSEL. While I believe that the December 2010 decision by the Board with respect to DUSEL was probably right—was the right one for the foundation, letting the project advance as far as it did before terminating it was certainly harmful and wasteful. So I would like to know what policies have been put in place since then to avoid a repeat of the situation.

Second, I would like to address the ongoing dispute between the Inspector General and NSF management with respect to contingency funds. I will begin by saying that I am comfortable with the definition NSF is using for contingency funds and it appears to be consistent with the private sector standard for project management and with practices at other agencies. As someone trained in systems engineering, I also think that calculating a contingency total based on the ensemble mean of all foreseeable risks across all aspects of a project and incorporating that into the total project cost is the right approach. But the IG has raised important questions regarding whether there are sufficient controls over draw-downs from the contingency fund and whether the funds should be held at the Agency or with the project.

I think there are good arguments on both sides of this issue, and I worry also that the projects currently underway are caught in this dispute between the IG and NSF management. I would like to hear how the IG and NSF are working to resolve their differences.

Finally, as stewards of taxpayer money, it is incumbent upon us to ask whether it is appropriate that any funds left over due to outstanding management or just plain luck should be returned to the NSF where re-scoping of that particular project can be balanced against other agency priorities. I know that NSF and Mr. Yeck are proud of how the IceCube Project came in under budget and rightly so. Mr. Yeck, from everything I know, from what you did, you did an exemplary job with the project under extraordinary conditions. I would like to learn more about what IceCube was able to accomplish with those leftover funds, but also ask the broader question of whether this is the most appropriate use of NSF dollars given that the most important science was already prioritized in the original scope and design of IceCube.

Now, I don't have answers to these questions, and I hope our witnesses will share their insights. But I do think it is critical that we align incentives with prudent project management and outcomes that are most appropriate in terms of both the science and the budget. Overall, I am very pleased with how far the Agency has come in the last few years in strengthening management and oversight of its large facilities and I look forward to using this hearing to explore where issues may remain and what the best way is to move forward.

And I yield back.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF RANKING MEMBER DANIEL LIPINSKI

Thank you Chairman Brooks. Ten years is probably too long a period between hearings on the important topic of how NSF manages and oversees its large facilities over their full lifecycle, especially given the many changes in the MREFC process in that time. So I am pleased we are having this hearing this morning and grateful to the witnesses who are taking the time to help us understand where we stand with MREFC and what oversight issues remain.

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While I don't have answers to these questions—and I hope our witnesses will share their insights —I do think it's critical that we align incentives with prudent project management and outcomes that are the most appropriate in terms of both the science and the budget.

Overall, I am very pleased with how far the agency has come in the last few years in strengthening management and oversight of its large facilities, but I look forward to using this hearing to explore where issues may remain.

Chairman BROOKS. Thank you, Mr. Lipinski.

If there are members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time, I would like to introduce our witnesses for today's hearing. Dr. Cora Marrett is Deputy Director of the National Science Foundation. Since January 2009, Dr. Marrett has served as NSF's acting Director, acting Deputy Director and Senior Advisor until her confirmation as Deputy Director in May 2011.

Dr. José-Marie Griffiths is the Chairman of the Subcommittee on Facilities of the National Science Board, NSB. Dr. Griffiths was appointed to the NSB in 2006. She is currently Vice President for Academic Affairs and University Professor at Bryant University in Smithfield, Rhode Island.

Mr. James Yeck is Director of the IceCube Neutrino Observatory located at the South Pole. That is a pretty good name, IceCube, for the South Pole. That is clever. Who came up with that? We will get into that in the questions. Mr. Yeck joined the University of Wisconsin-Madison as the IceCube Project Director in 2003. Previously, Mr. Yeck served as Deputy Project Director and Assistant Project Director for the National Synchrotron Light Source II project and as the Federal Project Director for the U.S. Large Hadron Collider Construction Project. Now, that is a mouthful. IceCube is easier to say.

Dr. Tony Beasley is the Chief Operating Officer and Project Manager of the National Ecological Observatory Network. Dr. Beasley has worked as an astronomer post-doc, staff member, and Senior Manager at the U.S. National Radio Astronomy and Project Manager for CARMA and ALMA millimeter telescopes.

And then finally, we have Dr. Tim Cowles. He is the Project Director and Principal Investigator of the Ocean Observatories Initiative, OOI, and serves as Vice President, Director, Ocean Observing activities at the Consortium for Ocean Leadership. Previously, Dr. Cowles served as Associate Dean and Interim Dean of the College of Oceanic and Atmospheric Sciences at Oregon State and served on the Leadership Council of the University National Oceanographic Laboratory System.

As our witnesses should know, spoken testimony is limited to five minutes each, after which the members of the Committee will have five minutes each to ask questions.

As an aside, we are scheduled to vote today at approximately 11:15. That is the advanced notice we have. Hopefully, we will be able to finish this hearing by then, but if not, as circumstances warrant, we will suspend and come back after the votes.

I now recognize our first witness, Dr. Cora Marrett. Dr. Marrett, you are recognized for your five minutes.

STATEMENT OF DR. CORA MARRETT, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. MARRETT. Thank you very much.

Chairman Brooks, Ranking Member Lipinski, and distinguished members of the staff, thank you for inviting me to participate in this hearing for I am pleased to have the opportunity to discuss the National Science Foundation's large facilities process with you.

As you well know, NSF is the primary federal agency supporting research at the frontiers of knowledge across all fields of science and engineering and all levels of science and engineering education. Its mission, vision, and goals are designed to maintain and strengthen the vitality of the U.S. science and engineering enterprise. As I start my remarks, I want to thank Congress on behalf of the Foundation for the sustained engagement and support you have shown NSF even in difficult economic times.

Throughout its 60-year history, NSF has contributed to maintaining U.S. leadership in science and engineering research by enabling the creation of advanced instrumentation and world-class, multi-user facilities for the science and engineering research community. Each NSF facility is chosen carefully to push technology and innovation to a new frontier of scientific discovery. In addition to enabling immense scientific return, these facilities serve as platforms to prepare the next generation of scientists and engineers and contribute to the need for high technology and services necessary for economic growth and innovation.

You will hear today about a few of our newest major facilities, about, as you have already mentioned, IceCube, the world's first neutrino observatory which has just opened a new window on the engines that power galaxies and other astrophysical processes throughout the universe. You will hear about the Ocean Observatories Initiatives, or OOI, and the National Ecological Observatory Network, NEON. These are our newest facilities under construction.

OOI and NEON are representative of a new transformational class of facilities for the 21st century. These are cyber-enabled distributed observing systems that acquire and stream scientific data on vast geographic scales. These are just a few examples of our facility portfolio, a portfolio which spans the gamut of research disciplines from physics and astronomy, engineering and material science, to earth and ocean sciences, and polar and biological sciences.

Major facility projects require special funding mechanisms that allow for multi-year construction. The Major Research Equipment and Facilities Construction account, or MREFC, was established by Congress in 1995 to support the acquisition, construction, and commissioning of large-scale facilities projects. Eligibility for MREFC funding is made on a case-by-case basis and is not solely dependent on cost but on scientific promise. Indeed, NSF requires that each MREFC candidate project represent an outstanding opportunity to enable breakthrough research and innovation, as well as education and broader impacts.

Mr. Chairman, NSF takes its facility stewardship responsibilities very seriously. Implementation of the largest NSF multi-user facilities requires investments of hundreds of millions of dollars to ensure success at this major scale of investment. NSF has strong processes in place for overseeing the planning, construction, and operation of its facilities and for managing our overall facility portfolio.

As you will hear shortly from Dr. Griffiths, the National Science Board also provides extensive guidance, review, and concurrence on NSF decision-making for facilities. NSF also works very closely with our Inspector General, the Office of Management and Budget, and in partnership with Congress to ensure that we are working to the very highest standards.

My written testimony outlines our processes from start to finish, including recent enhancements we have made to our procedures for facility planning and oversight.

Mr. Chairman, thank you again for the opportunity to appear before the Subcommittee to speak to you on this important topic. At an appropriate time I will be pleased to answer any questions you may have.

[The prepared statement of Dr. Marrett follows:]

Testimony of

Dr. Cora B. Marrett, Deputy Director
National Science Foundation

Before the

U.S. House of Representatives
Committee on Science, Space, Technology
Subcommittee on Research and Science Education

NSF Major Research Equipment and Facilities Management:
Ensuring Fiscal Responsibility and Accountability

March 8, 2012

Introduction

Chairman Brooks, Ranking Member Lipinski, and distinguished Members of the Subcommittee, thank you for inviting me to participate in this hearing on "NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability".

I am pleased to have the opportunity to discuss the National Science Foundation's (NSF) large facility process with you.

As you well know, NSF supports research at the frontiers of knowledge across all fields of science and engineering (S&E) and all levels of S&E education. Its mission, vision and goals are designed to maintain and strengthen the vitality of the U.S. science and engineering enterprise.

Throughout its 60 year history, NSF has contributed to maintaining U.S. leadership in science and engineering research by enabling the creation of advanced instrumentation and world-class multi-user facilities for the science and engineering research community.

NSF's investments in multi-user facilities are designed to provide unique, transformational research capabilities at the frontiers of science and engineering. The NSF multi-user facility portfolio spans experimental disciplines from physics and astronomy, engineering, and materials science, to earth and ocean sciences, polar sciences and biological sciences. The newest facilities comprise distributed sensor arrays, extensive cyber-infrastructure, and streaming data networks on continental scales. In addition to enabling immense scientific return, multi-user facilities serve as platforms to train the next generation of scientists and engineers, and provide the high technology equipment and services necessary for economic growth and innovation.

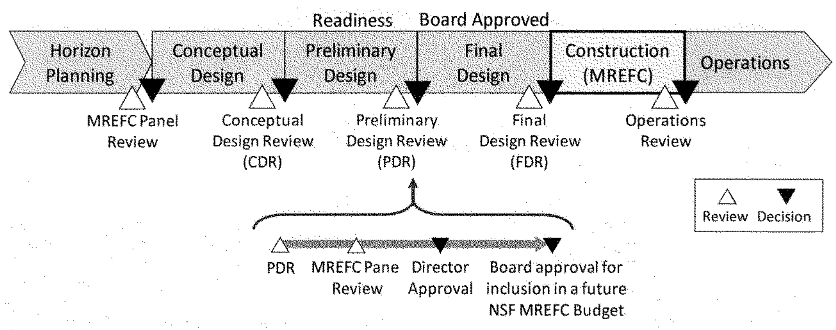
The Major Research Equipment and Facilities Construction (MREFC) account was established in 1995 to support the acquisition, construction, and commissioning of large-scale facility projects. NSF requires that each MREFC candidate project represent an outstanding opportunity to enable breakthrough research and innovation, as well as education and broader impacts. Each should offer the possibility of transformative knowledge and the potential to shift existing paradigms in scientific understanding, engineering processes and/or infrastructure technology. And each must serve an urgent contemporary research need that will persist through the process of planning and development.

NSF takes its facility stewardship responsibilities very seriously. Implementation of the largest NSF multi-user facilities requires investments of hundreds of millions of dollars. To ensure success at this major scale of investment, NSF has strong processes in place for overseeing the planning, construction, and operations of its facilities, and for managing its overall facilities portfolio. NSF has recently taken steps to make these processes even stronger. I am pleased to describe the large facility process in detail below.

The NSF large facility process from initial planning to operation

NSF enables and oversees the creation and operation of major multi-user facilities through a defined set of funding mechanisms, stewardship policies, and management processes. A number of National Academies of Science reports on federal science facility project development[1] provided the foundations for NSF's current process.

As illustrated in the figure below, large facility projects under consideration for MREFC funding undergo a multi-stage development, review and approval process. This process is fully defined in NSF's guideline document, the Large Facilities Manual[2]. Note that MREFC funds support only the Construction Stage of an approved facility project; preconstruction planning and design of a potential facility project and post-construction operations and maintenance of the facility are funded through the Research and Related Activities (R&RA) budget of the sponsoring Directorate or Office.



NSF Large Facilities (MREFC) process

Horizon Planning Stage: Ideas for potential large facilities originate in the scientific community and typically evolve conceptually over many years. Initially, NSF responds to opportunities articulated by the research community. These ideas are subjected to external merit review, and may receive funding by the cognizant Science and Engineering Directorate or Offices for further early- (pre-conceptual design) stage refinement. In parallel, the relevant scientific community may coalesce around a preferred concept or a prioritization of competing potential projects, and these preferences will be communicated to NSF via workshops, advisory committees, and authoritative reports from professional societies and the National Academies.

[1] *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*, NRC 2004 (and see NSF-NSB responding report of the same title, 2004); Improving Project Management in the Department of Energy, NRC, 1999 (and see succeeding publications in this series through 2005).
[2] The NSF Large Facility Manual is available online at www.nsf.gov/publications/pub_summ.jsp?ods_key=lfm.

The sponsoring NSF Directorate or Office may determine that a proposed horizon stage facility addresses high priority science goals and deserves investment in conceptual design and development according to the guidelines of NSF's large facility planning process. As illustrated in the figure above, the Directorate or Office may at this point request internal NSF review of the proposed project by the senior-level MREFC Panel[3], which in turn makes a recommendation to the NSF Director who may approve or decline the project's advancement to the Conceptual Design Stage. Key criteria are: the demonstration of a strong science case and readiness to undertake conceptual design activities defined by NSF guidelines. Approval only allows initiation of the first stage of formal preconstruction planning; it does not constitute a commitment by NSF to develop the project further.

Preconstruction Planning Stages: NSF preconstruction planning for potential NSF large facility projects comprises three stages: Conceptual Design, Preliminary Design and Final Design. The objective of preconstruction planning activities is to shepherd a project from the conceptual stage to construction readiness and approval. Activities include project planning and design by NSF awardees, and internal planning and oversight by NSF program management, NSF administrative units and NSF senior management. The sponsoring NSF program also establishes a strategy for supporting long-term facility operations, including sun setting, based on the operations plans and associated cost estimates developed by the project team.

As illustrated in the above figure, each preconstruction planning stage concludes with a corresponding formal review conducted by NSF utilizing an external independent panel of experts selected and charged by the responsible NSF Program Officer, in consultation with the NSF Large Facilities Office. The expert panel evaluates the scientific, technical, business, and post-construction operations plans, and the associated cost estimates for these according to NSF guidelines, and advises the Program Officer as to whether the project is ready to advance to next stage. The corresponding decision milestones comprise evaluation by the sponsoring Directorate or Office, review and recommendation by the MREFC Panel, and decision by the NSF Director to advance the project. The National Science Board also reviews and may endorse the Director's advancement decisions, as noted further below. The decision milestones also constitute "off ramps" for terminating the project if progress is not deemed satisfactory or NSF's plans or priorities change.

Conceptual Design Stage: NSF requires the project team to develop conceptual designs that include the definition of science goals and objectives the proposed facility will address, and the respective science, technical and functional requirements that are essential to achieve the

[3] NSF's senior-level MREFC Panel is composed of the NSF Deputy Director, Directorate Assistant Directors and Office Heads, and also includes the heads of the Large Facilities Office and Budget Division. More details on the Panel's role and responsibilities can be found in the NSF Large Facilities Manual.

research objectives. The project team must also develop an initial top-down budget estimate; an assessment of major risks; an analysis of potential partnerships for facility development, construction and/or operation; and an initial estimate of the future budget needed to operate the proposed facility. The sponsoring NSF program also develops an Internal Management Plan that defines its stewardship strategy – including plans for oversight during the later more-intensive stages of pre-construction planning, funding the design activity and defining off-ramp criteria should project development not progress as planned.

At the appropriate time, NSF conducts a Conceptual Design Review (CDR) to determine if the project is ready to advance to the Preliminary Design Stage. Note again that the NSF Director's approval only allows investment in preliminary design activities; it does not constitute a commitment by NSF to develop the project further.

Preliminary Design Stage (also, Readiness Stage): If approved by the Director and the Board, and funds have been requested by NSF and appropriated by Congress, the sponsoring Program may fund the project team to develop a preliminary design, which comprises development of a detailed scope of work – via a technical design and development activities, development of a detailed Work Breakdown Structure (WBS), a resource-loaded project execution schedule, identification of risks and a comprehensive risk management plan, and a bottom-up "risk adjusted" cost estimate composed of the baseline estimate and a contingency budget added to the estimate for changes that experiences shows will likely be required, taking those risks into account.

At the appropriate time, NSF conducts a Preliminary Design Review (PDR) to determine if the project is ready to advance to the Final Design Stage. The review comprises evaluation of the technical and management plans and cost estimate; the credibility of the proposed project team and institutional partners to carry out the project; and the proponent's projection of future operating plans and associated cost estimates. The outcome of the PDR process establishes the project's baseline, which is used as the basis for the request to Congress for MREFC funds.

Advancement entails a request by the Director to the National Science Board to include the facility project in a future NSF Budget Request for MREFC Funds. Board approval effectively constitutes a commitment by NSF that it intends to fund the facility project. Following Board approval, the project is proposed to the Office of Management and Budget (OMB) for inclusion in a future NSF Budget Request to Congress, and is advanced to the Final Design Stage. Should OMB concur, NSF subsequently presents the project – including the overall plan, total cost, requested multi-year MREFC funding profile, and estimated out-year operations funding profile – in the President's NSF BudgetRequest to Congress.

Final Design Stage (also, Board Approved Stage): The period between Preliminary Design Review and appropriation of funds typically requires at least two years. During the Final Design Stage, the project team is funded to continue to refine cost estimates, recruit additional construction staff, finalize partnership commitments, and complete other preparatory work that must be accomplished prior to commencing construction. During this time, NSF conducts annual cost update reviews to ensure that the assumptions underlying the baseline definition continue to be valid.

Around the time appropriated funds become available, NSF conducts a Final Design Review (FDR) to verify that the project is fully prepared to undertake construction activity, and that the project cost estimate continues to be valid. If the review is successful, NSF requests approval from the National Science Board to obligate funds to commence construction.

Construction Stage: During this stage, NSF receives monthly technical and financial status reports, and performs comprehensive reviews and site visits of the project at least annually. NSF requires projects to report their project cost and schedule performance using earned value methodology, and to report all changes to the project baseline, including budget, schedule, and scope changes. NSF also approves requested changes and/or calls on budget contingency that exceed pre-determined thresholds. The National Science Board is notified if any requested changes exceed ten percent of the total project cost. If the project is judged not to be performing satisfactorily, NSF may require its project awardee to implement a Corrective Action Plan or perform rebaselining, or NSF may take other actions including termination.

Operations stage: Facility operational activity begins following construction and commissioning of the new facilities, or in many cases concurrently with the completion of those activities. Generally, the entity responsible for constructing and commissioning the facility also has responsibility for initial operation. NSF continually reviews facilities as they develop and during full operations to ensure that the activities comprising the operational stage fulfill scientific goals within the available funding. NSF also requires operating facilities to develop annual work plans that set annual performance goals, to measure their performance against those goals, and report the results to NSF each year. In keeping with National Science Board guidance, NSF also promotes excellence and efficiency in facility operation by encouraging full and open recompetition of the subsequent award for continued operation and maintenance.

NSF's capacity to support ongoing operation and research utilization of its facilities – including investments in advanced R&D to maintain the vitality of facilities – are the pacing factors in the ability of NSF to support new research infrastructure. NSF and the National Science Board continually assess current infrastructure to determine what should be maintained and where redirection towards new opportunities is appropriate. Blue Ribbon Panels, Advisory

Committees, commissioning of external studies, and periodic facility reviews are all part of this process.

NSF staff roles in large facility stewardship: For each facility, a designated Program Officer within the sponsoring Directorate or Office executes stewardship responsibilities and serves as the NSF principal point of contact throughout the facility's life cycle. The Large Facilities Office, located within the Chief Financial Officer's front office and headed by the Deputy Director for Large Facility Projects, develops NSF's large facility process guidelines and assists program staff and senior management in project and facility portfolio planning and oversight. The Budget Division and Grants and Agreements Specialists in the CFO's organization engage in budget development, and in pre-award planning and post-award oversight, respectively.

Role of the National Science Board[4]: The National Science Board provides oversight throughout the entire life-cycle process for planning, constructing, operating, and eventually terminating NSF support for large facilities. It prioritizes among competing projects in preconstruction planning and relative to other opportunities, endorses project advancement from one preconstruction planning stage to the next, approves NSF's request to OMB to include a request for construction funding within a future NSF Budget Request to Congress, and approves the obligation of funds to commence construction following a Congressional appropriation. The Board conducts annual portfolio reviews of all NSF major multi-user facility projects at post-Conceptual Design Review stages of planning and those in construction and operation, offering guidance to NSF on the balance between investments in research infrastructure and support for other activities.

Recent modifications to the large facilities process

With the Fiscal Year 2009 Budget Justification, NSF implemented a "no cost overrun policy" designed to increase rigor in the planning and execution of projects within approved cost estimates. As stated in the FY 2013 Budget Justification, this policy requires that "(1) the total cost estimate for each project at the preliminary design stage include adequate contingency to cover all foreseeable risks, and (2) any total project cost increases not covered by contingency be accommodated by reductions in scope, provided that the actual enacted funding levels have been consistent with the established project profiles.... If the total cost for a project is revised during construction for reasons other than inadequate funding, NSF will identify mechanisms for offsetting any cost increases in accordance with the no overrun policy."

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[4] Please refer to the testimony of Dr. José-Marie Griffiths at this Hearing for further details concerning the Board's role.

In FY 2011, NSF implemented additional changes to its large facility process to improve handling of early-stage projects. The main objectives were to (1) clarify the distinction between "horizon" projects and projects in the formal "Conceptual Design Stage", (2) enhance the agency-wide strategy for enabling interdisciplinary planning at the early stage, and (3) fully align the facility planning and budget planning processes.

Previously, NSF did not make a strong distinction between what it called "horizon projects" and those in the defined preconstruction planning stages. While this practice maximized Directorate and Office flexibility to exploit facility opportunities in various stages of maturity, it was challenging for the agency to monitor the programmatic status of these early-stage concepts, and communicate these uniformly to stakeholders and potential partners.

