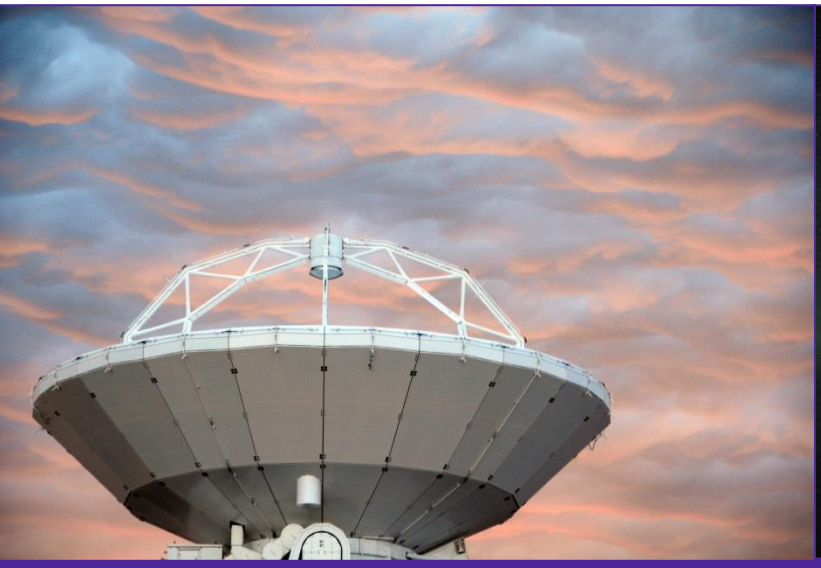
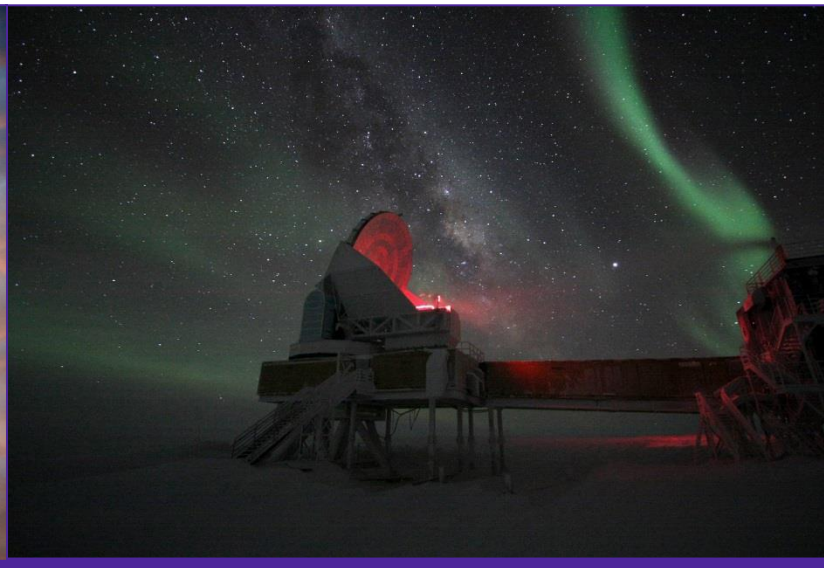
A Report by