As shown in the earlier figure, NSF now defines a "Horizon stage" prior to the "Conceptual Design Stage". Horizon projects are those priority activities under consideration within Directorates/Offices, but which are not yet ready for advancement through the MREFC preconstruction planning process. Projects in the Conceptual Design Stage follow Large Facilities Manual guidelines, and receive R&RA funding specific to developing the Conceptual Design of a potential future MREFC project.

Second, NSF now defines an agency-level transition milestone between the "Horizon Stage" and "Conceptual Design Stage", that is, an explicit entry point to the initial MREFC preconstruction planning stage that mirrors the transition review/approval process for all other stages. This comprises two steps: first, a formal review by the MREFC Panel of requests by Directorates or Offices to advance horizon projects to the Conceptual Design Stage; and second, a decision by the NSF Director – supported by the Panel's recommendation - on whether (and how) the project should advance. The Panel's review is conducted according to an established procedure and set of evaluation criteria.

These modifications enhance the roles of the Director and senior agency management in reviewing and advancing early-stage projects, and serve to ensure that adequate resources are invested at this early planning stage. In making these changes, NSF has also incorporated a requirement that sponsoring Directorates and Offices demonstrate increased early-stage planning and timeline development in order to strengthen alignment with the budget process; and engagement with the OMB and the Office of Science and Technology Policy (OSTP) as appropriate, particularly for interagency partnered projects.

It is important to emphasize again that this approval for advancement of a horizon project into the Conceptual Design Stage of planning does not imply NSF commitment to implement the project beyond that stage. As mentioned earlier, such NSF commitment does not come until after the successful conclusion of the Preliminary Design Stage and approval by the National Science Board.

Impacts on approved projects of underfunding of the MREFC construction account

NSF strives to make best use of the funds entrusted to it. To this end, NSF gives all projects in construction a higher priority than those proposed for future construction. NSF also develops multi-year project construction budgets that are "technically limited", that is, budgeted according to the optimum rate that work can be performed in order to obtain the lowest total project cost. The MREFC account has increased and decreased from year to year as a consequence of budgeting to meet project needs rather than planning the project activities according to a predetermined budget.

The success of this budgeting practice assumes that NSF will receive all of the MREFC funds requested from Congress for an approved project in a given year. When this does not happen, a project's plans must be adjusted accordingly, potentially leading to increased costs and reduced project scope and science capability.

If MREFC funding is less than requested, NSF gives highest priority to funding those projects farthest along in construction while deferring work on projects just getting underway, in order to avoid the added costs of suspending and restarting work in progress. NSF executed this policy in FY2011 when the enacted MREFC budget ($117 million) was less than requested ($165 million).

Selected Lessons Learned

Over many years of sponsoring the creation and operation of major multi-user research facilities, NSF has gained substantial insight into facility development best practices, and endeavors to adopt these uniformly as they are recognized. Here I note several "take-away" lessons that stand out in particular and that influence NSF's planning, investment, and oversight of major facility projects.

Experience at NSF and across the federal science facility enterprise confirms that adequate investment in preconstruction planning is essential to achieving a project's intended scope within its estimated budget. NSF experience is consistent with observations at other agencies that an amount equal to 10 to 25 percent of the total capital cost must be invested in preconstruction planning in order to assure that the project is well planned, risks are effectively understood and planned for, and that a credible project team is assembled and able to implement the proposed project.

Exceptional projects demand exceptional individuals in key positions of responsibility. Advisory and external review committees are very valuable as means to vet management capabilities. In addition, major projects must adequately invest in modern management tools. In particular, Project Management Control Systems are essential for determining the project's technically limited construction schedule and the associated funding profile, and so that, once in construction, the project manager can effectively ascertain technical and financial status, obtain a detailed picture of risks and contingency usage, and provide the necessary transparency to the agency needed to carry out an effective oversight role.

Finally, large facility projects often expend two-thirds, or more, of their total budget as subawards and subcontracts to other parties. Consequently, it is extremely important that during planning the project team develop effective plans for subawardee and subcontract monitoring and oversight, including Quality Assurance and Safety.

Conclusion

Mr. Chairman, the world-class equipment and facilities that NSF supports are essential to the task of discovery, and are vital to NSF accomplishing its mission of supporting fundamental U.S. science and engineering research. NSF will continue to enhance its policies and practices for stewardship of major research facilities and other infrastructure in concert with the evolving needs of the scientific community for these unique assets and capabilities.

I appreciate the opportunity to appear before the Subcommittee to speak to you on this important topic. I would be pleased to answer any questions that you may have.

Chairman BROOKS. Thank you, Dr. Marrett.
Next, the Chair recognizes Dr. Griffiths for five minutes.

STATEMENT OF JOSÉ-MARIE GRIFFITHS, CHAIRMAN, SUBCOMMITTEE ON FACILITIES, NATIONAL SCIENCE BOARD, VICE PRESIDENT OF ACADEMIC AFFAIRS, BRYANT UNIVERSITY

Dr. GRIFFITHS. Chairman Brooks, Ranking Member Lipinski, and distinguished members of the staff, I appreciate this opportunity to testify before you today regarding the role of the National Science Board in guidance and oversight of facility investments at the National Science Foundation.

Projects being considered for funding under the Major Research Equipments and Facility Construction account are high-profile, high-cost activities for unique, cutting-edge facilities. They require considerable research and development in the design stage. And since these types of projects require significant taxpayer funds, the Board and the Foundation invest substantial efforts to review scientific needs, construction costs, and operations and maintenance costs for projects in or being considered for inclusion under the MREFC account.

In my time on the Board, the Agency has made great strides in overseeing both the design and the construction of these critical facilities. The Board's role in oversight of the MREFC account includes approval of NSF-proposed projects for funding in future budgets, the funding priority list for previously-approved-but-not-yet-funded MREFC projects, and approval for the release of Congressionally appropriated MREFC funds to NSF awardees.

Current policy is for the Board to concur on the readiness of projects to proceed to the final design stage in the MREFC account. The most recent enhancement to this policy approved by the Board in February 2010 is the timeline for the Board's MREFC process, which the Board now receives in association with its annual facilities portfolio review.

The Board established the Subcommittee on Facilities in 2009 to oversee the Foundation's portfolio of facilities projects. The Subcommittee provides guidance to the Board on strategic planning for the NSF-funded research equipment and facilities portfolio. This guidance includes an annual review of existing MREFC and R&RA (research and related activities), large and mid-sized research facilities and infrastructure, and their impact on long-term budgets within the Foundation. The Subcommittee on Facilities reviews all phases of its facility design, development, construction, operations, and retirement.

As part of its review, the Board conducts a joint Committee on Programs and Plans and Committee on Strategy and Budget meeting in February to hear details of the NSF facilities plans for projects anticipated in the upcoming year. The plan contains information about the planning and budgeting process for facilities under construction, including a brief status report on those projects already funded under the MREFC account.

After the facility plan discussion, the Board conducts an annual portfolio review of projects at its May meeting. The objectives of this review are to examine the interrelationships between the proposed facility development and other activities across the Foundation to help guide the appropriate balance of investment in infrastructure and research. The review also examines the budgetary consequences, operations costs, and future liabilities of further development and guides NSF in managing risk and also in being able to respond to opportunities. It also can guide policies and recommend specific action for the coordination and optimization of partnerships between NSF and other agencies, private foundations, and foreign entities in support of major facilities.

NSF's major multi-user facilities and its MREFC program are integral to the NSF investment portfolio. Selecting the best projects, providing adequate program management, and oversight for the operation of such facilities are all substantial challenges. These challenges must be met while ensuring that we continue to provide adequate balanced support for the individual research or proposals for potentially transformative research.

On behalf of the National Science Board and the science and engineering research and education communities, I would like to thank the members of the Subcommittee for your long-term recognition of and commitment to support for the National Science Foundation and we look forward to continuing our productive working relationship with you and service to the Nation.

[The prepared statement of Dr. Griffiths follows:]

Statement of Dr. José-Marie Griffiths
Chairman, Subcommittee on Facilities
Committee on Strategy and Budget
National Science Board
to the
Subcommittee on Research and Science Education
Committee on Science, Space and Technology
United States House of Representatives
on

NSF Major Research Equipment and Facilities Management:
Ensuring Fiscal Responsibility and Accountability
March 8, 2012
10:00 a.m.

Chairman Brooks, Ranking Member Lipinski, and Members of the Subcommittee, I appreciate the opportunity to testify before you today regarding the role of the National Science Board in guidance and oversight of facility investments at the National Science Foundation (NSF). I am José-Marie Griffiths, a member of the National Science Board (Board), and Chairman of the Subcommittee on Facilities (SCF). I am also Vice President for Academic Affairs and University Professor at Bryant University in Smithfield, Rhode Island. In 2006, I was nominated to the Board by President Bush and confirmed by the Senate.

In my experience on the Board during these past six years, I have been consistently impressed with the quality of research supported, the long reach of NSF activities, and by the dedication and expertise of the agency's staff. In addition, the working relationship that has developed between the Board and NSF management during this time has been especially rewarding. This collaborative relationship has served the Nation well.

Introduction

On behalf of the entire Board, I would like to thank the Members of this Subcommittee for your long-standing commitment the NSF and its investments in a broad portfolio of research and education in science, technology, engineering, and mathematics (STEM). NSF is the primary funding source for academic basic research across non-biomedical science and engineering (S&E) disciplines. NSF funds cutting-edge research at the frontiers of knowledge, and also supports scientific facilities and activities in STEM education. Over its history, NSF's broad portfolio of investments has underwritten a wealth of research that has directly and indirectly benefitted the American economy and the general public.

When Congress established NSF in 1950, it defined dual responsibilities for the National Science Board. First, the Board was to oversee the activities of, and establish the policies for, the National Science Foundation. Second, the Board was to serve as an advisory body to the President and Congress on national policy issues related to science and engineering and education in science and engineering. For today's testimony, I'd like to focus on our first responsibility, that of oversight of NSF, and more specifically, the Board's role in management of the facilities portfolio.

Leading-edge research infrastructure, including facilities and instrumentation, is essential to researchers working at the frontier of science and engineering, and is critical to maintaining U.S. leadership in science and engineering. Entire fields of research now depend upon access to new generations of research facilities, most of which are large and complex with a significant information technology component.

Board MREFC Review

The Board's oversight of the Major Research Equipment and Facilities Construction (MREFC) account involves approval of NSF-proposed projects for inclusion in future budget requests to Congress, approval of the funding priority list for previously approved MREFC projects that have not yet been funded by Congress, and approval for release of congressionally-appropriated MREFC funds to an NSF awardee. Each of the three projects that are testifying with us today, the Ocean Observatories Initiative, the National Ecological Observatory Network, and IceCube all received Board scrutiny and approval.

MREFC projects are high profile, high cost activities that are unique, meaning that they require considerable research and development in the design stage. In my time on the Board, the agency has made great strides in overseeing both the design and construction of these critical facilities. Since these types of projects often require significant taxpayer funds, the Board and the Foundation invest substantial efforts to review scientific needs, construction costs, and operations and maintenance costs in the MREFC process.

While construction of major facilities is supported through NSF's MREFC appropriations account, NSF funds the pre-construction design and operational activities predominantly from its Research and Related Activities account (R&RA). Pre-construction planning and design phases for developing MREFC projects usually require significant levels of funding from the R&RA account. This R&RA commitment helps to ensure community involvement in and support for the proposed facility.

As part of congressional guidance to NSF to strengthen its management of facility activities, in 2002 Congress requested Board oversight for the MREFC appropriations account. NSF was also instructed to limit its use of the MREFC account is to the acquisition, construction, and commissioning of large scale research facilities. Planning, design, operations, and maintenance costs were to be funded from the R&RA appropriations account.

Subsequent reports from the National Academy of Sciences and the National Science Board in 2004 and 2005 respectively provided guidance to NSF on prioritization of facility projects after Congress became concerned about a backlog of Board-approved MREFC projects that had not received funding. The Board's report in particular committed NSF and the Board to specific criteria for approving and prioritizing large facility projects.

Additional policies for funding MREFC projects were approved by the Board in 2005. Those policies specify that the Board is to concur on the readiness of projects to proceed to the final design phase. As a matter of practice, the Board had often been provided with information on the status of candidate MREFC projects during their planning and pre-construction design phase. The most recent enhancement to this policy is the timeline for the Board's MREFC Process, which was approved by the Board in February 2010. As the part of this timeline, the Board now receives this information in association with its annual facilities portfolio review.

Also feeding into the current oversight process was a 2008 Board report to Congress required by the 2007 America COMPETES Act. COMPETES directed the Board to evaluate the appropriateness of NSF's policies for preconstruction funding and maintenance and operations costs for major research equipment and facilities. The report concluded that the Board should be more formally engaged in reviewing all post initial proposal stages for MREFC projects.

Overview of Board Involvement in Facilities

Board oversight of facilities supported by NSF continues to evolve. For individual projects that will be funded through the MREFC, Board review and approval is mandated by statute. The Board's Committee on Program and Plans (CPP) has jurisdiction over these individual project awards. In order to ensure balance across the Foundation, the Board has recently instituted an annual facilities portfolio review which is conducted each May. This function, which reviews both MREFC projects and smaller multi-user facilities, is part of the responsibilities of the Committee on Strategy and Budget's Subcommittee on Facilities (SCF).

When considering a facility project for approval, the Board reviews the need for such a facility, the research that will be enabled, the readiness of plans for construction and operation, construction budget estimates, and operations budget estimates. Prior to formal Board consideration, however, NSF supports substantial planning efforts by the scientific community. These potential facilities are often subject to years of research and development planning and preparation before they are ready for inclusion in a funding request to Congress.

Outline of NSF Process for MREFC

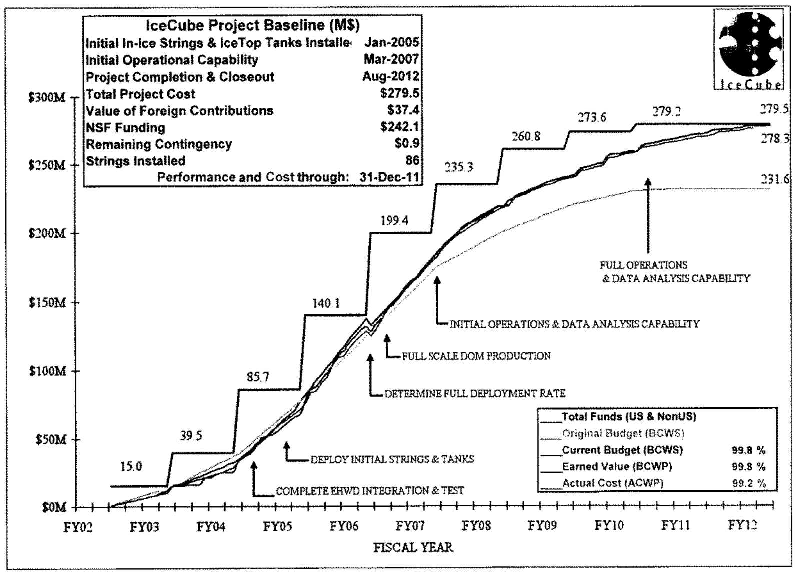
For MREFC projects, NSF designates four project evolution phases of this planning and preparation: (1) conceptual design, (2) preliminary design, (3) final design (readiness), and (4) construction. As previously mentioned, Board involvement in each of these phases has evolved over the past several years. It now includes approval of each individual project at the final design phase and reviewing the facilities portfolio as a whole.

The conceptual design phase involves the formulation of science questions, defining requirements, and identifying enabling technologies and high risk factors. During the conceptual design phase, NSF may award funds to academic institutions to organize one or more workshops to solicit essential input from the user community and other stakeholders. Top down cost, contingency, and risk analyses are included in this phase, which concludes with an initial proposal submission to NSF.

Budgeting for contingency includes planning, risk identification, analysis, response planning and monitoring and control of project resources, including contingency funds. Currently, NSF senior management and the agency's Office of the Inspector General are working closely on resolving differing interpretations of contingency cost standards. The Board, through its Audit and Oversight Committee, receives updates on these negotiations at each meeting and we are pleased with the progress made to date.

The subsequent phases for MREFC projects, preliminary design, final design, and construction, also involve NSF awards for the preparation of the more detailed designs. Multiple design awards may be made, particularly in the preliminary design phase, so that competing approaches can be evaluated through NSF's Merit Review process. After NSF has identified projects that warrant progression from the preliminary design phase to the final design phase, the Board approves the project before it is included in a future budget request. This is done initially by CPP and then the full Board in the late spring of each year. The Board's Committee on Strategy and Budget (CSB) then meets in the summer to review and approve NSF's budget submission to OMB. This submission also requires full Board approval.

The technical, cost, and schedule performance of the IceCube MREFC Project was consistent with the original project baseline and the NSF funding plan approved in 2004. The following chart highlights the cost and schedule plan and performance.



How and why was IceCube identified and selected as a worthy large facilities construction project?

A series of reviews organized by NSF, DOE, and the National Academy Sciences concluded that the proposed IceCube detector would open a new window on the Universe by detecting very high energy neutrinos from objects across the Universe. The scientific and technical review committees found the science to be well motivated and exciting and the detection technique proven. Construction plans matured and eventually committees advised that the IceCube MREFC project was ready for construction.

The process of identifying IceCube as worthy and ready for construction included robust peer and management review organized by NSF and eventually an assessment by the National Academy. This six-year process started with the submission of a Letter of Intent in February 1998 and concluded with approval by the National Science Board in April 2004.

budgetary consequences, operations costs and future liabilities of further development, and guides NSF in managing risk and being able to respond to opportunities. It also can guide policies and recommend specific action for the coordination and optimization of partnerships between NSF and other agencies, private foundations, and foreign entities.

An important aspect of this review involves recompetition of facilities. In 2008, the Board endorsed the principle that all expiring awards are to be recompeted. For major facility awards, the Board concluded that after construction is completed and an appropriate time period is implemented to bring the facility to sustainable operations, full and open competition of the operations award will be required. NSF is working to implement this policy through its Business and Operations Advisory Committee and continues to update the Board on the progress.

Closing Remarks

NSF's major multi-user facilities and its MREFC program are integral to the NSF investment portfolio, enabling access to and construction of facilities to perform research on new frontiers. Selecting the best projects, providing adequate program management, as well as oversight for the operations of such facilities, are all substantial challenges. However, an equally important challenge is that by supporting these essential facilities we not sacrifice our ability also to provide adequate support for the individual researcher proposals that for potentially transformative research.

On behalf of the National Science Board and the S&E research and education communities, I would like to thank the Members of the Subcommittee for your long-term recognition of and commitment to support for the National Science Foundation. We look forward to continuing our productive working relationship with you in service to the Nation.

Chairman BROOKS. Thank you, Dr. Griffiths.
The Chair next recognizes Mr. Yeck for five minutes.

STATEMENT OF JAMES H. YECK, ICECUBE PROJECT DIRECTOR, UNIVERSITY OF WISCONSIN–MADISON

Mr. YECK. Chairman Brooks, Ranking Member Lipinski, and distinguished members of the Subcommittee, thank you for the opportunity to testify. My name is Mr. Jim Yeck, and I am the Project Director of IceCube, an NSF MREFC Project that created the IceCube Neutrino Observatory. My testimony provides an overview of the IceCube project from its beginning and responds to questions from the Subcommittee.

IceCube is a particle detector embedded in a cubic kilometer of deep, very transparent South Pole ice that was designed to detect high-energy neutrinos from nearby and across the universe. The science capability of the observatory greatly exceeds that of previous detectors and those currently under construction, and thus, its capacity for transformational discovery is very significant.

The IceCube MREFC project was proposed in 1999 and final approvals for constructions were given in 2004. Installation of detector instrumentation started in 2005 and concluded in December of 2010. Final project closeout will be completed this year. The total MREFC cost was $279.5 million with NSF providing 242.1 million and funding partners in Belgium, Germany, and Sweden providing support valued at 37.4 million.

The bottom line is that the project was completed at cost and on schedule and that the detector exceeds its original performance and sensitivity goals. A series of peer reviews organized by NSF and the National Academy of Sciences concluded that IceCube was a worthwhile MREFC investment. Construction plans matured and eventually the MREFC project was ready for construction. This six-year process concluded with approval to begin full-scale construction by the National Science Board in April 2004.

The primary strengths of the approval process were the quality of the external peer review, the close and effective coordination between the NSF's Office of Polar Programs and the Division of Physics, strong institutional commitment and engagement by the University of Wisconsin-Madison, and the international interest and support of the project. The primary weaknesses of the approval process were the general environment of uncertainty, the potential for discontinuities in financial support, and the fact that both the NSF and UW–Madison were still maturing in terms of their large project experience and capabilities.

An approval process that is stretched out or unclear in its outcome creates an environment of uncertainty that is difficult to manage at the facility level. Construction and operations are managed under the terms of a cooperative agreement between the NSF and UW–Madison. The partnership between NSF and UW–Madison provides the management accountability necessary to ensure that resources are used efficiently and that goals are consistently achieved. Key management arrangements used to manage IceCube include these clear lines of accountability and authority from NSF to UW–Madison to IceCube; detailed scope, schedule, and budget definition; explicit cost and schedule contingency derived from risk assessment; regular reviews by external committees; tracking and progress reporting against established milestones, budget, and performance metrics; and routine oversight by NSF, UW–Madison, and the foreign funding agencies.

The essential tool of project management is to define an explicit contingency budget within a total project cost baseline. The IceCube project performance baseline included a 22 percent contingency budget. In order to create this contingency budget within funding constraints, the base cost estimates were squeezed and the project scope was reduced creating an incentive for all parties to control cost in order to restore the original scope.

The management flexibility enabled by contingency expenditures improved scheduled performance and resulted in cost savings and ultimately the restoration of the original project scope. Peer reviews organized by NSF were absolutely essential to IceCube's success. These reviews were typically on an annual basis and ensured transparency, early identification of critical issues, and project plans that included input from outside experts. Performance metrics were developed to ensure efficient use of American taxpayer dollars. Early operation results are excellent with 98.5 percent of the censors taking data and detector uptime at over 99 percent.

The biggest challenges with the MREFC projects are often the transition phases—R&D and project definition into a construction start, the ramp-up into full construction, the efficient ramp-down of the construction effort, and the transition into operations. Discontinuities in funding and support can be detrimental as the facility managers strive to maintain a team of talented and motivated people, which is essential to the program's success.

The stewardship of a large facility requires engagement, problem-solving, and support over decades. Facility stewardship requires an active role by the funding agency and involves joint ownership and partnership with the facility managers. The MREFC program has matured significantly over the last decade since IceCube was originally proposed. There is excellent sharing of experiences, lessons learned, and the ingredients to success.

Thank you for the opportunity to testify. I would be happy to answer questions.

[The prepared statement of Mr. Yeck follows:]

Written Testimony of Mr. James H. Yeck, IceCube Project Director
before the
UNITED STATES HOUSE OF REPRESENTATIVES
Committee on Science, Space, and Technology, Subcommittee on Research and Science Education hearing entitled *"NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability"*,
March 08, 2012.

Chairman Brooks, Ranking member Lipinski, and distinguished members of the Subcommittee, thank you for the opportunity to testify. My name is Mr. Jim Yeck and I am the Project Director for IceCube, an NSF Major Research Equipment and Facilities (MREFC) Project that created the IceCube Neutrino Observatory. My testimony provides an overview of the IceCube MREFC Project from its beginning to its successful conclusion last year and its operations and responds to the questions from the Subcommittee.

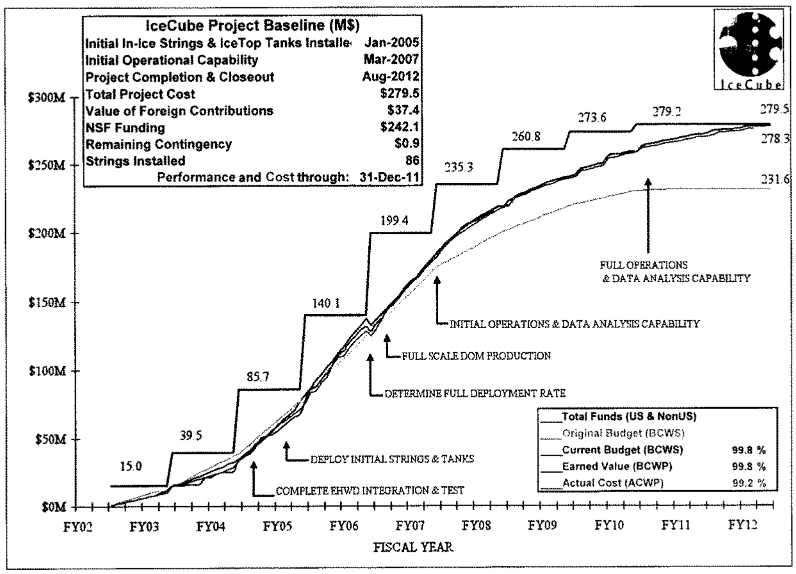
Overview of IceCube MREFC project, from inception to its operations today.

IceCube is a particle detector embedded in a cubic kilometer of deep, very transparent South Pole ice that was designed to detect high-energy neutrinos from nearby and across the Universe. The science capability of this observatory ranges from detecting neutrinos from dark matter annihilations that are predicted to take place in the sun to bursts of neutrinos from stellar explosions in our galaxy and other nearby galaxies to ultra-high energy neutrinos produced by violent astrophysical events at the centers of active galaxies across the Universe. The capability of IceCube greatly exceeds that of previous detectors and those currently under construction, and thus its capacity for transformational discovery is very significant.

The IceCube MREFC project was proposed in 1999 and final approvals for construction were given in April 2004. Detector installation started in January 2005 and was completed in December of 2010. A special hot water drill was used to embed the detector instrumentation in the South Pole ice (the ice melted was almost three times the volume of the Capitol dome). Once the holes were drilled in the ice, deployment specialists carefully connected digital optical modules to cables and lowered them into the drill holes to a depth of 2.5 kilometers. Each cable has 60 modules attached to it, and there are 86 cables in total. IceCube has a surface component called IceTop that serves as a cosmic air shower array. The construction effort required almost ten million pounds of cargo and over 30,000 person-days of work at South Pole. The total MREFC Project cost of IceCube is $279.5 million. The National Science Foundation provided $242.1 million and funding partners in Belgium, Germany, and Sweden provided support valued at $37.4 million. The IceCube detector exceeds its original performance and sensitivity goals.

The IceCube Collaboration of scientists and professionals includes about 250 people from 39 institutions in 11 countries.

The technical, cost, and schedule performance of the IceCube MREFC Project was consistent with the original project baseline and the NSF funding plan approved in 2004. The following chart highlights the cost and schedule plan and performance.



How and why was IceCube identified and selected as a worthy large facilities construction project?

A series of reviews organized by NSF, DOE, and the National Academy Sciences concluded that the proposed IceCube detector would open a new window on the Universe by detecting very high energy neutrinos from objects across the Universe. The scientific and technical review committees found the science to be well motivated and exciting and the detection technique proven. Construction plans matured and eventually committees advised that the IceCube MREFC project was ready for construction.

The process of identifying IceCube as worthy and ready for construction included robust peer and management review organized by NSF and eventually an assessment by the National Academy. This six-year process started with the submission of a Letter of Intent in February 1998 and concluded with approval by the National Science Board in April 2004.

IceCube Scientific and Construction Readiness Review Timeline

Feb 1998	Letter of Intent submitted to the NSF by Professor Francis Halzen, University of Wisconsin-Madison
May 1999	Astroparticle Physics with High Energy Neutrinos – Open Meeting for the scientific community organized by Francis Halzen
Nov 1999	**IceCube Proposal submitted to the NSF** on behalf of the U.S. IceCube Collaboration; separate proposals submitted to the German (DESY and Ministry), Sweden, and Belgium (Flemish and Walloon) funding agencies
Early 2000	NSF Peer Review of the IceCube Proposal
Apr 2000	DOE-NSF Science Advisory Group for Experiments in Non-Accelerator Physics (SAGENAP) Review of the IceCube Proposal
June 2000	NSF Readiness Assessment by a External Panel
Oct 2000	National Science Board Approval to Submit IceCube in a Future Budget Request.
Fall 2001	Endorsement of IceCube by the High Energy Physics Advisory Panel's Subpanel on the Future of Particle Physics in the U.S
Oct 2001	NSF Readiness Review by an External Panel
Nov 2001	NSF Review by an External Panel of the IceCube Enhanced Hot Water Drill Final Design
Sept 2002	International Workshop on Neutrinos and Subterranean Science – Community Input
Sept 2002	NSF Review of IceCube Drilling Plans
Early 2003	National Academy Neutrino Facilities Assessment Committee Review: Neutrinos and Beyond: New Windows on Nature
Sept 2003	NSF External Panel Annual Review
Feb 2004	NSF Review by External Committee of the proposed IceCube MREFC Project Baseline
Apr 2004	**NSB Approval to Proceed with IceCube Construction**

A National Academy Sciences study reaffirmed the scientific merit of IceCube in 2003, noting that the capability of IceCube greatly exceeds that of previous detectors and those currently under construction, and thus its capacity for transformational discovery was very significant.

What were the strengths and weaknesses of the process?

The primary strengths of the approval process for IceCube were the quality of the external review; the close and effective coordination between NSF's Office of Polar Programs and the Division of Physics; strong institutional commitment and engagement by the University of Wisconsin–Madison; and the international scientific interest and support of the NSF approval process. It was extremely valuable to be able to defend scientific goals and project plans in front of the highest quality external committees. The breadth and depth of the experience of those assembled for these reviews resulted in better implementation plans and higher confidence that the IceCube MREFC Project would be successful. The shared commitment to achieving successful approval helped the partners to work constructively together during the approval process. NSF's Office of Polar Programs and the Division of Physics, working with the Large Facilities Office, interacted constructively with UW-Madison and the international partners.

The primary weaknesses of the IceCube MREFC Project approval process were the general environment of uncertainty, the potential for discontinuities in financial support, and the fact that both NSF and UW-Madison were still maturing in terms of their large project processes and general capabilities.

The most cost effective projects are those where there is an early commitment to move the project forward on a schedule that is only limited by the ability to make technical progress. An approval process that is stretched out or unclear in its outcome creates an environment of uncertainty that is extremely difficult to manage at the facility level where day-to-day activities include hiring, placing contracts, and paying bills. The most influential factor in the ability of a project to succeed is acquiring experienced and capable staff. Discontinuities in funding and uncertainty can make this challenging, if not impossible. UW-Madison became heavily vested in the success of IceCube and used local resources to bridge funding delays and gaps. This was manageable but not desirable.

NSF large facilities management continues to improve and the guidance and rules are stabilizing. Around 2000, when IceCube was getting started, the NSF large facility guidance was still evolving; e.g., when IceCube was approved it was not permissible to include Education & Outreach in an MREFC Project, now it is. As NSF builds a history of successful MREFC projects there is higher confidence in its management practices. The situation at UW-Madison was similar, and the support arrangements for IceCube evolved in the beginning from a project initially supported out of the Physics Department to an autonomous center within the Graduate School.

How is IceCube currently managed?

IceCube is managed through contracts and memoranda of understanding between the participating legal entities; partnerships between the stakeholders; and line management arrangements that ensures top-to-bottom accountability and open communication.

Management and Contractual Arrangements

NSF and the UW-Madison. The IceCube Construction Project and the Maintenance and Operations (M&O) Program of the IceCube Neutrino Observatory are managed under the terms of Cooperative Agreements between the NSF and UW-Madison. A Project Management Plan details the management arrangements for the Construction Project and an Operations Plan covers the M&O Program. UW-Madison executes subawards to U.S. universities and laboratories for both the Construction Project and Operations Program.

IceCube Collaboration. The group of scientists motivated by the IceCube scientific goals and their institutions form the IceCube Collaboration. The Collaboration Governance Document describes the organizational matters of the collaboration including the election procedure for the Spokesperson [icecube.wisc.edu/collaboration/governance.php]. As described in the Cooperative Agreements and in the Collaboration Governance Document, UW-Madison executes a Memorandum of Understanding (MOU) that defines the institutional responsibilities for all constituent institutions. The Construction Project MOUs defined each institution's construction "deliverables" and the Maintenance & Operations MOU addresses the responsibilities of each institution in support of successful operations.

Antarctic Support. The Office of Polar Programs (OPP) has lead responsibility for the IceCube program within NSF. OPP tasks their Antarctic support contractor, Raytheon Polar Services Company (RPSC), and the Air National Guard, to provide the logistics and field support required for IceCube construction and operations. During the construction phase UW-Madison defined the IceCube construction project support requirements and OPP provided IceCube MREFC funding to RPSC via their contracts. This three-party arrangement was initially challenging but worked well as the project matured.

International Oversight and Finance Group (IOFG). NSF and representatives of the foreign funding agencies typically meet on an annual basis to review IceCube progress. The foreign funding agencies made significant contributions to the construction project and operations program. The foreign collaborating institutions are accountable to their respective funding agencies to deliver on their construction project and operations support commitments. In addition to in-kind contributions of hardware and labor there is a cash contribution to a "common fund" to support the computing and software necessary for the large IceCube data volumes.

Management Partnerships

IceCube Collaboration and UW-Madison. IceCube management is based on effective partnerships between stakeholders that share ownership in the success of the entire IceCube program. There is close partnership between the IceCube Collaboration (over 250 scientists and professionals from 39 institutions and 11 countries) and UW-Madison, which serves as both a collaborating institution and as host institution for both the construction project and the operations program. The IceCube Collaboration worked on every aspect of the detector. A remarkable aspect of the construction phase was the wide distribution of the hardware development across the collaboration. Production and testing of digital optical modules was completed in Sweden, Germany, and the U.S. (UW-Madison).

NSF and UW-Madison. The partnership between NSF and UW-Madison provides the management accountability necessary to ensure that resources are used efficiently and that construction and operations goals are consistently achieved. NSF is the primary funding agency for IceCube having provided about 85% of the construction project funding and providing 63% of the annual M&O support. Over 80% of the NSF MREFC funding was allocated directly to, and managed by UW-Madison, with the remainder allocated to RPSC and the Air National Guard.

NSF/UW-Madison and Foreign Funding Agencies. The direct engagement of the NSF program managers and the UW-Madison IceCube leadership with the primary foreign funding agencies is a partnership demanded by the international nature of the support for the scientific collaboration. Representatives of the foreign funding agencies are invited to review project plans, participate in external reviews, evaluate reports, and provide general oversight to the IceCube program.

Key Management Arrangements

The key management arrangements used to manage IceCube include: 1) clear lines of accountability and authority from NSF to UW-Madison and to the IceCube construction project and operations program, 2) detailed scope, schedule, and budget definition, 3) explicit cost and schedule contingency derived from risk assessment, 4) regular reviews by external committees, 5) tracking and progress reporting against established milestones, budgets, and performance metrics, and 6) routine oversight by NSF, UW-Madison, and foreign funding agencies. It is important to emphasize the IceCube approach used for contingency management, external reviews, and project oversight.

Contingency Management. An essential tool of project management is to define an explicit contingency budget within the total project cost baseline that is derived from an assessment of risk. The IceCube MREFC project performance baseline was approved in April 2004 and included a 22% contingency budget. In order to create this contingency budget the project scope was reduced from 80 deep ice cables to 70. The built-in incentive for all parties was to control costs in order to restore the original project scope. The management flexibility enabled by the project contingency budget allowed significant efficiencies to be gained in the deep ice drilling and instrumentation production and testing program. Schedule performance made possible by contingency expenditures resulted in cost savings and full scope restoration to 80 cables plus an additional six cables made possible by additional foreign contributions.

External Reviews. Peer reviews organized by NSF were absolutely essential to IceCube success. These reviews were typically carried out on an annual basis beginning after the submission of the initial proposal and continuing throughout the duration of the MREFC Project. The review committee membership was tailored to the needs of the project and the committee recommendations and advice were always constructive and helpful. It is a great strength of the scientific community that its members embrace the opportunity to help each other through service work on these types of committees. The UW-Madison IceCube Project Office established a standing Project Advisory Panel, Science Advisory Committee, and Software & Computing Advisory Panel. These advisory bodies met annually and provided input directly to the project. The combination of the NSF organized reviews and the IceCube project advisory bodies ensured that critical issues were identified early and that project plans included input from experts.

Project Oversight. NSF provided effective oversight of IceCube. The NSF Program Manager during the approval and construction phase was a senior and experienced NSF program manager. There was a high level of engagement with UW-Madison and the IceCube Project

Office. IceCube, like all large complex projects, encountered significant challenges during each project phase and the NSF Program Manager coordinated input within NSF and provided clear guidance to the IceCube Project Director. The NSF Program Manager and the IceCube Project Director had an open approach to communicating project information while respecting their distinct roles. The UW–Madison IceCube Leadership Team, chaired by the UW–Madison Chancellor, met on a quarterly basis and provided consistent oversight of the IceCube MREFC Project. This maintained a high level of institutional commitment throughout the construction project and the transition into operations.

Construction and Transition to Operations Strategies

The main project strategy was to maximize the installation of instrumentation each South Pole summer by ensuring that installation was not limited by the availability of instrumentation. This placed a priority on the critical activity—safely drilling holes in the South Pole ice sheet. Major constraints included the limited construction season of three months during the Antarctic summer, limited transport flights for cargo and fuel, and available bed space at the McMurdo and South Pole stations for people. The U.S. Antarctic Program infrastructure, including the bases, supply chain, and experience, was critical to project success.

What are the roles and responsibilities of the facility staff and the roles and responsibilities of NSF in the management and oversight of IceCube?

As noted earlier in this testimony there was a close partnership between the NSF and UW–Madison. One of the main reasons that this partnership worked extremely well was the clear and common understanding of the distinct roles and responsibilities of the two parties and an environment of mutual respect and trust. Respect and trust developed during the startup phase of this relationship enabled effective management of critical challenges as the two parties worked efficiently together.

NSF Roles and Responsibilities

The NSF is responsible for seeing that the IceCube MREFC Project meets its baseline requirements of cost, schedule, scope, and technical performance. The NSF has a special role in IceCube because of its responsibilities in managing operation of the Amundsen-Scott South Pole Station. These responsibilities include: safety; physical qualification of project staff; environmental protection; transport of personnel, fuel and equipment; and the provision of housing, food service, support personnel, logistical support, IT support, and general infrastructure support.

Within the NSF the Office of Polar Programs (OPP) is the lead organizational unit responsible for the conduct of scientific, technical, cost, schedule and management reviews, general progress reviews, and agency guidance regarding the IceCube Project. OPP designates a Program Officer (PO) who provides continuous oversight and guidance through direct communication with the UW–Madison IceCube Project Director and site visits to UW and other project sites, including the South Pole Station. The IceCube Program Officer is the Project Director's point of contact at the NSF.

UW-Madison Roles and Responsibilities

The UW-Madison is the host institution for the IceCube Project Office and the home university of the Principal Investigator. The responsibilities of the host institution include:

- Providing internal oversight for the project.
- Appointing the Project Director (subject to concurrence by the NSF, and the IceCube Collaboration Board).
- Ensuring that the Project Office has adequate staff and support.
- Ensuring that an adequate management structure is established for managing the project and monitoring progress.
- Ensuring that accurate and timely reports are provided to the NSF, IOFG, and the IceCube Collaboration.
- Developing subawards with other U.S. collaborating institutions and providing appropriate funding.
- Establishing MOUs between the UW and non-U.S. collaborators defining the non-U.S. collaborators' deliverables.

IceCube Principal Investigator

The Principal Investigator is responsible to the Vice Chancellor for Research and the NSF for the overall scientific direction of the IceCube Project. The Principal Investigator is Co-Spokesperson for the IceCube Collaboration during the construction phase and an ex-officio member of the IceCube Collaboration Board. The Principal Investigator communicates to the Project Director the scientific goals established by the IceCube Collaboration and concurs on the project implementation plan established by the Project Director.

Project Director

The IceCube Project Director (PD) is appointed by the Vice Chancellor for Research, subject to concurrence by the IceCube Collaboration Board and the NSF. The UW holds the Project Director (PD) responsible for execution of the construction project. The PD serves as the primary point of contact for the IceCube Collaboration and the NSF on all construction matters. The PD establishes the detailed Project Execution Plan that supports the IceCube scientific goals as described in the IceCube Proposal and in the Cooperative Agreement. The PD executes and controls project activities to ensure that project objectives, including cost and schedule baselines are met. The PD also serves as Co-Principal Investigator on the Project, and advises the Principal Investigator and the Collaboration Spokesperson on all issues that affect the IceCube scientific goals.

Other responsibilities of the Project Director include:

- Development of project scope and integrated cost and schedule baseline plans that are consistent with funding plans.
- Approval of annual budgets and funding allocations for institutions receiving NSF funding and MOUs with non-U.S. collaborating institutions.

- Ensuring that adequate project management control and reporting systems are implemented.
- Establishment of the IceCube Change Control Board and approval of baseline changes at Change Control Level 1.
- Chairing monthly project status reviews involving the Level 2 managers and selected Project Office staff.

How do you work with NSF to ensure that the American taxpayer is getting a return on this investment?

The IceCube MREFC investment is carefully managed as addressed earlier in this testimony. Performance metrics were developed for the Operations Program that help to ensure that this continuing investment is also an efficient use of American taxpayer. Over 5,000 digital optical modules (DOMs) instrument one billion tons of ice (cubic kilometer) a mile and a half below the South Pole surface.

Early operational results with the IceCube instrumentation are good:

- A total of 98.5% of the 5,484 DOMs installed and frozen into the deep ice at the South Pole are currently taking data and reliability analysis indicates that 98.0% of these DOMs will still be taking data in ten years.
- Detector uptime is approximately 99.0%.
- Every hour the IceCube Neutrino Observatory detects over 10 million downward-going cosmic particles and about 5 upward-going neutrinos.

The international IceCube Collaboration carries out the scientific program and shares responsibility for the M&O program including service work by research groups to manage the large data volumes and direct financial support. The details of these contributions are managed and tracked at a very detailed level.

IceCube M&O Support for Fiscal Year 2011 ($'000)

Total Required M&O Support	NSF M&O Core Support	U.S. Base Grant Support	U.S. Institutional Support	Non-U.S. Support
15,888	6,900	1,512	1,628	5,847
100%	43%	10%	10%	37%
100%	**U.S. = 63%**			**Non-U.S. = 37%**

The return on the IceCube investment is primarily measured by the quality of the scientific output. This is measured by the scientific publications [icecube.wisc.edu/pubs] and regular peer review of IceCube research proposals routinely submitted by Principal Investigators from the collaborating institutions. IceCube is unique in its discovery potential given the large instrumented detector volume in the Southern Hemisphere. The merit of the investment in IceCube is broadly acknowledged and there are plans to construct a detector of similar scale (KM3NET) in the Mediterranean Sea. This is largely a European initiative and would result in a Northern Hemisphere neutrino observatory that is complementary to IceCube.

How was the entire life cycle of the project, including management and operations after construction, taken into account in the management and oversight of IceCube?

The biggest challenges with MREFC projects are often the transition phases: 1) R&D, project definition and planning, and the transition into a construction start, 2) ramp up into full construction, 3) efficient ramp down of the construction effort, and 4) the transition into operations. MREFC funding does not cover R&D, operations, or research and therefore these transitions and the full program of support require multiple proposals and an integrated funding plan by the NSF. These transition phases were also difficult for IceCube but managed successfully by the collaborating parties. Discontinuities in funding and support can be detrimental as the facility managers strive to maintain a team of talented and motivated people, which is essential to the program's success. The NSF MREFC program has matured over the last decade and there is now substantial institutional experience that benefits the current generation of MREFC projects.

IceCube R&D and Construction Start

NSF and other parties supported AMANDA, essentially a prototype of the IceCube detector. AMANDA operated prior to and then concurrently with the initial IceCube construction and provided valuable experience regarding relevant hardware, software, and data management and helped to develop the scientific, engineering, and institutional experience within the IceCube Collaboration needed to propose IceCube. The IceCube proposal was based on the success of AMANDA, although the scale-up to IceCube was significant.

Transition to Operations

The initial IceCube proposal and the reviews that followed provided opportunities to present and critique the life cycle requirements of the facility. For example, the IceCube proposal submitted in 1999 included an estimate of the annual operating requirements; the project baseline reviews in 2004 assessed the plan for transitioning into operations; the NSF and foreign funding agencies began meeting to discuss operations plans in 2005; and, initial operations funding was provided in 2007.

Research

The development of the IceCube scientific goals and exploitation of the scientific potential of the facility requires continuing support to the collaborating groups. Collaborating university groups in the U.S submit proposals to the NSF on a three-year cycle and these proposals undergo peer review. This foundation of research support enables the return on the MREFC investment.

What have been the biggest challenges you have faced with the project thus far and how were they rectified?

The biggest challenges encountered include the scale-up from AMANDA to IceCube; establishing management capability and support arrangements at UW-Madison; ensuring the safety of the deep ice drilling operation; and, the limited NSF experience in the stewardship of large facilities during the late 1990's. A major challenge was a potential hold on IceCube when a policy of no new construction starts was imposed following a change in administration. This uncertainty was resolved once it was clarified that the National Science Board had already approved IceCube for inclusion in future NSF budget requests, thus building on the ongoing success of the AMANDA project.

The success of the AMANDA detector was essential but still not sufficient to move forward with IceCube. The scientific collaboration needed to grow in depth and capability. Deep ice drilling and instrumentation fabrication needed to transform from R&D scale into large-scale production. A substantial engineering effort was made to design detector systems for high reliability since the sensors, once frozen in the ice, are not physically accessible and cannot be repaired. The design was also optimized for ease of maintenance and operation. For example automatic calibration systems were a design goal to limit ongoing operations efforts at the South Pole. The time between the IceCube proposal submission and the start of construction in 2004 allowed the transformation and the scale-up that was needed.

Establishing an effective Project Office at UW–Madison required the active engagement of the university leadership. The business, administrative, and human resource systems that are effective for typical university business are not well suited for a schedule driven large project like IceCube. UW–Madison moved to establish IceCube as a center within the Graduate School with direct control over support personnel and resources. Experienced managers and engineers were hired from outside the university and the dialogue between the project personnel and the university leadership was focused on what was needed to succeed and the actions to be taken for that success.

The IceCube production drilling operation required the drill to operate 24 hours a day for 7 or more continuous days. This required three shifts that needed to operate in a seamless manner with each new shift picking up where the last shift left off. In the first year of IceCube deep ice drilling there was a serious accident requiring immediate medical evacuation from the South Pole and recovery in New Zealand. This accident provided a serious wake up call to all the parties and many improvements in training, staffing, and equipment were implemented before the second drilling season. Examples of improvements include retention of experienced drillers and additional shifts. An additional 85 holes were drilled over the next five years without another serious injury and with an exemplary safety record.

The stewardship of a large facility requires engagement, problem solving, and support over decades. The needs of a large facility are quite different than those of a research grant. Facility stewardship requires an active role by the funding agency that goes beyond the mantra of "NSF responds to proposals" and is more of a joint ownership and partnership. The MREFC program has matured significantly over the last decade since IceCube was originally proposed. There is excellent sharing of experience, lessons-learned, and ingredients to success. A brief distillation of these points is provided below.

Lessons Learned from the IceCube MREFC Project Experience

Set realistic goals for the MREFC Project baseline
- Scope reduced to 70 cables (86 final total)
- Operations ramp up when detector ready to start science program

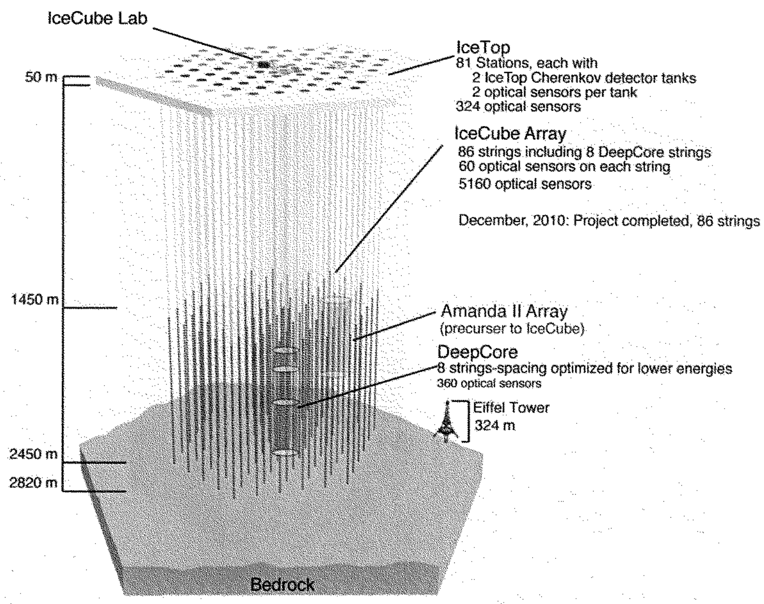
NSF support and oversight
- NSF collaborated with UW-Madison to best support the project
  - Dedicated and experienced IceCube Project Officer
  - Annual peer reviews of project performance and recommendation tracking
- MREFC Project funding secure and predictable
- Start-up, operations, and research funding requires advance planning

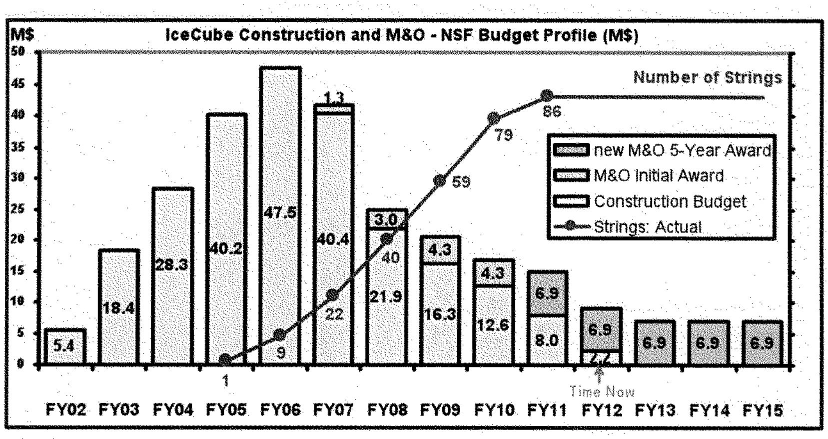
UW-Madison commitment and support
- University leadership involvement critical at key junctures
- Recruiting experienced personnel essential to project success
- Establishing expert advisory committees to inform project plans

Project management
- Create partnerships—share information, integrate efforts, and jointly share successes and failures
- Integrate the physics and engineering efforts; creating a single line of accountability promotes teaming and shared ownership of results
- Recruit production expertise—achieves higher quality and lower production costs
- Openly communicate issues and ensure transparency—shifts approach from ignore and hope to open responsibility and action (no surprises)
- Invest in safety—goal is shared responsibility and excellence
- Automate project tracking tools—reduces the time and effort from performance measurement to corrective responses
- Overarching goal is to eliminate uncertainty and risk—resolution is better than perfection
- Facility management of the contingency budget with full transparency on decisions

Ingredients to IceCube and MREFC Program Success

- Funding agency (NSF and European Partners) commitment with clear roles
- Strong facility/host role (UW-Madison) as an equal partner with NSF
- Project organization populated with high quality people - recruit experience
- Project & Collaboration leaders
  - Made timely decisions
  - Served as an umbrella for the distributed team so they could do their jobs
  - Managed expectations and communicated plans and results
- Understood the project including characteristics that were common to other large projects and those that were unique, e.g., Antarctic support and environment
- Established realistic project goals, developing a track record of success
- Maintained credibility with stakeholders
- Sought collective ownership of problems and solutions


IceCube Lab
IceTop
81 Stations, each with
2 IceTop Cherenkov detector tanks
2 optical sensors per tank
324 optical sensors
IceCube Array
86 strings including 8 DeepCore strings
60 optical sensors on each string
5160 optical sensors
December, 2010: Project completed, 86 strings
Amanda II Array
(precurser to IceCube)
DeepCore
8 strings-spacing optimized for lower energies
360 optical sensors
Eiffel Tower
324 m
50 m
1450 m
2450 m
2820 m
Bedrock


IceCube Construction and M&O - NSF Budget Profile (M$)
M$
Number of Strings
new M&O 5-Year Award
M&O Initial Award
Construction Budget
Strings: Actual
5.4
18.4
28.3
40.2
47.5
40.4
1.3
3.0
21.9
4.3
16.3
4.3
12.6
6.9
8.0
6.9
2.2
6.9
6.9
6.9
1
9
22
40
59
79
86
Time Now
FY02 FY03 FY04 FY05 FY06 FY07 FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15

Chairman BROOKS. Thank you, Mr. Yeck.

The Chair next recognizes Dr. Beasley for five minutes.

STATEMENT OF TONY BEASLEY, CHIEF OPERATING OFFICER/PROJECT MANAGER, NEON, INC.

Dr. BEASLEY. Chairman Brooks, Ranking Member Lipinski, and distinguished members of the Subcommittee, thank you for the opportunity to testify.

My name is Dr. Tony Beasley and I am the Project Manager for the National Ecological Observatory Network and Chief Operating Officer of NEON, Inc. I appreciate the opportunity to provide you an overview of the NEON project today. My testimony will also address questions about the NSF MREFC program directed to me by the Committee.

I would like to begin with a scientific motivation for NEON. Living systems on this plant are experiencing some of the greatest rates of change in history. The basic scientific knowledge needed to understand these changes on human scales—that is regional to continental scales—calls for standardized physical and biological measurements on meter to multiple-kilometer scales. Creating a national observatory to gather that information is the goal of NEON.

In 1998, the National Science Board's Taskforce on the Environment identified NEON as a potential major facility, and after public hearings and discussions with the research community, the NSB qualified NEON as a potential MREFC project in August of 1999. Four years later, a National Academy of Sciences study also recommended the establishment of a national ecological observatory. Following these recommendations, the NEON project team began design and development efforts and passed through the MREFC process and reviews during 2006 to 2009. In May of 2010, the National Science Board approved NEON construction and the NSF fully funded NEON construction in August of 2011 after authorization by Congress. From concept to start of construction was approximately 12 years, and we are recently underway.

The MREFC process reviews all aspects of facility projects, including design, risk, cost estimates, and organizational capabilities. It examines whether the project will meet the scientific objectives of the facility in a safe, cost-effective and low-risk manner, and includes off-ramps where projects can be halted. Between late 2006 and early 2010, more than 16 major reviews of NEON construction and operation plans took place involving more than 100 scientists, engineers, project managers and administrators from the research and other communities.

NEON's goals and implementation complement efforts in other organizations and we have worked extensively with state and federal partners to ensure our plans are understood and to identify new opportunities to use NEON data for resource management and other relevant purposes. At the project level, we have a continuous dialogue underway with the NSF reporting progress, issues, opportunities to guide facility construction and to allow project performance monitoring. Annual reviews of the project by external experts ensure that resources are being effectively used and progress is on track.

Over the past decade, the MREFC process has become a well defined framework within which a facility can be conceived, designed, planned, reviewed, and constructed. The process is constituent with those used by the Department of Energy, NASA, and other large organizations to construct major facilities and experiments. In my opinion, it is a reasonable framework, but I note that individual outcomes in the process will vary as projects are subject to different risks and sensitivities to external circumstances.

There are areas for development. The MREFC process currently focuses on domestic facilities like those represented here today, but the scale of scientific research has grown rapidly over the past two decades, and large international facilities may be needed to address the important scientific issues of tomorrow. The NSF Large Facilities Office has recently spearheaded efforts to improve community understanding of the challenges of international partnership and over time I would expect that the MREFC processes will be expanded to include interfaces to the international analogs.

In summary, the field of ecology includes many complex scientific problems that increasingly can be addressed by new technologies, networking, and research collaboration styles, and NEON's goal is to facilitate this new path. The MREFC process provides an objective and effective management framework for facility construction and its rigor has undoubtedly improved NEON's project definition and performance.

We look forward to continuing work with the Large Facilities Office, the National Science Foundation, and Congress to make a national ecological observatory a reality.

Mr. Chairman and members of the Subcommittee, thank you once again for the opportunity to testify and I would be happy to discuss any issues the Committee may wish to explore.

[The prepared statement of Dr. Beasley follows:]

Written Testimony of Dr. Anthony Beasley, Chief Operating Officer and Project Manager, National Ecological Observatory Network (NEON), Inc. before the UNITED STATES HOUSE OF REPRESENTATIVES Subcommittee on Research and Science Education hearing entitled "NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability", March 08, 2012.

Chairman Brooks, Ranking member Lipinski, and distinguished members of the Subcommittee, thank you for the opportunity to testify. My name is Dr. Tony Beasley, and I am Project Manager for the National Ecological Observatory Network (NEON), and Chief Operating Officer of NEON, Inc. I appreciate the opportunity to provide you an overview of the NEON MREFC Project from its inception to the construction underway today. My written testimony specifically addresses questions about NEON and the National Science Foundation Major Research Equipment and Facilities program directed to me by the committee, with a few general observations on the issues included.

I would like to begin with an introduction to the scientific motivation for NEON. Living systems are experiencing some of the greatest rates of change in the history of life on Earth. A suite of human-driven processes (climate and land use change, invasive species) are collectively affecting living systems by altering the fundamental relationships between life and the non-living environment that sustains it. Our current understanding of these changes is based on knowledge obtained either from small plot (less than 1 hectare) research, operational monitoring and assessments, or from satellite-scale remote sensing. The basic scientific knowledge needed to understand the biosphere at human scales (regional to continental scales), to quantify the strong and weak forces regulating the biosphere, and to predict the consequences of climate and land use change on living systems cannot be extrapolated from studies at these extreme scales.

NEON was designed by the ecological research community to address this gap in hypothesis-driven research capability – functioning as a fully integrated, multi-scale sensor to detect, understand, and forecast changes in the biosphere at regional to continental scales. The scientific and technical requirements that led to the Observatory's design were specifically derived to address these fundamental hypothesis driven questions about the forces driving biosphere change while concurrently assessing the biosphere responses and feedbacks. The NEON experimental design calls for in-situ infrastructure that will measure drivers and biological responses at the meter scale, couple these to simultaneous biological/physical measurements at the meter to kilometer scale (i.e., airborne remote sensing), and join these estimates to biological/physical measurements at multiple kilometer scale (i.e., satellite remote sensing). It is the coupling across scales that provides the unique capability required to understand the multi-scale processes driving living systems and evaluate the fundamental theories of how living systems operate, respond, and adapt. The sensitivity and ability of the Observatory to address the fundamental theories derives from the scientific and statistical underpinnings of the infrastructure deployment and integration via cyberinfrastructure into a single in situ sensor of the biosphere. Testing these theories about the biosphere cannot be accomplished by only integrating data from existing monitoring networks, infrastructure, assessments, or remote sensing.

I will now specifically address the following questions received from the Subcommittee:

How and why was NEON identified and selected as a worthy large facilities construction project?

All NSF large facilities projects arise initially from analysis and collaboration in the research community to identify important scientific opportunities that might best be addressed by a new large-scale facility. The overarching scientific motivation for NEON is discussed above; in 1998, the National Science Board's Task Force on the Environment (TFE) identified NEON as a potential large-infrastructure project. Subsequently, there were NSF-funded workshops organized by the research community to further explore the needs of such an infrastructure. In addition, the NSB TFE held a public hearing, a symposium, and a town hall at various locations throughout the country. These community engagement activities informed the NSB's decision to qualify NEON as a potential MREFC project in August 1999. In 2003, a National Academy of Sciences study "NEON: Addressing the Nation's Environmental Challenges" was completed, recommending the establishment of a national observatory.

Following these recommendations, proposals for design and development efforts were requested and awarded by NSF, and work began in the research community and at NSF to define the facility. In 2006, a Conceptual Design Review for NEON took place, followed by a Preliminary Design Review in mid 2009 and Final Design Review in late 2010. All these reviews were successful and indicated a facility ready for consideration. Subsequently, the National Science Board approved NEON Construction in May 2010, and upon enactment of the requisite appropriations and concurrence by Congress, NSF awarded construction funding in August 2011.

What was the MREFC approval process experience for NEON?

The approval process included mandatory NSF-organized reviews as required by the NSF Large Facilities Office Manual for MREFC projects (NSF 07-38), including Conceptual, Preliminary and Final Design Reviews. In addition, a NSF-led Blue Ribbon Science Review of NEON was held in February 2009. Based on the recommendations from NSF review panels and significant input from the research community, NEON identified areas of risk that required an active risk-retirement strategy and conducted its own prototyping and reviews, and in some cases, commissioned external expert groups to address identified risks. In total, between late 2006 and early 2010, more than sixteen separate major reviews of NEON design, project structure and planning took place, involving more than a hundred scientists, engineers, project managers and administrators from the research and facility communities in assessing NEON's plans. The result of this input was to improve and refine the design of the facility, to reinforce and guide best practices in project management and planning, and to ensure NEON was being implemented as an engineering-oriented initiative which would be built on the basis of measurable and incremental progress. This process engendered an outcome and deliverable-oriented culture that aligned with the major approval stages required of any such large project.

The design/development and MREFC approval efforts were significant and important. Producing a facility design which would meet the science requirements that initiated the program, and a project plan including a credible budget and schedule for construction in a safe and cost-effective way, was an important requirement for both the NSF and NEON, Inc.

How do you work with NSF to ensure that the American taxpayer is getting a return on this investment?

At the program level, NSF is cognizant of the need to establish a clear linkage between fundamental research and societal needs and has reinforced that attitude with the NEON development team. To this end, NSF has established formal relationships with other Federal agencies via Memoranda of Understanding that include stipulations on potential collaborative activities based on NEON. Two examples are highlighted: an MOU between NSF and the United States Geological Survey and another between NSF and the United States Environmental Protection Agency. NEON utilizes these relationships established by NSF as a framework for structuring our interactions with executive and middle-level Federal science managers. We do this in order to identify opportunities for using NEON data and information for resource management and other relevant purposes. These types of interactions are also facilitated by NSF's interagency forums that highlight NEON's complementarity with initiatives undertaken by other Federal agencies. Avoiding duplication of effort or waste by coordinating efforts with other agencies has been a priority during NEON design and development.

At the project level, daily-weekly interactions with the NSF reporting progress, issues and opportunities are used to guide development, and formal monthly reporting allows performance monitoring. Annual reviews of project progress by external experts are mandated; during these reviews, performance of the project is examined to ensure that resources are being used effectively, progress is on track, risks are being monitored, etc. During facility design, appropriate design practices to minimize cost and environmental impact were followed, and some consideration of the life-cycle costs were undertaken, e.g., designing the facility to lower long-term operating costs.

What were the strengths and weaknesses of the process?

The NSF MREFC process has become a well-defined framework within which a project can be conceived, designed, planned, reviewed and constructed. The general approach used is highly consistent with similar processes used by the Department of Energy, NASA and other large organizations to construct major facilities and experiments. The documentation and other data deliverables required as part of the process provide key stakeholders (e.g., the design/development team, the NSF, Congress and taxpayers) with objective information about the facility's plans and progress, and there are many evaluation points and gates for the program to pass through before construction funding is awarded. This is done to ensure the best possible scientific return for the research dollars invested, and provide opportunities for oversight to ensure that cost-effective progress is being made. Both at the project level and at the NSF, regular evaluations of the processes are conducted to seek improvements.

I have some familiarity with the management processes that are used by similar science organizations in other countries (e.g., CSIRO in Australia and the STFC in the United Kingdom), and it is my opinion that the MREFC process in use by NSF is typically more rigorous and more effective (in an administrative sense) than the processes used for facility construction in those countries. It has engendered a professional project management mindset in the scientific community which was less obvious before the NSF Large Facilities Office began the early 2000s.

I cannot identify major intrinsic weaknesses in the process; it is a reasonable framework, in my opinion. Individual outcomes in the process will vary; facility projects sit differently inside the framework, and are subject to different risks and sensitivities to external circumstances. It could be that further development of the MREFC process to address project-to-project differences could provide better interface performance between NSF and the projects, addressing issues more readily. It is generally the case that funding a project more slowly than originally planned over a series of years will lead to "marching army" and other increases in the total cost of a project, and careful planning and negotiation between the project, NSF and Congress is required to avoid these issues.

The scale of scientific research (and therefore the facilities to address the burning issues) has grown rapidly over the past two decades, and it is increasingly apparent that large international facilities may be the only way to address the important scientific issues of tomorrow. Successfully merging national facility development processes like the MREFC framework with those used by foreign partners to produce effective international collaborations has been, and will continue to be, a challenge. The Large Facilities Office has recently spearheaded an effort to improve community understanding of those challenges and gather input on how to address them; over time, I expect that the MREFC processes will be expanded and refined to include clear interfaces to international analogs.

What have been the biggest challenges you have faced with the project thus far and how were they rectified?

During my time with NEON, the initial challenge faced was to help our scientists understand the formal project management techniques needed to produce a facility design and operations model on the scale being considered, and understand the importance of a systems engineering approach to development. Formal and informal training helped address this concern, including attendance at the "Large Facilities" and "Project Science" Workshops supported by the NSF.

As an ecological observatory with multiple sites, environmental review and permitting were significant challenges identified as a risk to the development schedule during our early reviews. We responded by significantly increasing staff in this area, and expanding our outreach and coordination efforts both with the land owners (including federal agencies) and the research community.

How is NEON currently managed?

The NEON construction project is managed by NEON, Inc. under a cooperative agreement with the NSF. NEON, Inc. is a non-profit 501(c)(3) company established to undertake the design, development and construction of the NEON facility. NEON, Inc. is a membership organization, comprised of more than 55 university and commercial partners interested in the facility. A Board of Directors elected from the member institutions and from the broader community provides oversight. The Chief Executive Officer of NEON, Inc. is the Principal Investigator on the NSF NEON award. A NEON Project Director and Project Manager (reporting to the NEON, Inc. CEO) manage the day-to-day operations of the construction project. In the next year, a NEON Observatory Director will be hired to oversee the facility operations.

What are the roles and responsibilities of the facility staff and the roles and responsibilities of NSF in the management and oversight of NEON?

Organization of the NEON construction project under the Project Director and Project Manager includes a team of senior managers responsible for key deliverables to the facility (for example, Civil Construction, Computing, Science, Systems Engineering, Safety). NEON, Inc. managers and staff are responsible for the safe, cost effective, timely and high-quality completion of tasks and deliverables associated with the construction and operations of the facility. NEON managers oversee progress, and quantitatively report progress and issues to the Project Manager, who integrates the information and reports to the NEON Project Director, NEON, Inc. Board and the National Science Foundation on a regular basis. I personally aim at a "no surprises, keep informed" relationship with NSF.

Under the cooperative agreement in place with the NSF, significant reporting and change request requirements are in place and being followed. Progress reporting and issue management takes place between the project and key NSF officials (including the BIO Directorate Program Officer and the Large Facilities Office) on a daily-weekly basis, with monthly formal reporting. NEON has a clear responsibility to communicate fully with and request approval from NSF in a wide variety of circumstances. NSF reviews NEON planning, monitors NEON progress, and continuously assesses and advises on management practices and interactions with the research community.

How is the entire life cycle of the project, including management and operations after construction, taken into account in the management and oversight of NEON?

An important deliverable of the MREFC-process Preliminary Design Review is an Operations Plan for the facility under consideration. This plan includes information and estimates concerning the facility research objectives and products, management structure, planning assumptions, staffing and annual operating costs, risks and interfaces to the research community,. The Operations Plan is reviewed in detail at both the Preliminary and Final Design Reviews, and the maturity of planning and the cost estimate for operations are an important consideration for both the National Science Board and the NSF when approving the facility to move forward into the MREFC queue. In addition to these construction-level reviews, an independent NSF-led Operations Review is mandated to carefully examine the facility operations definition, and ensure safe, cost-effective and high-quality scientific operation of the facility.

One important area examined by the MREFC process is the transition between construction and operations. The nature of this transition varies widely between facilities (e.g. a telescope which is ultimately fully assembled and begins observation at a given time versus a distributed infrastructure like NEON which has substantial components in full operation while other components are still under construction). Minimizing the costs associated with the transition is a particular area of focus in the MREFC process.

Mr. Chairman and Members of the Subcommittee, thank you once again for the opportunity to testify about the National Ecological Observatory Network. I would be happy discuss any issues the Subcommittee may wish to explore with respect to the NSF MREFC process and NEON.

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SUMMARY

- The National Ecological Observatory Network (NEON) construction project began in 2011, as part of the National Science Foundation (NSF) Major Research Equipment & Facilities Construction (MREFC) program. The scientific motivation for NEON arose from the research community in the late 1990s, and the specific design for NEON and plans for operation of the facility were developed in collaboration with the community over the past several years.

- During 2006-2011 NEON followed all required MREFC processes, refining and improving the definition of the program. Expert reviews of all aspects of NEON planning and documentation provided important information to assessment of the facility plans.

- Important challenges faced by NEON include leading the exploration of new technologies and collaboration styles to the ecological community, and the permitting of the field infrastructure sites.

- NEON management is focused on safe and cost-effective execution of the construction program, and providing the NSF and all stakeholders with the information needed to understand project status in a timely and effective manner. NEON management works closely with NSF to stay informed about related activities in other Federal agencies to maximize the utility of the planned infrastructure.

- A detailed Operations Plan is reviewed at both the mandated Preliminary and Final Design reviews. Maturity of planning and the cost estimate for operations are important considerations for both the National Science Board and the NSF when approving the facility to move forward into the MREFC queue.

- Future improvement of the MREFC process may involve consideration of international collaboration complexities and interfaces.

Chairman BROOKS. Thank you, Dr. Beasley.
The Chair next recognizes Dr. Cowles for five minutes.

STATEMENT OF TIM COWLES,
VICE PRESIDENT AND DIRECTOR,
OCEAN OBSERVING, CONSORTIUM FOR OCEAN LEADERSHIP

Dr. COWLES. Thank you, Chairman Brooks, and Ranking Member Lipinski, and distinguished members of the Subcommittee and staff. Thank you for this opportunity to expand upon the comments already made and describe the Ocean Observatory's initiative and how it fits within the family of MREFC projects and has adjusted to and adapted to the processes now in place.

I think a good starting point for our—my testimony is to refer to the two quotations that are behind you on the wall, which both refer to vision. Observatories provide the opportunity for us to open new windows onto the natural world. It is only through the opportunity for scientists to open new windows on scales previously unavailable to them that we can see further into the future and use the observatories as leverage to ask compelling new questions for science. So it is within that context that all of us at the table here are trying to push forward with observing science.

The Ocean Observatories Initiative represents a midpoint of the three programs at the table today—NEON just getting started, IceCube well into the operational mode, the Ocean Observatories Initiative is about halfway through the 5–1/2 year construction period. The Ocean Observatories Initiative consists and will consist of a very sophisticated cyber-network of ocean instrumentation—some of it fixed in place, some of it mobile and robotic—that spans multiple locations in the world's oceans, coastal sites, and seafloor capability. The transformative nature of the OOI has direct and short-term societal benefits to address aspects of coastal ecosystem health, ocean circulation, climate variability, and a range of topics around seafloor activity and geodynamics. Those short-term benefits lead later to long-term forecasting improvements over a range of ocean processes.

The MREFC experience for the Ocean Observatories Initiative is similar to the points that Mr. Yeck and Dr. Beasley have already made. A sequence of intensive peer-reviewed processes from initiation through final approval by the NSF through the National Science Board forges a level of rigor in the project team that is essential for both the construction and transition into the operational phase. For the OOI, the initial initiation or inception of the idea of a major ocean observatory system had its birth in the late 1980s. Many community workshops and panels met. There were reports at the national level that supported the concept of an extensive ocean observing system. In 2000, the NSB recommended that the idea of an ocean observatory system was worth further planning. In 2004, the National Science Foundation funded the opening of a project office for planning. Beginning in 2006, conceptual network design progressed through preliminary design reviews, and then final design reviews in late 2008 and early 2009 resulting in project approval in 2009 and construction initiation under stimulus or ARRA funding in September of 2009.

The project has benefitted extensively from the process imposed by the NSF. We work very closely with the NSF on reporting and oversight. We implement; the NSF provides the oversight. The interaction of the project and the NSF and the external community is critical in the success of the observatory. And I would like to stress the point that the OOI as a product of the MREFC process builds upon a partnership between public, private, industrial, and the NSF. That integration of complementary capabilities is a very effective use of public funds.

So I welcome the opportunity once again to discuss the OOI with you and I certainly will be available to answer any questions you have. Thank you.

[The prepared statement of Dr. Cowles follows:]

March 8, 2012

Written Testimony of Dr. Timothy Cowles, Program Director, Ocean Observatories Initiative (OOI)
Vice President and Director, Ocean Observing Activities, Consortium for Ocean Leadership

UNITED STATES HOUSE OF REPRESENTATIVES
Subcommittee on Research and Science Education

NSF Major Research Equipment and Facilities Construction Management: Ensuring Fiscal Responsibility and Accountability

Chairman Brooks, Ranking member Lipinski, and distinguished members of the Subcommittee, thank you for the opportunity to testify about the MREFC process. My name is Tim Cowles, I am the Program Director and Principal Investigator of the Ocean Observatories Initiative (OOI). I also serve as Vice President and Director of Ocean Observing Activities within the Consortium for Ocean Leadership.

I will begin with an overview of development of the OOI MREFC project from its creative start to today's mid-point of project construction. My testimony also will address the questions posed to me by the committee.

Overview of the Ocean Observatories Initiative

The Vision

The dream of long-term observatories in the ocean has been explored for more than twenty years. It has long been recognized that expeditionary-based ocean research provides essential insights into ocean processes occurring during and within the region of the expedition. However, such focused research often lacks a temporal and spatial context for interpretation. The extensive spatial and temporal variability of ocean processes complicates interpretation of focused studies, thus driving the need for sustained measurements across a range of spatial scales, from the sea surface to the seafloor. In addition, the critical linkages between physical, biological, chemical and geological processes in the ocean require that a wide range of properties be measured.

Sustained observing from the ocean surface to the ocean floor will certainly yield unexpected insights into ocean processes, just as satellite remote sensing revolutionized our understanding of global surface processes. Occasional 'snapshots' of portions the global surface were replaced by 'movies' created by repeated orbits of satellite sensors – these 'movies' provided new, dynamic, and unpredicted structures in the images of the surface layer of the ocean. We eagerly await the opportunity to replace our 'snapshots' of ocean and seafloor processes with the 'movies' that the OOI will provide through sustained observations of many ocean properties, through the full ocean depth range.

As early as 1988, the ocean sciences community began discussions about the scientific themes, design concepts, and engineering challenges of modern ocean research observatories. These early discussions and workshops led to the formation of the International Ocean Network (ION) in 1993. The first national committee was formed in 1995 with NSF funding, and broadened into the

Dynamics of Earth and Ocean Systems (DEOS) committee, tasked with providing a focus for exploratory planning for an ocean observatory network that built upon the compelling scientific themes unable to be addressed through other oceanographic research approaches.

The first International Conference on Ocean Observing Systems was held in 1999 in San Rafael, France, and focused interest on fixed and mobile observing systems. The international Global Eulerian Observatory (GEO) committee was formed the same year and later (2003) became *OceanSITES*.

Momentum for research-oriented ocean observing built further upon two National Research Council (NRC) studies in 2000 and 2003 ("Illuminating the Hidden Planet: The Future of Seafloor Observatory Science" [2000]; "Enabling Ocean Research in the 21st Century" [2003]), along with a series of community workshops that stressed the scientific and societal benefits of sustained observations. Building on this momentum, the OOI was approved by the National Science Board (NSB) in 2000 as a potential Major Research Equipment and Facilities Construction project for inclusion in a future National Science Foundation budget, thus allowing for focused planning efforts under NSF financial support.

Setting the Foundation

In 2003 and 2004, the U.S. Commission on Ocean Policy and the Pew Oceans Commission issued reports containing recommendations designed to improve society's use and stewardship of, and impact on, the coastal and global ocean. These recommendations highlighted key areas that require continuous, sustained investigation to enable timely and sound decision-making and policy development. Global, regional, and local climate variability and its impacts, coastal hazards, ecosystem-based management and the relationship between the ocean and human health were among the critical issues noted in the Commissions' recommendations that pointed to the need for a sustained, research-driven, ocean observing capability.

In response to recommendations from these reports and at the direction of the Administration, in 2006 the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology developed the *Charting the Course for Ocean Science for the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy* document (ORPP), which provided a framework for research investments to advance current understanding of critical ocean processes and interactions that facilitate responsible use of the ocean environment. The ORPP identified *ocean observing* as one of three key areas for research and management.

Early Planning and Conceptual Design

In 2004, the NSF Division of Ocean Sciences (NSF/OCE) established the OOI Project Office to coordinate further OOI planning. In 2005, the OOI Project Office asked for the ocean research community's help in developing the OOI network design by soliciting Request for Assistance (RFA) proposals, using the science themes of ocean observing to structure the request. A total of 48 proposals were submitted by 549 individually-named proponents representing 137 institutions, agencies and industries in 35 states. These proposals were subjected to peer review and formed the basis for the initial Conceptual Design of the OOI.

Using the responses from the RFA process and associated review results, the OOI Project Office and external Advisory Committees developed an initial Conceptual Network Design (CND) for the

OOI, which then served as the focus of community discussion at the OOI Design and Implementation Workshop in March 2006.
In July 2006, NSF assembled a Science Panel to provide a merit review of whether the CND would provide the ocean research community with infrastructure capable of addressing high-priority science questions motivating the OOI. This Panel endorsed the OOI as a worthy investment that, when implemented, would advance our understanding of the Earth and the oceans. In August 2006, NSF convened a Conceptual Design Review (CDR) to assess the Project's technical feasibility and budget, the Project's Management Plan, including schedules and milestones, and education and outreach plans. The CDR Panel affirmed that the scientific and technical basis of the OOI, as proposed, would transform oceanographic research in the coming decades.

Formation of the Project Team

The major partners in the OOI construction process, three of the four OOI Implementing Organizations (IO), were selected in 2007 by a competitive acquisition process similar to that used in large federal acquisitions. Subawards were established with the University of Washington as the IO for the *Regional Scale Nodes*, the University of California San Diego (UCSD) as the IO for the *Cyberinfrastructure*, and the Woods Hole Oceanographic Institution with two consortium partners, Scripps Institution of Oceanography and Oregon State University, as the IO for the *Coastal and Global Scale Nodes*. The fourth IO, Rutgers, The State University of New Jersey, was selected in 2011 as the IO for the *Education and Public Engagement* software infrastructure component, with its partners University of Maine and Raytheon Mission Operations and Services.

It is important to note that the OOI project team builds upon the strengths of public, private, and non-profit institutions, along with industry partners. This integration of complementary capabilities is a powerful recommendation for the MREFC process, and represents an efficient use of public funds.

With three of the Implementing Organizations on-board in 2007, the OOI Project Team worked towards generating the Preliminary Network Design (PND). The PND development was guided by recommendations and principles established by the advisory structure and the NSF Large Facilities Office, taking into consideration long-standing program and design concepts, the OOI Science User Requirements and the project cost constraints.

As part of the external review process, NSF convened a second Science Review Panel in October 2007 to assess the OOI Network Design and its ability to provide transformative research capabilities for the ocean science community. This Panel stated that the OOI would provide opportunities to address "broad and compelling interdisciplinary scientific questions that cannot be adequately investigated with current methodologies" and offered a series of recommendations on design, management, and public engagement.

Path Toward a Construction Baseline

The Preliminary Design Review (PDR), convened by NSF in December 2007, assessed the current state of planning for the OOI. The PDR Panel was very positive about the progress of planning for the OOI and about the transformative scientific rationale for the initiative. The OOI Team responded to the recommendations of the PDR Panel and then underwent the Final Design Review (FDR) in November 2008, which scrutinized the technical, programmatic, cost and schedule readiness of the Project. The FDR Panel noted the technical readiness of the Project and recommended that the OOI proceed with construction in July 2010.

After the FDR, extensive discussions were held in early 2009 within NSF to address the need for the OOI Network to increase the focus on urgent issues in ocean science research. Given the ocean's vital role in the global transfer of heat, carbon and water, it was decided to focus on developing facilities to better understand oceanic climate signals as well as the impact of carbon cycling on ocean acidification, ocean carbon sequestration and the impact on coastal marine ecosystems. As a result, NSF identified a variation on the OOI Network Design using ocean infrastructure and sensors deemed to be construction-ready at the FDR. This modified network design incorporated enhancements to the Coastal/Global Scale Nodes (elements that had been part of earlier design iterations) and reductions to the Regional Scale Nodes. A Review Panel in March 2009 expressed support for the infrastructure additions and noted that the intellectual merit and the broader impacts of OOI were very high and perhaps unique in the Earth and Ocean science communities as a whole. The project baseline that emerged from this review process formed the basis for the request to the National Science Board. On May 14, 2009, the National Science Board authorized the Director of NSF to award funds for the construction and initial operation of the OOI. On September 2, 2009, NSF and the Consortium for Ocean Leadership signed the Cooperative Agreement that initiated the construction phase of the OOI.

The OOI project is now 30 months through the 66-month construction phase. During those 30 months, the project's accomplishments include the successful installation of 880 kilometers of cable (power, communications) across the seafloor off Oregon and Washington, the development and release of the first stage of Cyberinfrastructure software, ocean tests of four different mooring systems and configurations, the procurement of autonomous vehicles and sensors, as well as the successful completion of the NEPA process for the OOI.

It is a pleasure and an honor to work within a project team that possesses the creative vision, technical expertise and commitment to complete the full infrastructure of the OOI. The short- and long-term societal benefits of the OOI more than justify the hard work.

What was the MREFC approval process experience for OOI?

Early members of the project office (2006-2009) had some government experience with large projects (NOAA, DoE), and others involved in the early planning had extensive ocean research experience and expertise. That oceanographic perspective is reflected in the recommendations included in many of the workshop reports, NRC reports, and review panel reports from the late 1990s through the mid-2000s. These documents provide a historical record of the early stages of moving the OOI from a concept to a tangible infrastructure.

The approval process (Conceptual Design Review, Preliminary Design Review, Final Design Review, NSB approval) can be viewed from at least two perspectives. On the one hand, as a project moves into and through the MREFC approval process, the creative leaders of the project must move smoothly from a research project viewpoint (their career perspective) to a more structured, systems engineering and project management viewpoint. This is widely recognized within the large facility community as one of the biggest challenges for a new MREFC project. On the other hand, the approval process educates the initial project team about the essential rigors of System Engineering, the need for a 'technical baseline,' the importance of vigilant oversight of processes and budgets, the requirement to track the performance metrics of earned value management, and the need to search for cost efficiencies and approaches within construction that will carry over into Operations and Maintenance.

A number of overarching science objectives guided the early planning stages of the OOI. As described in the initial section of this testimony, those science objectives informed the Request for Assistance (RFA) process that solicited proposals from the ocean sciences community. The integration of the 48 submissions from that process led to the consolidation of many excellent research themes and approaches and resulted in an observatory vision that included 10 Global sites, 6 Coastal sites, and a seafloor cabled array with 5 sites on the Juan de Fuca plate. The experts comprising the Conceptual Design Review panel, in concert with the NSF, acknowledged the vision as important and worth pursuing, but requiring a more extensive analysis of scope and costs. The identification of Implementing Organizations in March 2007 permitted the Program Management Office at the Consortium for Ocean Leadership, as prime awardee, to begin integrating system engineering processes across the project while detailed cost analyses were conducted on the various envisioned elements of the observatory. The cost analyses led to a revision of the conceptual design, with external advisory committees consisting of experienced ocean scientists providing input to the team and to the NSF following Conceptual Design Review. At the time of Preliminary Design Review (December 2007), the scope of the OOI had been identified as 3 Global Sites, 2 Coastal Arrays (Pioneer and Endurance), and 5 major sites on the Juan de Fuca tectonic plate that would be connected to the undersea cabled array. This extensive consolidation of scope reflected the transition from 'science ideas' to 'engineering/budget reality.' It was during the interval between Conceptual Design Review and Preliminary Design Review that the OOI team also developed the extensive technical documentation required by the MREFC process, including, at the top level, a Project Execution Plan, Systems Engineering Management Plan, Configuration Management Plan, science to design requirements traceability, etc. The distributed team enhanced its understanding of the technical needs of an MREFC project during this phase of planning and preparation.

The interval between Preliminary Design Review and Final Design Review led to further refinement of the technical data package (policies, procedures, cost bases, etc). The recommendations of the Final Design Review panel in November 2008 included a strong recommendation for additional 'risk' to be considered during the construction phase. The panel recommendation was incorporated in the next risk estimation for the project in early 2009.

In summary, the multi-step MREFC approval process forged the distributed implementing organizations into a cohesive observatory team, while refining the technical and budgetary boundaries of the project. From the point of view of the OOI, the MREFC approval process was an essential, and positive, experience.

What were the strengths and weaknesses of the process?

The MREFC approval process provided the planning team with important external advice and guidance, assisting the team in developing documentation and cost estimates for each successive level of review. The clear structure of the MREFC process greatly facilitates the development of a strong team. For example, one key area of strength of the MREFC process for the OOI team was the requirement for incremental incorporation of increased technical and budgetary rigor - this discipline was extremely beneficial to the OOI team and built confidence across the project during the pre-construction phase. In addition to the benefits to the OOI team, the rigor of the process, and its transparency, benefits the sponsoring agency, the ocean sciences community, and the public.

Another important strength of the process is the opportunity for sophisticated management coordination to develop between NSF and the project team. This coordination, and the cooperative exchange of ideas and solutions, is vitally important as the project moves from approval to construction. This management coordination also assures more efficient use of public funds during construction and operations.

From the point of view of the OOI and our experience to date, there are no obvious weaknesses in the MREFC process. It has worked well for us. While each MREFC project has unique characteristics and unique technical challenges, it is necessary for the NSF and the Large Facilities Office to sustain a framework that supports the development and maturation of a project team during the early inception and subsequent approval stages. It is also important that the MREFC process have sufficient flexibility to adapt if a particular project encounters unusual challenges with scope, budget or schedule.

What have been the biggest challenges you have faced with the project thus far and how were they rectified?

The project began construction in September 2009 with fewer staff than the work plan required. It was more difficult than anticipated to reach full staffing levels during the first year of construction. We addressed this challenge and reached our staffing targets by involving the institutional leadership of each Implementing Organizations in the solution.

The OOI faced several challenges in environmental assessment during the first year of construction, particularly in responding to public comments and for completion of the environmental assessment within the project timelines. Through close coordination of informational events and public feedback events by the OOI team, NSF, and interested stakeholders, the project completed the environmental assessment and NSF signed a Finding of No Significant Impact for the OOI.

How is OOI currently managed?

The OOI has a hierarchical structure, with the Consortium for Ocean Leadership (a non-profit) as the 'prime' and each Implementing Organization as a 'subawardee.' A Cooperative Agreement between Ocean Leadership (OL) and the NSF establishes a set of terms and conditions for the project, which flow down to each subawardee. The OOI Program Management Office at Ocean Leadership is responsible for project compliance to those terms and conditions, including reporting of financial status and technical progress against milestones. On a functional basis, the program management office monitors and coordinates the work within the milestone-driven project schedule through daily interactions between Ocean Leadership and each major subawardee (via Contracting Organization Technical Representatives (COTRs) and project managers). Several teleconferences are conducted each week by the Program Management Office to facilitate communications across the geographically-distributed team.

Discussions and meetings occur with NSF several times each week. The development and submission of monthly progress reports by the Program Management Office to the NSF also serves as an important management tool for the Program Management Office, as these reports involve the monthly integration of Earned Value metrics as well as assessment of monthly project progress against schedule milestones.

The Executive Committee of the Board of Directors of the Consortium for Ocean Leadership provides project oversight, both through direct interaction with the OOI Program Director and through reports from the OOI Program Advisory Committee (an external panel of non-conflicted senior ocean scientists).

What are the roles and responsibilities of the facility staff and the roles and responsibilities of NSF in the management and oversight of OOI?

I serve as the OOI Program Director, coordinating leadership actions with the senior staff at each Implementing Organization, and communicating on a regular basis with the NSF. I report to the CEO of the Consortium for Ocean Leadership. The OOI Senior Project Manager, reporting to the Program Director, has responsibility for overall project management and engineering integration for the entire project. The other members of the senior management team of the OOI at Ocean Leadership are responsible for numerous areas, including System Engineering, Safety, Quality, Science, Communications, and Environmental Compliance. As mentioned in an earlier section, the COTRs assigned to each Implementing Organization are responsible for the coordination and integration of day-to-day work, and function as the conduit for effective communication to and from the Program Management Office.

The Program Management Office also assures that project activities are governed by the OOI technical baseline (approved policies and procedures) and are administered via formal 'change control' procedures when necessary. All project actions are documented, reported, and archived.

Under the Cooperative Agreement, the Program Management Office has specific reporting and procurement compliance responsibilities to the NSF, with the clear distinction that the OOI team is responsible for *execution* and the NSF is responsible for *oversight*. In addition, prudent project management dictates that the OOI team maintains open channels of communication with the NSF about all project activities. We therefore have frequent interaction and information exchange (often daily). This level of interaction has been extremely beneficial through the approval process as well as through this phase of construction.

How do you work with NSF to ensure that the American taxpayer is getting a return on this investment?

The overarching scientific justification of the OOI project is the sustained delivery of many types of ocean data across a range of temporal and spatial scales, from the sea surface to the seafloor. This data delivery will have direct, short-term societal and economic benefits (coastal storm hazards, linkages between offshore and near-shore processes, improved ocean circulation modeling, seasonal ecosystem responses, etc), which will develop into long-term improvements in forecasting of ocean conditions. These connections between ocean research and 'broader impacts' are at the core of NSF's science objectives. The OOI is therefore perfectly poised to provide significant return on the taxpayer's investment.

To optimize that outcome, NSF and the OOI collaborate to maintain significant connections with other projects and other entities involved in ocean observing. The Consortium for Ocean Leadership has a Memorandum of Understanding with Ocean Networks Canada, a seafloor observing facility off Vancouver Island, British Columbia. The NSF co-chairs an Interagency Working Group on Ocean Observing (coordinated at Ocean Leadership) that facilitates the cost-effective development of observing capabilities across the federal family. Of particular note is the cross-agency and cross-project collaboration between NSF, NOAA, the OOI, and the Integrated Ocean Observing System (IOOS). The two agencies are co-funding a data management project that will assure interoperability between the NSF and NOAA systems.

As described earlier in this testimony, the OOI project team builds upon the strengths of public, private, and non-profit institutions, along with industry partners. We feel that this integration of complementary capabilities is an efficient use of taxpayer funds.

At a more detailed level, the taxpayer benefits from the cost efficiencies that resulted from the several stages of review of the OOI scope of work and the aggressive actions to reduce the costs to build and operate that scope. On an annual basis, the OOI project team is mandated by the Cooperative Agreement to develop and submit to NSF an Annual Work Plan that describes the work to be completed in the coming year, along with the funding request for that work. Only after review and approval by NSF, often involving sequential edits and revisions of the Annual Work Plan by the OOI team, is funding provided to Ocean Leadership for allocation to the work elements of the project, via subawards to the Implementing Organizations. We use monthly tracking of expenses and completed work compared the project baseline to generate Earned Value metrics, thus giving us valuable performance metrics for each Implementing Organization. Every month the project submits a formal report to NSF with extensive data on progress as well as challenges. We also work closely with NSF on procurements of capital equipment or major services to assure that appropriate acquisition procedures are followed. Each of these steps represents a collaboration between the OOI team and NSF to be cost-effective.

How is the entire life cycle of the project, including management and operations after construction, taken into account in the management and oversight of the construction project?

The initial, steady-state phase of Operations and Maintenance (O&M) of the OOI will begin in 2015 following the completion of Construction. The OOI team initially developed an Operations and Maintenance Plan in preparation for Preliminary Design Review. Since that time, the O&M Plan has been revised and updated to reflect the maturation of the construction schedule and an improved understanding of operational assumptions and expenses. During construction, the O&M team is integrated into *design reviews* and *production readiness reviews* to assure that operational issues (e.g., service costs, replacement costs) have been considered during the design and acquisition of subsystems or their components. The technical issues identified during construction, for any element, are included within the deliverables that accompany that element in its transition from construction to operations.

This aspect of life cycle considerations has been an active topic of discussion at each of our external reviews, and is a priority for the project managers in construction and O&M.

Mr. Chairman and members of the Subcommittee, I wish to thank you for this opportunity to answer questions about the MREFC process and the Ocean Observatories Initiative. I would be happy to discuss any of these topics with you during the hearing.

Chairman BROOKS. Thank you, Dr. Cowles.

I want to thank the panel for their testimony. Reminding members that committee rules limit questioning to five minutes, the Chair will at this point open the round of questions. The Chair recognizes himself for five minutes.

My first question is for Dr. Griffiths. The issue of contingency continues to be an area of concern not only for the National Science Foundation Inspector General but for Congress as well. You testified that the Board receives updates on the discussions between the Inspector General and NSF senior management. In that vein, I have three questions.

First, does the Board have an opinion? Second, can you expand on the Board's role, if any, in the ongoing discussions and actions around this issue? And third, does the Board plan to take any action on this issue? So first is opinion; second, the Board's role; and third is action.

Dr. GRIFFITHS. Thank you, Chairman Brooks. The first one, on the Board having an opinion, the Board has spent a lot of time, particularly the Subcommittee on Facilities and the Committee on Programs and Plans, looking at how contingency is defined by the Board. And I will say it took a little while for us to understand that because of more common uses of—or multiple uses of the term "contingency" in our other environments. But I think the Board has a tendency to agree that the definition that is being used is fine. Now, the question is what are the implications of that definition going forward? The Board's role in the discussion, we have been—the Committee on Audit and Oversight has been receiving updates on the negotiations between NSF management and the Inspector General's office at every one of our meetings. So every meeting we have had a report. And we are pleased with the progress made to date. So at this point we haven't weighed into those interactions but we are receiving reports.

Chairman BROOKS. Second question would be for Dr. Marrett and Dr. Griffiths. Choose amongst yourselves who wants to take first crack at it. For three straight Inspector General semi-annual reports, Inspector General Auditors have found unallowable contingency costs for three separate MREFC projects, $76 million for NEON, $88 million for OOI, and $62 million for ATST. What is the NSF doing to rectify this continuing problem and what steps are being taken to prevent similar problems with other projects?

Dr. MARRETT. Thank you. I will start. Actually, there is a question about whether there are problems. I will say that those audits were of the proposals from particular projects, not from the actual expenditures once construction has begun. Thus, we are asking—and I believe the Inspector General's office is prepared now—to do audits not of the proposals but of the actual expenditures. The consequences are likely to be quite different.

I would also elaborate a bit more on what Dr. Griffiths just said about the very notion of contingency. We know that for any project there are known risks and that is what the contingency is to cover, the known risks that are there. Thus, this is associated with our policy of no cost overrun. So no project is to go above what those costs are. The contingency is there to keep it within the bounds, then, of the kinds of costs that would be associated. Thus, what we are doing in collaboration with the Office of the Inspector General is clearing up the understanding that the processes that we use for contingency are those that are consistent with other agencies, and industry. Because of the very strong relationship we have with the wonderful Office of the Inspector General, we are convinced that we will be able to resolve—what seemingly are differences, that we are not quite sure are as deep as might be implied in the semi-annual reports.

Chairman BROOKS. Thank you, Dr. Marrett. I am going to move to Dr. Beasley and Dr. Cowles for a moment.

Would each of you briefly explain your side of the contingency issue for the $76 million concerning NEON and the $88 million concerning OOI?

Dr. BEASLEY. Mr. Chairman, as Dr. Marrett just indicated, the $76 million in contingency that was identified in the IG report is all of the contingency of the program at the proposal level. And so what you are seeing, as Dr. Marrett described, is not necessarily a difference between execution of the program and what we said; it is really the fact that our original proposal produced a risk-adjusted estimate, which included a contingency. And so they have found all of the contingency to be unallowable. And so that is the original of the $76 million number in the IG report.

Chairman BROOKS. Thank you, Dr. Beasley. Dr. Cowles?

Dr. COWLES. Yes. Really, the answer is essentially the same. So when we began examining the construction costs for the OOI, we evaluated, using industry practice, the risk-based elements using clear formulae for assessing risk for every item in the construction and totaled that up and we end up in our proposal with $88 million. That, as Dr. Beasley said, is not the expenditure. It is not a number that is automatically expended. It is there to be drawn upon by the project through NSF approval process and our own internal controls only when the risk has to be addressed and mitigated through application of contingency funds. From a project standpoint, the $88 million for the OOI is an essential part of how we must address risk through construction. Independent of how the IG looks at it from a practical, pragmatic standpoint, if we didn't have a contingency amount in our project budget, the initial budget would have had to have risk included in the construction costs.

Chairman BROOKS. Thank you, Dr. Cowles. I finished my questions before the five minute mark, but with the answers, we blew right on by it.

At this point, I will recognize Mr. Lipinski.

Mr. LIPINSKI. And Mr. Chairman, it's your Subcommittee so you can go as long as you want I think.

I just want to thank all of our witnesses for their testimony and thank Mr. Yeck, Dr. Beasley, and Dr. Cowles for their—the work that they have done. I think what we are—we know we are looking at—the work that you are doing is looking at very important scientific questions and what we are trying to do here is to make sure that we are getting the most out of the funding and we are doing things in the best way possible.

I want to start out by talking about DUSEL. The NSF's experience with DUSEL facility clearly indicates that planning and funding problems can affect not only the construction phase of MREFC projects but the preliminary design phase as well. And I think the NSF made the right choice regarding DUSEL but it is important that the lessons learned from this episode are used to improve the project evolution process.

So I wanted to ask Dr. Marrett and Dr. Griffiths, can you discuss the steps that have been taken to improve the process for the early stages of MREFC projects so that this doesn't happen again?

Dr. MARRETT. Yes, there are three things I would say about what we have learned from the DUSEL experience. One is that we have tightened up what we mean by horizon projects; sums but more importantly perhaps, there is greater engagement early on of the National Science Board; third, we give systematic attention now to operations and management, more than had been the case when we first started looking at a number of the projects in this account.

I would elaborate a bit more on the role of the Board. The Board has always had a role with reference to setting priorities. It wasn't as necessarily involved in the very early stages when we were talking about conceptual design, moving from the horizon stage to the conceptual design stage. We now have the Board engaged at every stage in the process. One of the things that the Board, in the case of the DUSEL project, certainly brought to attention was the importance of thinking about the matter of stewardship. As Dr. Griffiths will elaborate I am certain, this came to a question of what is the appropriate agency for stewarding a project of this size? We remain extremely interested in the science, the engineering that could emanate, but the question of the infrastructure itself was the one that was central for the Board's deliberation. I am sure that Dr. Griffiths will say more on that.

Dr. GRIFFITHS. Yes. Mr. Lipinski, we had three big concerns that came up with respect to the DUSEL project. One was the role of the partners and the stewardship model that wasn't really clearly defined at the stage at which we were looking at moving DUSEL forward. The second was the cost and scope of DUSEL as—inconsistent with the roles and responsibilities of NSF and the total project. And the third was we were concerned about NSF investment in underground science needed to be placed in the context of other international activities.

But as Dr. Marrett has said, we have redefined the Board's role in the entire MREFC process, so we are in fact actively engaged at every stage. In particular, we recognize that moving a project from conceptual design through preliminary design is a significant investment of taxpayer money. We have focused our efforts particularly at the post-conceptual design stage. We have established the Subcommittee on Facilities to conduct an annual portfolio review at that point in time. Prior to that, facilities projects were looked at as they came in, one at a time, and one at a time you could say everything looks good.

What we decided we had to do was to consider any new facilities project in the context of the existing portfolio of projects, how it adds, how it maneuvers resources, and in the context of the R&RA funding for the planning, the operations and maintenance, and most importantly, the research that the new facility would enable so that the portfolio review, which is conducted annually is going to become a major tool for decision-making for the Board and the

Foundation. And that occurs for all facilities projects at every stage from horizon to decommissioning where we look at the entire portfolio of facilities, not just for the MREFC level of funding but actually all the way down through mid-scale funding as well so that we have a much better feel for the total portfolio. And we are currently looking at ways to develop key indicators of the health of that portfolio. So it is not just to look at the portfolio as a whole from the Foundation management process as a whole; we also look at the portfolio from the perspective of the directorates and the different divisions and the impact that new facilities will have on their available funding.

Mr. LIPINSKI. Thank you. I think it is critical that we make sure that we are watching, you are watching more closely from the beginning. And we just—especially in these tight budget times make sure that we know—especially for the—so the people understand that these projects are important and we are doing the best that we can to fund them at the—in the appropriate way.

So thank you. I yield back.

Chairman BROOKS. Dr. Marrett, is the National Science Foundation requiring more contingency now so that they stay under their "no cost overrun" policy?

Dr. MARRETT. If you mean are we requiring more for every project to have contingency, we are doing that. But if you mean are we requiring more in the contingency, no. What has to be there, has got to be specific to each project. What the contingency amount will be will vary depending on what the known risks are for any given project. Thus, if you are interested, we can provide you later, if you would like, how contingency does vary across projects because that is consistent with again what the known risks are for a project.

Chairman BROOKS. Now, Dr. Marrett, another question. In your testimony you noted, "the decision milestones also constitute 'off-ramps' for terminating the project if progress is not deemed satisfactory or NSF's plans or priorities change." How are these "off-ramps" identified and by whom?

Dr. MARRETT. The off-ramps are identified first within the given program, next by the Major Research Equipment and Facilities Construction panel, and then that panel makes its recommendations to the Director. Each stage in our process offers the possibilities for off-ramps, so there is nothing that says a project that makes it through that first stage—from horizon to conceptual design—will actually end up in construction because any number of things could lead to the decision that it is not ready. Those, then, represent the off-ramps. If a project does not make it through conceptual design review, for example, it doesn't move to the next stage in the process. All of that is handled by, first, the program; secondly, by the panel that advises the Director; then finally by the Director.

Chairman BROOKS. How many projects have been terminated for failure to meet the milestones?

Dr. MARRETT. We will get back to you. I am not sure I have the exact figures. There have been lots of projects that have come into the process. That is why I said in one way we have tightened up on the notion of horizon projects because a lot of people interpreted horizon as a dream in an eye, and that is not what we meant there. There has to be a level of commitment by the sponsoring organization for something to move to the next stage. There are lots of activities that never really reach that stage of moving from horizon. There are others, and as I said, we can get to you the information on the number and conditions associated with the failure of a project; to move from one stage to the next.

Chairman BROOKS. Offhand, can you recall any projects that have been cancelled for failure to meet milestones?

Dr. MARRETT. Let us see. Yes, although I am trying to remember right now what are some of the precise ones. In Rare Symmetry Violating Process (RSVP) we have an example of a project that had been terminated because it didn't proceed according to our process.

Chairman BROOKS. In your judgment, does that threat of termination of the project encourage the meeting of milestones?

Dr. MARRETT. We certainly hope so. What has to be understood from the outset is that nothing again is guaranteed. This is the communication we have with the communities. That is one of the reasons why these are cooperative agreements when things are finally worked out because they have to be cooperative between the National Science Foundation and the proposing project. Thus, we make the case all the time that there is nothing that says you will automatically move to the next stage. We set forth in the criteria what is essential for the kind of transition from one stage to the next. So we believe that that really does tighten up on what is going to come forth and certainly will tighten up on where allocations have to be made.

Chairman BROOKS. And are there additional issues that may cause a termination not accounted for in the decision milestones?

Dr. MARRETT. Potentially, there are. I can say a few of the things that we do take into account are extremely relevant. In the case of multi-user facilities, for example, there has got to be clarity that there is a user community, a large user community that wants to make use of those facilities. If things change over time and there is a strong indication that there isn't a community that is going to be appropriately making—benefitting from that, that is something that is important.

Other kinds of developments—there can be challenges as other international projects might come onto the scene that make something less than the cutting edge that we had anticipated when the process might have started. Sometimes there are personnel changes that make it very difficult for us to anticipate that this is something that is going to move in the directions that would be there. We think we have identified key developments, key issues, but this is a process always under examination, always subject to our learning more about what are the conditions that have to be considered.

Chairman BROOKS. Thank you, Dr. Marrett.

The Chair next recognizes Mr. Lipinski for an additional set of questions and then we will move to Mr. Hultgren from the great State of Illinois.

Mr. LIPINSKI. Thank you, Mr. Chairman.

I just want to continue on a little bit with what the Chairman was asking about. We were talking about off-ramps here and as these projects move forward and you are examining them and say a project should not move forward. Where does Congress come into this? Where should Congress come in? What is the relationship—what kind of communication goes on with Congress? I mean that is a critical role, obviously, that—up here that we face. And I just want to know up to this point where—what has that relationship been with that communication been on these projects?

Dr. MARRETT. Well, I can tell you Congress makes an ultimate decision about an on-ramp or off-ramp having to do with funding because once the project has moved from preliminary to final design, that is the stage at which we can talk about it being included in a future budget. When we say this could be included in a future budget, as you know, budgets are negotiated, discussed extensively with Congress. So that is one of the key stages that Congress is clearly involved.

The other stages, Congress has always had the possibilities of pursuing, as this hearing is doing, the stage of particular projects, and we are always open to providing information in some cases about the portfolio—that is what has been asked— or in other cases about particular projects. We stand open [today], then, to Congress at any time being very much involved. So it is for the final—what happens to a final project. It is also the engagement about what happens before something goes into the MREFC account because the funding for that stage comes from the research and related accounts. Congress then also oversees what happens in the funding of those accounts. So I would say the funding role is a critical one.

Mr. LIPINSKI. Well, this isn't a criticism particularly of anyone or anything that has gone on before, but maybe this Committee should have—be watching more and not leave it up just to the appropriators to be playing the role in this. I certainly think that is an important role for this Committee to be taking.

I am not sure how much we can get into this in the amount of time I have left, but we are talking about contingency funding, and I think it is a little fuzzy about what this is. It is certainly not a slush fund. My understanding is on average a project—the expectation that a project will be completed at total cost—that is the sum of a fixed, predictable amount plus the contingency fund, which captures the expected cost of the uncertain portion of the project. So my understanding is there is a calculation of how much you expect because you can't know exactly how much everything is going to cost, but you create a contingency fund. Is the expectation, then, that you are going to—the spending is going to be the mean of that contingency fund? You are going to spend—that half the contingency fund will be spent or where is the expectation of—because, you know, I am looking at this as, you know, do you calculate a normal curve and say this is what our expectation is for how much it is going to cost because there is certain specific uncertainty for each portion of the project? So what is the real expectation in terms of the contingency fund? It is not—my understanding is it not on top of what is—you plan—that you are expected to spend but you expect to spend some of that contingency fund?

Dr. MARRETT. For that, I will give a general response but I think the more detailed response would come appropriately from those who have had to handle the matter of contingencies. So I would say again we go back to that there are given risks. When a budget is prepared, it should be that minimal budget, the budget that is going to have to be there given that there are always potential risks and we can't come in over what we have included there. That is the way, then, the contingency is to be built in.

I know one of the questions that has come up periodically is, don't you expect, then, the contingency not to be spent and to be returned to the Federal Government? If that is the case, we can return. But more frequently it is there because the risks actually do come about and we have to have a way for covering those. As I said, I think it would be appropriate probably for Mr. Yeck, who had to work with this with reference to IceCube.

Mr. LIPINSKI. Before we go to Mr. Yeck, is the expectation, though, that contingency—some of it will be spent or is the expectation that it won't be spent?

Dr. MARRETT. The expectation is it will be spent, that there will be those risks. That is why we have said these are not just some kind of speculation. It is the set of known unknowns as sometimes they are called. You know that there are going to be the risks and there are the estimates of what are the costs associated with those. Thus, you do expect to have to pay to cover those risks. So that is the way, as I said, I believe I could elaborate on what that has meant for IceCube, but that is the kind of expectation from the National Science Foundation.

Mr. LIPINSKI. Mr. Yeck, it is up to the Chairman now. Mr. Yeck, if you—to add more to—go ahead, Mr. Yeck, if you have more to add to that from your experience.

Chairman BROOKS. Go ahead.

Mr. YECK. Yes, I can make some comments. The short answer is that the expectation is that the contingency will be spent. Project management——

Mr. LIPINSKI. Wait. Some of the contingency?

Mr. YECK. All of it.

Mr. LIPINSKI. Or all of it?

Mr. YECK. All of it. Project management—there is a science to it and there is an art, and part of the art is to squeeze base budgets so that the responsible managers are in a constant discussion with the higher level management about how funds are used, and contingency is one way of having a transparent dialogue on that. Specifically, there are examples— may I respond to the question earlier, Mr. Lipinski, about IceCube. You know, the boundary conditions when IceCube was baselined—this period where you start construction, where you are defining the performance baseline where you have—are very general to MREFC projects. You have a five to ten year project; you do not want to go back for more funding. There is a high level of engagement and oversight by the NSF like any MREFC project. Specific to IceCube, we had the recognition that it would be exceedingly expensive to go back and try to add instrumentation at a later date given the South Pole logistics framework.

Leading up to project baseline, we did a bottom up cost estimate. It came up over $10 million higher than the funding plan, which was 242.1 million. And at this point, the partnership between NSF, UW–Madison, and the scientific collaboration engaged to look at how best to develop the final project baseline, including a contingency. And we de-scoped from 80 to 70 strings in terms of the plan, the project plan, and established this 22 percent contingency budget that I mentioned, which we expected to spend on the 70 strings.

When the project was approved by the Science Board, it was approved to go up to 80 strings, the original baseline, and we had an incentive built in to try to save costs—reduce costs, and the best way to do that is schedule. So we worked very hard to maximize the insulation of strings each year at the South Pole and we reached record numbers and saved fuel, which is a big expense for IceCube. And so in the end of our total contingency budget, less than 25 percent went into the cost of restoring these strings.

Further comment if I may that this practice is actually modeled off another project which DOE and NSF supported—which I was involved in which was the LHC—there was a cap contribution to the European lab in particle physics. The detectors de-scoped to create a 50 percent contingency given the high risks in those projects, and in the end, about 50 percent of that contingency went to scope restoration. So it is an approach that works very well from a project-management standpoint to have that incentive. Typically, you would expect to spend the contingency on the baseline scope.

Thank you.

Mr. LIPINSKI. Thank you.

Chairman BROOKS. Thank you, Mr. Yeck.

Thank you, Mr. Lipinski.

The Chair next recognizes Mr. Hultgren from the great State of Illinois.

Mr. HULTGREN. Thank you.

Thank you all for being here. Sorry it is a busy day. We have got a lot of different committees going on in markups. So I know other people would love to be here. We are all kind of running around so—but thank you so much for your work.

Dr. Marrett, I wondered—just a question. Major Research Equipment and Facilities projects often span decades from inception to operation. How does the Foundation plan 30 years in advance or more if ramp-up is 10 to 15 years and a facility may be in operation for an additional 30 years for the continuous support of these projects?

Dr. MARRETT. We are talking about the MREFC account, which is a construction account. The other parts of this that you are asking about will have to do with the research support that is going to have to be there. As I have indicated a bit earlier, we are now giving a lot of attention at the outset to what will be the operational, the maintenance cost, and what is the likelihood that there will be continued demand from the research community. Anticipating what is going to happen from the community is very much a part of this process but that is funded not through this account, that is funded through the research and related account or the education and human resources account. So we don't really try to ask about funding from MREFC for what will happen for support of the advancement of the knowledge over the years.

Your overarching question suggesting that all of this has to be taken into account and the long lead time does have to be considered very much. There is a long lead time in the actual development of construction projects, and then once there is the construction, there is an anticipation of a certain lifetime for the research that would be done. So I hope that comes somewhat close to what you were interested in.

Mr. HULTGREN. I appreciate that. And again I do thank you all for being here. And I yield back.

Chairman BROOKS. Mr. Yeck, one follow-up with you if I might. "IceCube is a particle detector imbedded in a cubic kilometer of deep, very transparent South Pole ice that was designed to detect high-energy neutrinos from nearby and across the universe." And this is from your testimony. And then you also add that it "includes about 250 people from 39 institutions in 11 countries." If you could, please give the members a primer of sorts on why the South Pole was chosen for this particular endeavor and then also what is the expected scientific reward for what we are doing.

Mr. YECK. Thank you. The South Pole provides a unique opportunity to have the large detector volume that is needed. So detectors of this type previous practice would be to build a large tank, excavate a cavern to create the volume that is needed. In the case of IceCube, that volume exists in the icecap at the South Pole. So the challenge, then, is to drill into the ice and install the sensors that are needed. And the South Pole is an ideal location because not only is that icecap there but the infrastructure is in place through the U.S. Antarctic Program. So the logistics chain exists and so the instrumentation that was produced around the world could be moved efficiently to the South Pole, and then the drilling crews and the scientists could be supported at the South Pole to carry out that construction. So that was very—it was very cost-effective. If you imagine trying to do this at a location that did not have that infrastructure, it would be exceedingly expense.

IceCube is a detector that is opening up a new avenue to discovery, neutrino astronomy. So it is as likely that the science coming out of IceCube will be something unexpected, as it is the expected science of neutrino detection, high-energy neutrinos outside of our galaxy. So this is now underway, the collaboration of institutions, which are about half in the United States and half worldwide are actively analyzing data and pursuing their science objectives.

Thank you.

Chairman BROOKS. Thank you, Mr. Yeck. And I believe Mr. Lipinski has one more round of questions.

Mr. LIPINSKI. Thank you, Mr. Chairman.

I have a question for Dr. Marrett. The Large Facilities Office is responsible for a budget as large as the Office of Cyberinfrastructure, which sits in the Office of the Director and similar funds critical research infrastructure. Why is the Large Facilities Office within the CFO's office and not the Director's office like OCI where it would have direct access to the Director and more leverage in its relationship with research directorates?

Dr. MARRETT. Actually, the location of an office or any other entity of NSF does not indicate always the access that is there. The Office of the Director has to be concerned with all parts of the Foundation. Thus, the offices—the directorates very much report to the Director. That is the same case, then, for the Large Facilities

Office. It does come through Budget & Financial Administration, but that is not to indicate that there isn't the kind of ongoing interaction between that office and the Office of the Director, the way that it is for the Office of Cyber Infrastructure.

One of the things that the Deputy Director for the Large Facilities Office does is to prepare a monthly report on where things stand, a report that comes to the Director and to me and that we review very carefully. We then spend whatever time is essential that might be requested from any number of angles to ensure that we are very familiar with what happens in that particular office. Thus, as I said, location is not always an indication of oversight or engagement in the kinds of concerns that the Foundation has to be concerned with.

Mr. LIPINSKI. Well, was there a reason that OCI was put in the Director's office when it was created?

Dr. MARRETT. Yes, there were a couple of reasons and some of those are really being reexamined right now to be perfectly honest. There are sometimes reasons for the location of particular offices and operations that don't always hold up over time. So we are reviewing all of the operations that currently report to the Office of the Director because, as I said, sometimes that is interpreted as giving greater access to the Director than the directorates and other offices that are not listed as a part of the Office of the Director. Since that is really not the way it happens, we are just taking a look at all of the structure to ensure that there is an understanding of the engagement that has to be there, again, with all of the key things the Foundation has to oversee.

Mr. LIPINSKI. Thank you, Dr. Marrett.

I yield back.

Chairman BROOKS. I would like to thank the witnesses for their participation in today's hearing and also thank the members for their questions. And most importantly, we were able to finish before the votes start on the House Floor in about 10 to 15 minutes.

With that, the members of the Subcommittee may have additional questions for the witnesses and we will ask you to respond to those in writing should any be forthcoming. The record will remain open for two weeks for additional comments from members.

The witnesses are excused and this hearing is adjourned.

[Whereupon, at 11:17 a.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Cora Marrett, Deputy Director, National Science Foundation

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITEE ON RESEARCH AND RESEARCH AND SCIENCE EDUCATION
Hearing on
NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

March 8, 2012

Dr. Cora Marrett
Deputy Director
National Science Foundation

Questions for the Record Submitted by Mo Brooks and Daniel Lipinski

Questions for Dr. Marrett

1. **For fiscal years 2009-2011, as a total across all MREFC projects in each of those years, how much contingency funding was carried over to the following fiscal year (and beyond)?**

The table below shows this information, further broken down by funding source (ARRA and MREFC) and by project. Annual construction budget requests contain sufficient contingency to manage risks and uncertainties that may arise during each year. The delayed enactment of the FY 2010 budget and the full-year FY 2011 continuing resolution distorted that planning. ARRA funds were obligated to each project in its entirety during 2009 and 2010 as the projects became construction-ready.

Annual Carryover of Budget Contingency	FY 2009		FY 2010		FY 2011	
Total:	**$48.31**		**$112.49**		**$54.99**	
	MREFC	**ARRA**	**MREFC**	**ARRA**	**MREFC**	**ARRA**
Carryover by account:	**$23.66**	**$24.65**	**$67.03**	**$45.46**	**$26.78**	$28.21
Carryover by project:						
AdvLIGO	$ 13.46		$ 19.67		$ 8.58	
ALMA	$ 1.02		$ 16.20		$ 1.17	
ARRV	$ 2.33		$ 7.14	$ 24.22	$ 6.44	$ 16.19
ATST			$ 5.12	$ 20.60	$ 2.59	$ 11.40
IceCube	$ 6.85		$ 4.00		$ 2.38	
NEON					$ 2.01	
OOI		$ 24.65	$ 14.90	$ 0.64	$ 3.61	$ 0.62

2. **Contingencies are calculated using widely accepted statistical methods; however, there is some discretion involved in these calculations. What factors may influence decisions about individual inputs into contingency calculations? How does or should NSF's no-cost-overrun policy influence contingency calculations? How do you avoid incentivizing the projects to maximize contingency estimates? How does the no-cost-overrun policy influence the balance between maximizing the scientific scope and minimizing the total negotiated project cost of any new project?**

<u>What factors may influence decisions about individual inputs into contingency calculations?</u>

Decisions about how to derive individual inputs to contingency are determined on an element by element basis by staff of the project developer based on their professional expertise and engineering judgment. NSF policy requires the cost proposed in the agency budget to be a 'risk adjusted total project cost' including contingency for cost risks that are algorithmically calculated from risk assessments and engineering judgments at the lowest level of the project work breakdown structure (WBS). In general, each WBS element requires an assessment that combines joint estimates of likelihood and impact on costs that vary from element to element due to unique technical, cost, and schedule factors.

Some cost elements contain vendor supplied materials and services – these elements depend on the developer's expertise with contracting and procurement. Other elements contain unique internally developed technologies – these depend on engineering and fabrication capabilities. Many projects incorporate contributions-in-kind from other sources and rely on judgments about their reliability and cost risks.

How does or should NSF's no-cost-overrun policy influence contingency calculations?

The 'no-cost-overrun policy' reinforces the need for a rigorous contingency calculation. Because of this policy, the contingency budget has to be high enough to assure NSF that the proposed scope can be accomplished with a proposed budget in light of the known risks.

How do you avoid incentivizing the projects to maximize contingency estimates?

Cost realism, assurance that the total cost estimate is not inflated, is determined through external assessment by experts with experience on comparable projects.

Project developers are universities or not-for-profit institutions representing a wide research community and do not respond to conventional financial incentives. These developers do not receive fee or incentive payments and cannot incorporate unused contingency into a fee pool. Each uses non-advocacy external reviews by expert panels including engineers, managers, as well as scientists from related disciplines who advise NSF on every major cost category of the project. Every project developer independently advises NSF as to whether a project's proposed scope is consistent with its scientific rationale and whether scope, cost estimates, and cost risks are realistic. For example, the "delta-cost" review to examine the rebaselined ALMA total project cost was followed by a separate expert panel 'contingency review' in 2006. This panel advised that contingency for NSF sponsored work, then at about 18% of the estimated cost of the remaining work, was too low and recommended a value closer to 25%. Ultimately, the approved rebaselined budget was closer to the panel's recommendation. NSF's approach to project management oversight is a continuing safeguard against inflated contingency estimates.

Comparison with the NASA Air Force Cost Model (NAFCOM) cost model suggests that NSF's typical project contingency levels are conservative. NSF sponsored facility projects appropriated from 2000-2009 were capped at 5 – 29% total aggregated contingency (see table below). The cost weighted average value was 19%. NAFCOM imposes a 25% minimum contingency reserve for new space hardware that has been through PDR and 35% for "new designs within the state-of-the-art" or for which there are vendor "estimates" (maturity levels that approximately correspond to the NSF cost cap)[1].

Facility	MREFC year	Total Cost $	Contingency %
ATST	2009-17	298	25
AdvLIGO	2008-14	205	23
NEON	2007-16	434	21
OOI	2007-16	386	29
ARRV	2007-09	199	21
ALMA* (rebaselined)	2006-12 1998-12	499 344	13 8

[1] SAIC, "NASA/Air Force Cost Model", 2002 version

And initial ALMA			
SODV	2005-07	115	8
EARTHSCOPE	2003-08	197	5
ICECUBE	2002-10	242	22
NEES	2000-04	82	14

**ALMA contingency at rebaselining is shown as a percentage of the cost to complete the project. Excluding financial obligations for work in progress, the rebaselined budget contingency was ~25%.*

<u>How does the no-cost-overrun policy influence the balance between maximizing the scientific scope and minimizing the total negotiated project cost of any new project?</u>

The no-cost-overrun policy is primarily a tool to achieve budget predictability with some ancillary benefits but it does place extra burdens on the developer and NSF review panels. Credible construction planning requires that the desired project scope be consistent with the project execution plan and budget requested. NSF, through its external review processes, ensures that the project budget is sufficient to cover the scientific scope with realistic contingency to mitigate project risks. The no-cost-overrun policy requires cost realism during the early design of a project. It also guards against scope creep, inefficient execution and poor contingency management. The developer and NSF review panels must pay careful attention to cost estimating in addition to technical design in early construction. The panels must monitor cost performance in addition to progress toward achieving science capabilities during construction. Cost effective performance protects the scientific scope and can, in some cases, allow more scientific scope to be proposed and built. Ultimately, because the developer is usually the post-construction facility operator, it has a vested interest in fulfilling the facility's anticipated scientific capabilities. Reducing scope or deferring unfinished work impacts user satisfaction and can (and has) resulted in replacement of the operator as a consequence.

3. **Why does NSF allow projects to expand their scope with any leftover funding rather than require them to return such funds to the agency to be weighed against other agency priorities?**

NSF de-obligates unexpended funds from the award instrument at the conclusion of construction so that they can be available for other agency priorities. NSF believes that its expert panel reviews and risk based contingency estimating approach contribute to producing an excellent match between scientific scope and the developer's capabilities and resources. NSF policy is that a developer can propose to use small amounts of unused contingency before the end of construction to (a) restore descoped features or (b) to increase the scientific capability that is consistent with the original scientific justification or that enables research that has emerged since the facility was originally approved for construction. A proposal of this nature is subject to the conventional NSF external review and internal assessment process to ensure scientific merit and priority, and require approval as a scope change at the appropriate level.

4. It seems that many of the science agencies have similar policies with respect to calculating and including contingency funding in the total project cost. But with respect to where contingency funds are held and what level of permission is required for drawdowns, the NSF appears to give more discretion to the non-federal project manager than any other agency. What justifies this practice at NSF given that other agencies, such as the DOE Office of Science, require a federal official to approve all contingency drawdowns? Why doesn't NSF transfer contingency funds to the project on as-needed basis?

NSF, unlike other agencies, does not directly build or operate facilities, in accordance with its organic act that limits it to an oversight role[2]. The overseers are not construction managers but usually scientists or engineers with extensive research experience within the disciplinary area served by the facility. The project manager is an employee of the awardee organization with many years of experience in related projects. As described later, NSF oversees the use of contingency through the use of approval thresholds.

In contrast, at the DOE Office of Science, a Federal Project Director, who is also an experienced project manager, is co-located at the project site with the project manager. The DOE Federal Project Director usually allocates the contingency to the project, although we understand that DOE allows some flexibility on this. Specifically, in the DOE system the project manager has authority to utilize contingency below specified thresholds (0.3% represents a typical threshold) in consultation with the Federal Project Director. Contingency usage above threshold requires formal change control.

The contingency allocation is for in-scope deliverables. It is included in the baseline budget to expeditiously mitigate cost risks and resolve cost estimating omissions and inaccuracy within the approved project scope[3]. Contingency management and as-needed drawdown is a function assigned to the project manager to align authority with responsibility, and is an essential tool that the project manager must be able to use to accomplish the project. This is a recognized best practice in federal, state and local capital asset construction and in industry[4]. It is intended to give maximum flexibility for balancing between scope and budget without 'cost-cutting' that reduces quality or impacts the total project outcome. Time-critical decisions on the use of contingency are often necessary to avoid delaying project schedule, so it is important that a project be able to manage these funds expeditiously.

NSF is informed of all allocations of budget contingency, and must provide prior approval for allocations exceeding thresholds defined in the terms and conditions of the funding instrument (Cooperative Agreement) to the awardee. These thresholds are less than 0.1 percent of the total project cost. Budget thus flows in and out of the contingency category as risks materialize and

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[2] 42 USC 1873(b), which states "The Foundation shall not, itself, operate any laboratories or pilot plants".

[3] "GAO Cost Estimating and Assessment Guide", GAO09-03SP

[4] See for example discussions in "Cost Estimating Guide", DOE G 413.3-21, "Elements of Realistic Project Budgets", The Architect's Handbook of Professional Practice, 13th edition, 2007, AIA Best Practice BP 13.04.03, and Hart, D. A. "Managing the Contingency Allowance" AIA Best Practice BP 13.04.05.

are mitigated in different areas of the work breakdown structure (WBS) or project work packages. In summary, the authority to apply or pull back expenditures thus resides with the project manager who has both the responsibility for and day-to-day contact with project execution, and with proven expertise; but funding is ultimately approved by NSF.

5. **In the case of IceCube, a significant portion of the contingency fund was leftover for reinvestment in the scope of the project. In that case it was about 20 percent. How often does NSF expect there to be significant leftover, and what does NSF define as "significant"?**

IceCube *began* construction with 22 % of the total 8-year project cost designated as contingency funding (about $44 million). By the time of the referenced "reinvestment," 7 years of construction elapsed and all but about $7 million of the contingency (or 3 % of the risk-adjusted Total Project Cost) was allocated to manage risks and uncertainties that the project previously encountered.

The initial level of contingency was established through an external baseline review. Project proponents originally proposed an 80-string array (the number of instrumented holes in the Antarctic icecap) at a total estimated cost of more than $280 million, to be funded by a combination of US and foreign contributions.

NSF directed the project to replan a 70 string array with reduced technical performance and a US cost target of less than $250 million, based on a bottom-up estimate of all project costs and known risks and uncertainties, including project risks ranging from instrument development, delays associated with the long logistics chain, bad weather and extreme environmental conditions at the South Pole, and commodity price increases (e.g. fuel).

The project (University of Wisconsin as lead) produced a technical justification that a 70-string array was the minimum viable size detector, along with a proposed budget that included 22.5 % contingency (the amount of the budget contingency divided by the base budget), for a total US project cost of $243 million. This contingency was estimated as necessary to accomplish a minimum 70-string project scope. National Science Board approval included the possibility, if contingency was managed appropriately, to build back to the originally intended 80-string array. Project contingency was consumed managing these risks through the life of the project. Savings realized through operational efficiencies as project personnel gained experience, and particularly from savings in fuel consumption as the drilling process was refined, allowed usage of some of this contingency to build back the originally planned 80-string array. As the project evolved, contingency was managed appropriately toward completion of the approved scope of work with annual reassessments of contingency needs and regular decisions by the project manager to allocate contingency funds in accord with prior planning. The justification to build 80 strings was built into the annual project execution plans that were reviewed and approved by NSF following annual external review. The only scope change accommodated by contingency funds was installation of the Deep Core Array. This was a set of 6 strings that created a denser array of detectors in the lower-middle part of the array to allow IceCube's energy sensitivity to overlap other large observatories aimed at lower-energy neutrinos (e.g. Super KAMIOKANDE in Japan). The amount of IceCube contingency used for the Deep Core Array was about $1.5 million; this was used for drilling the six holes and installing the strings of in-ice detectors. Instrumentation for the Deep Core Array was provided by European partners. In accord with NSF policy, a proposal for this change in scope was externally reviewed and the proposed program-level decision was reviewed by the Director's Review Board and the National Science Board was briefed prior to a final approval by the Office of Polar Programs.

As noted above, NSF expects that the risk-adjusted Total Project Cost (TPC), defined when the project is baselined and validated through a robust baselining review, is entirely necessary to achieve the project goals. The TPC for IceCube included the baseline contingency and was approved by the National Science Board prior to award. As long as the project is managed within the framework of the approved scope and budget, there is no expectation of significant leftover funding. Any changes in scope, or possible increases in the budget, require additional review and approval by the National Science Board prior to NSF's authorization for implementation.

This practice is in accordance with GAO's Cost Estimating and Assessment Guide (GAO09-03SP) – a reserve to manage the "known unknowns" in a project is part of the project budget and managed by the project manager. A review of eight major multi-user facility projects completed during the last five years (six MREFC projects and two slightly smaller projects) supports the assertion that total project costs and contingency budgets are conservatively estimated: six projects expended substantially all available funds and descoped to stay within budget, one project (IceCube) added contingent scope based on favorable cost performance, and one project (now completing) experienced an underrun. The unexpended budget will be retained by NSF for other use.

UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITEE ON RESEARCH AND RESEARCH AND SCIENCE EDUCATION
Hearing on
NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

March 8, 2012

Dr. Cora Marrett
Deputy Director
National Science Foundation

Questions for the Record Submitted by Mo Brooks

Questions for Dr. Marrett

1. **Aside from the construction and operations and maintenance costs associated with an MREFC, can NSF tell how much they are investing in actual research at an operational facility? In other words, once a facility is operational, how much additional investment is the US making in research at that facility or in using that piece of equipment? If you are not tracking this, why not?**

NSF does not systematically track all of the NSF-funded research associated with its facilities. NSF funds investigator-driven research and facility operations independently. NSF does not generally fund researchers to use specific NSF-supported facilities. Many users of NSF facilities do not receive NSF funding.

NSF does track the total research investment in each scientific field that utilizes these facilities. NSF also assesses the scientific productivity of its facilities, and their contributions to the accomplishments of the research communities they serve. Their opportunity costs are assessed regularly by Divisional and Directorate advisory committees, the National Science Board, and occasional National Academies studies. The amount of investment in research is only one of many measures that ultimately address the question of the balance between financial support for facilities and other uses of NSF funds.

NSF's facilities differ enormously in character: some (EarthScope, Institutes for Research in Seismology, and National Nanotechnology Information Network for example) collect very large amounts of data that are analyzed by tens of thousands of researchers who carry out this work without additional direct NSF support. In those cases, NSF tracks relevant metrics such as the number of times data are accessed, the number of distinct data users, and the number of scholarly publications citing this data. In astronomy (National Optical Astronomy Observatories, National Radio Astronomy Observatories, Arecibo Observatory, National Solar Observatory) at least 80% of the national facility users have no NSF financial support. For those facilities, NSF tracks the number of users and the amount of grant support for those receiving it[5]. Other facilities (the Academic Research Fleet, Integrated Ocean Drilling Program, for example) are utilized by researchers supported by NSF and by other agencies and foreign countries. (Funds to support operating costs are also contributed by NSF's partners.) The number of on-board research participants is tracked, but a more indicative measure of productivity is a consequence of the fact that samples collected during operations are distributed to thousands of additional researchers for analysis, and these researchers do not receive direct NSF support. A few facilities (the ATLAS and CMS detector collaborations at CERN's Large Hadron Collider, the Laser Interferometer Gravitational Wave Observatory, the IceCube Neutrino Observatory at the South Pole) are major science experiments, planned and built by the experimenters and their international partners, who are now acquiring and analyzing the data to further the experiment's goals. NSF tracks the research funding provided to the US participants, but the scientific productivity of the experimental activities is a consequence of the much larger community of collaborators involved.

2. **How many requests does NSF receive for MREFC projects annually? How many projects begin Horizon planning but go no further? How many are currently making it through the process from Horizon to Conceptual Design, from Conceptual Design to Preliminary Design, and from Preliminary Design to Final?**

   NSF receives, at most, a few initiatives each year that may eventually result in a future MREFC project. Since inception of the MREFC budget for funding large projects in 1995, about 50 projects in the Horizon category were discussed at the agency-wide level, and only nine emerged to become part of MREFC budget requests. [6] There is currently one project advancing towards a Conceptual Design and one project advancing from Conceptual Design to Preliminary Design. There are no projects currently in the Final Design stage.

3. **It is my understanding that the project sub-awardees are managed by the MREFC project, not by NSF, is this correct? How are those subawardees managed? Does NSF have any role in that relationship?**

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[5] For instance, in the field of astronomy, over 1500 individuals associated with US institutions are principal investigators (PIs) or co-PIs annually, on accepted observing proposals to NSF-funded ground-based astronomy facilities. Most of these investigators have no separate research support coming directly from NSF. Those who are supported generally receive awards for investigations that involve multiple threads; the typical NSF three-year astronomy grant may make use of data from NASA observatories, private optical observatories, foreign observatories, and new observations from NSF facilities, as well as including theoretical modeling. Because of the complexity involved in assigning fractional values to the different facilities, and the separate awards of observing time from the different facilities, award amounts for use of national facilities are not specifically tracked. In a typical year, ~30% of Directorate for Physical and Mathematical Sciences/Division of Astronomy (MPS/AST) research awardees make use of an MPS/AST facility for some portion of their work. This indicates an upper limit of ~$15M in annual awards associated with use of MPS/AST facilities, compared with ~$130M in annual operating costs for those facilities.

[6] Page 46, FY 2007 NSF Facility Plan, http://www.nsf.gov/pubs/2007/nsf0722/nsf0722.pdf.

That is correct. The financial award instrument used to fund the project explicitly states that the MREFC awardee is responsible for subawardee performance. Plans and capabilities to carry out subaward oversight are part of the scope of Final Design Review. NSF also approves subawards exceeding value thresholds as defined in the Cooperative Agreement. At Final Design Review, external assessment of acquisition strategy and the project's plan for subcontract oversight and subawardee monitoring is reviewed. Monthly project cost/schedule status reports and periodic external reviews keep NSF informed during construction.

Responses by Dr. Jose'-Marie Griffiths,
Chairman, Subcommittee on Facilities, National Science Board;
Vice President of Academic Affairs, Bryant University

Questions for the Record
The Honorable Mo Brooks and the Honorable Daniel Lipinski

House Committee on Science, Space, and Technology
Subcommittee on Research and Science Education

NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

Thursday, March 8, 2012
10:00 A.M.

Question for Dr. Griffiths:

Question 1: Why does NSF allow MREFC projects to expand their scope with any leftover funding rather than require them to return such funds to the agency to be weighed against other agency priorities? Does the NSB have any thoughts or concerns on this matter?

Answer: This question may be best answered by explaining how MREFC projects are planned and built. After calculating the risk-adjusted total cost, the contingency budget is set so as to cover the project risks that are likely to occur, but not so high as to result in a funding request that leads to any money being "leftover". Awardees then must manage the project by trading cost and scope while staying within the NSF "no cost overrun" requirement. In practice, this means that awardees plan their projects so that they can be de-scoped if necessary. The most critical components are built first, and if there are insufficient funds later in the project, other elements do not get built and the project's scientific scope is reduced.

If, however, the project proceeds as planned (without unlikely obstacles arising) everything can be built as originally scoped. But we must emphasize that this is not an expansion, nor does it mean that leftover money is being spent. The original project scope is a result of a thorough scientific, approval, and appropriations processes.

In summary, MREFC funding may only be applied toward aspects of a project that were part of the NSF and NSB approved project baseline. Any additions to this baseline --- an expansion of scope --- would require subsequent NSB approval. But if a project completes all of its originally scoped construction activities, and there are unexpended funds, NSF guidance states that these funds must be returned to the agency.

Questions for the Record
The Honorable Mo Brooks

House Committee on Science, Space, and Technology
Subcommittee on Research and Science Education

NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

Thursday, March 8, 2012
10:00 A.M.

Question for Dr. Griffiths:

Question 1: With regard to recompleting expiring awards, what does the Board consider to be "an appropriate time period" to bring a facility to "sustainable major operations" as you testified? Have all facilities that have met this threshold been recompeted?

Answer: The National Science Board issued a resolution establishing a recompetition principle in 2008. The principle applies to all NSF awards, not just major facilities. However, operation of large facilities is such a special case that it was addressed specifically in the Board resolution (NSB-08-12), which states:

> "... all expiring awards are to be recompeted, because rarely will it be in the best interest of U.S. science and engineering research and education not to do so. Furthermore, the Board endorsed a recompetition policy for major facility awards which is transparent to the research community such that after construction of major facilities is completed, followed by an appropriate time period to bring the facility to sustainable operations, full and open competition of the operations award will be required."

Following the adoption of this principle, it has become the Board's practice to include a requirement for recompetition at award end when granting authority for new large-facility awards. This enables awardees to plan their commitments and investments in a way that will enable recompetition without significantly threatening the sustainability of the asset.

Our modern, large scientific facilities involve multiple institutions and partners that play differing roles, contribute key resources and property, impose somewhat confining contracts and agreements, and depend on the facility to meet needs that cut across various timeframes. If a facility manager does not know in advance that all of these must be in synchrony at some specific point in time so that a recompetition can happen, the resulting entanglements make it extremely difficult to impose a date for recompetition without threatening the sustainability of the facility or its ability to meet its obligations. Thus, the Board handles the question of when recompetition should occur on a case-by-case basis for facilities that were already in place when the recompetition principle was approved. Finally, NSF's Business and Operations Advisory Committee is developing an implementation policy for recompetition of major, multi-user facilities for the Board's consideration. This policy will include lessons learned from previous recompetitions that can be applied to future recompetitions, to improve outcomes. The policy will help standardize recompetition policies and procedures and make it easier to ensure that recompetitions occur in the most fair and sustainable manner possible.

Questions for the Record
The Honorable Mo Brooks and the Honorable Daniel Lipinski

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

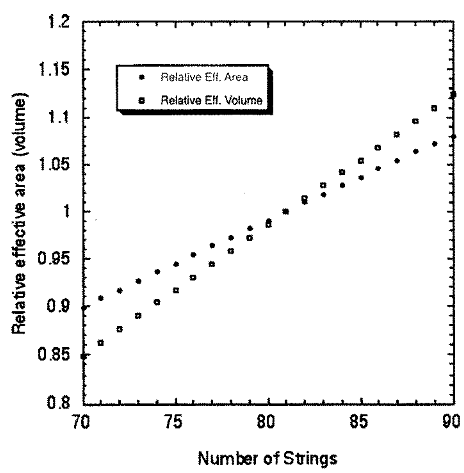
NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

Thursday, March 8, 2012
10:00 a.m.

QUESTIONS FOR MR. YECK

1. Understanding that you were working under a total project cost cap, what was the scientific basis for your decision to reduce from 80 to 70 deep ice cables when the contract for IceCube was being negotiated several years ago? You decide then you could eliminate 10 cables and still have a world class facility, so what were you giving up? When it became clear that you had sufficient funds left over, why was rescoping IceCube to 80 cables the right decision when balanced against other priorities, including funding research grants for IceCube users?

IceCube was designed as a discovery instrument with a wide range of science goals spanning a broad energy range, particle flavors and corresponding background rejection tools. The decision to define a minimum scope by reducing the IceCube construction project baseline from the 80 deep ice cables (strings) proposed to greater than or equal to 70 strings was informed by sensitivity analysis of the expected detector. The figure below was produced in 2004 in support of the decision-making process and shows the relative change of effective area (muons) and effective volume (cascades) at typical energies between 10 and 1000 TeV. The effective area is defined as the average geometric area for all directions. The effective volume is defined as the contained volume covered by strings. The graph and the following table of important detector parameters and science sensitivity describe the effects of a perturbation of ten strings relative to the nominal 80-string plan.



IceCube Detector Parameters and Performance Sensitivity

Number of strings	80	70 Change (%)	90 Change (%)
	Detector Parameters		
Effective area	1	-9	+9
Effective volume	1	-14	+14
Angular resolution	0.7°	-7	+7
	Science Sensitivity		
Point sources (E^{-2}, 3 years)	$E^2\Phi \leq 2.4 \cdot 10^{-9} cm^{-2} s^{-1} GeV$	-16	+16
Diffuse n_m (E^{-2}, 3 years)	$E^2\Phi \leq 4.2 \cdot 10^{-9} cm^{-2} s^{-1} sr^{-1} G$	-12	+12
GRB $\nu_{\mu, e, \tau}$	$\Phi(500 GRB) \leq 0.2 \cdot \Phi_{W/B}$	-10	+10
GRB ν_{μ}		-12	+12
WIMPs from sun		-20	+20
Cascades diffuse flux		-17	+17
Tau neutrino identification		harder	easier
Supernova sensitivity		-6	+6

The project strategy of reducing the minimum string commitment from 80 to ≥70 was never intended to be a permanent de-scope of the detector and did not require a re-optimization of the detector design. Project contingency was increased to enhance the probability of achieving a minimum of 70 strings and to create a path towards increasing the number of strings to the original goal of 80 strings, possibly more. This approach placed clear incentives on all parties to meet schedules, reduce costs, and to seek additional international financial support.

The process of restoring the ten cables to the scope was a gradual process over four years and was implemented in incremental steps following an approved baseline change control procedure. A minimum of three years is required to move from instrumentation procurement and production to a cable installed at the South Pole. UW-Madison and the Collaboration worked to restore the ten strings from the very beginning of the project with the understanding that this could only realistically be achieved while the IceCube MREFC project was actively drilling deep ice holes at South Pole. After the IceCube drilling program was completed the IceCube drill equipment was transferred to NSF and ultimately to other NSF sponsored projects.

The IceCube MREFC funding was optimized to deliver the optimum detector for a long-term research program. Research proposals submitted by U.S. university groups are funded under the NSF Research & Related Activities (R&RA) account and cannot be supported under the NSF MREFC account.

Responses by Mr. James H. Yeck, IceCube Project Director, University of Wisconsin-Madison

Questions for the Record
The Honorable Mo Brooks and the Honorable Daniel Lipinski

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND SCIENCE EDUCATION

NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

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10:00 a.m.

QUESTIONS FOR MR. YECK

1. It is my understanding that project sub-awardees are managed by the MREFC project, not NSF. How are those sub-awardees managed? Does NSF have any role in that relationship?

IceCube MREFC Project Sub-awardees are managed by the primary awardee, UW-Madison, with oversight by the NSF. UW-Madison manages the IceCube MREFC Project in accordance with an integrated multi-year construction project baseline plan approved by NSF. Prior to each Project Year (April 1 – March 31) the UW-Madison submits an annual Project Execution Plan (PEP) to the NSF for review and approval. The PEP submittals included the list of sub-awardees; and the scope of work, budget, schedule, and key personnel for each sub-award. This detailed information is taken directly from the integrated construction project baseline plan and the performance of each sub-awardee is measured against the approved plan. NSF approves significant changes to the plans, including the sub-awardees.

2. Will the change in Antarctic logistical support contractors from Raytheon to Lockheed Martin affect the IceCube closeout processes or operations and maintenance?

We do not expect any adverse impacts from the change in Antarctic logistical support contractors. The Raytheon logistic support effort for the IceCube MREFC project was completed during the last South Pole season and closeout activities are limited to determining the final actual costs and the subsequent validation of costs by the NSF.

Responses by Tony Beasley, COO/Project Manager, Neon, Inc.

neon
NATIONAL ECOLOGICAL OBSERVATORY NETWORK

June 12, 2012

Molly Keaton
US House of Representatives
Committee on Science, Space & Techonology
2321 Rayburn House Office Building
Washington DC
20515-6301.

Dear Molly,

Please find below the NEON response to the question posed by the committee:

QUESTION FOR DR. BEASLEY:

1. ***It is my understanding that project sub-awardees are managed by the MREFC project, not the NSF. How are those sub-awardees managed? Does NSF have any role in that relationship?***

Answer: Project sub-awardee management is a direct responsibility of the NEON project office, operating under sub-awardee management guidelines stipulated by the NSF in the cooperative agreement with NEON, Inc. (including approval thresholds), and following corporate sub-awardee monitoring and management guidelines. NSF is not involved in the direct day-to-day management of sub-awardees, but monitors their progress via reporting required by the MREFC program (e.g. earned value reporting) and NEON, Inc. corporate policies.

Sincerely,

Dr. Tony Beasley
NEON Project Manager

Responses by Dr. Tim Cowles, Vice President and Director, Ocean Observing, Consortium for Ocean Leadership

Cowles – follow-up to MREFC Hearing on March 8, 2012
(submitted April 15, 2012)

MREFC and the Ocean Observatories Initiative (OOI): Management of MREFC subawardees by the Consortium for Ocean Leadership

In response to the question from the Subcommittee:

How are the project subawardees managed? Does NSF have any role in that relationship?

ANSWER: As outlined in the written testimony for the hearing on March 8, major subawards were established in 2007 with the University of Washington, the University of California San Diego (UCSD), and the Woods Hole Oceanographic Institution. Rutgers, The State University of New Jersey, was added in 2011 as another major subawardee.

The Program Management Office of the OOI, within the Consortium for Ocean Leadership (COL), directly manages the subawardees under the authority of the Cooperative Agreement between COL and NSF. The Cooperative Agreement provides NSF with direct access to the subawardees, but principal management responsibility of the OOI is held by the awardee (COL). The terms and conditions of the parent Cooperative Agreement 'flow down' to each subawardee via the individual subawards. Under these terms, the OOI Program Management Office has authority and responsibility for the management and performance of the subawardee, and provides the NSF with monthly reports about financial and programmatic performance of each subawardee.

The OOI Program Management Office has assigned a Contracting Organization Technical Representative (COTR) to each major subaward. The COTR, under the supervision of the OOI Senior Project Manager, oversees the execution of work by the subawardee, validates that expenditures comply with the terms and conditions of the subaward, and checks that work performance is within the scope and schedule of the project baseline. The OOI Program Management Office, via the COTR, the Senior Project Manager, and the Director, interacts by telephone and/or in person multiple times per week with each subawardee. Weekly reports from each COTR are submitted in writing to the Senior Project Manager, and form the basis for both near-term and long-term management decisions and approaches. Compliance and performance issues with individual subawardees are addressed and resolved by the Program Management Office, in consultation with the NSF. In addition to these frequent direct awardee-subawardee interactions, the OOI Program Management Office conducts twice-weekly teleconferences that include all the managers from each of the subawardees in order to discuss and resolve cross-project issues and concerns.

The OOI Program Management Office has frequent (multiple times per week) teleconferences or in-person meetings with NSF about the progress of the MREFC project. These meetings include open discussions of any and all financial and programmatic issues or concerns with the OOI subawardees. The OOI Program Management Office benefits from a collaborative and transparent interaction with the NSF, and applies the resulting advice and guidance to make the management of the subawardees as effective and efficient as possible in order to complete the MREFC project within the approved budget and schedule.

Appendix II

Additional Material for the Record

ADDITIONAL RESPONSES FOR THE RECORD AS SUBMITTED BY
DR. CORA MARRETT, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

Testimony Insert #1 Page 44
Committee on Science, Space, and Technology
Subcommittee on Research and Science Education
March 8, 2012
NSF Major Research Equipment and Facilities Management: Ensuring Fiscal Responsibility and Accountability

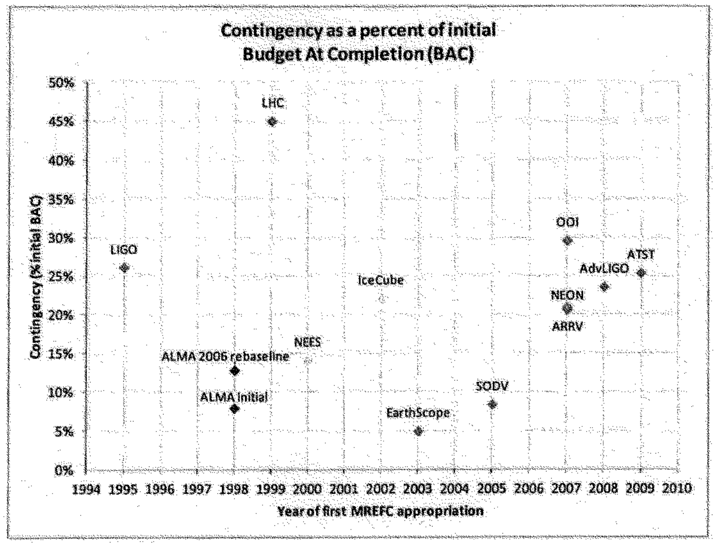
NSF does not require a predetermined level of contingency to be set for its supported projects. Contingency is instead determined on a project-by-project basis as part of the bottom-up risk and cost estimation process during preconstruction planning. Specifically, the final budget contingency is set at a level sufficient to cover the *ensemble risk across the project* that is evaluated to be highly likely to occur – i.e. necessitating that all of those contingency funds will likely need to be spent to complete the project. No additional arbitrary "extra" contingency is added into the budgets of NSF-sponsored projects.

The following table and figure provide contingency levels for current and historical MREFC projects where contingency was employed[1]. In the table and figure, the percentage of contingency for a project is expressed as the proportion of Contingency relative to the base budget (Budget at Completion, BAC), where BAC plus Contingency equals the Total Project Cost (TPC).

As the figure and table show, historical contingencies have ranged from 5-45% relative to the base budget. In the ten-year period prior to FY 2007, contingency levels were often set in the 10% or lower range. These low levels often proved to be insufficient, however, and consequently a number of those projects had to reduce scientific scope to avoid cost overruns. Subsequent enhancements to NSF's formal preconstruction planning processes, which are consistent with those used at other agencies and in industry, resulted in budget contingencies in the range of 20-30% relative to the base budget.

[1] Note: Contingency was also employed, at relatively low levels, for both the Gemini Observatory project and the South Pole Station Modernization project, but the specifics of their budget histories make it difficult to compare these cases to the other projects shown in the table and figure.

Facility	MREFC Approps First Fiscal Yr	MREFC Approps Final Fiscal Yr	Millions of dollars Total Project Cost as budgeted	Millions of dollars BAC at project start	Millions of dollars Contingency at project start	Contingency % (Cont/BAC)
Advanced Technology Solar Telescope (ATST)	2009	2017	$297.9	$237.7	$60.2	25.3%
National Ecological Observatory Network (NEON)	2007	2016	$433.8	$359.6	$74.2	20.6%
Ocean Observatories Initiative (OOI)	2007	2016	$386.4	$298.3	$88.1	29.5%
Advanced LIGO	2008	2014	$205.1	$166.1	$39.1	23.5%
Atacama Large Multimillimeter Array (ALMA) initial baseline	1998	2012	$344.4	$319.1	$25.2	7.9%
ALMA 2006 rebaseline	1998	2012	$499.3	$442.6	$56.6	12.8%
IceCube Neutrino Observatory	2002	2010	$242.1	$198.3	$43.8	22.1%
Alaska Region Research Vessel (ARRV)	2007	2009	$199.5	$165.0	$34.5	20.9%
EarthScope	2003	2008	$197.4	$188.2	$9.3	4.9%
Scientific Ocean Drilling Vessel (SODV)	2005	2007	$115.0	$106.1	$8.8	8.3%
Network for Earthquake Engineering Simulation (NEES)	2000	2004	$81.8	$71.7	$10.1	14.1%
Large Hadron Collider (LHC), NSF contribution (including ATLAS and CMS)	1999	2003	$80.9	$44.5	$36.4	45.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)	1995	1998	$272.5	$216.1	$56.4	26.1%


Contingency as a percent of initial
Budget At Completion (BAC)
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Contingency (% initial BAC)
LHC
LIGO
IceCube
OOI
ATST
AdvLIGO
NEON
ARRV
NEES
ALMA 2006 rebaseline
ALMA initial
SODV
EarthScope
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year of first MREFC appropriation

Testimony Insert #2 Page 45

As described in Dr. Marrett's testimony, NSF's MREFC process is rigorous and has many entry criteria, decision milestones, and "off ramps". Throughout NSF's history – including during the MREFC era, many early stage NSF horizon facility concepts have been contemplated; however, only a few highly-vetted projects have advanced into and through the MREFC process. Almost all of the others were terminated prior to conceptual design and development. Some of the scientific objectives were incorporated into other projects that did move forward, and in a few cases were implemented on a smaller scale with Research and Related Activities.

For high priority candidate MREFC projects, NSF invests heavily in preconstruction planning and oversight, particularly during the Preliminary and Final Design Stages. Only two NSF MREFC projects in those stages have failed to be completed successfully. The DUSEL project was terminated in FY 2010 by the National Science Board during the Preliminary Design Stage prior to the Preliminary Design Review. As Dr. Marrett stated at the hearing, the Rare Symmetry Violating Processes (RSVP) Project was terminated by NSF during the Final Design Stage prior to construction start, in FY 2005.

NSF policies on termination are stated in the 2005 NSF-NSB report, Setting Priorities for Large Facility Projects Sponsored by the National Science Foundation, NSB-05-77: "Individual large facility projects may be removed from the Readiness List due to insufficient priority over the long-term, failure of the plans to reach construction readiness, eclipse by other projects, collapse of major international agreements, or any other reason that the Director deems appropriate."

As Dr. Marrett described at the hearing and in her written testimony, NSF's collective experience with MREFC projects, including the above cancellations, have contributed to lessons learned that drive continual efforts to improve NSF's stewardship processes for large facilities.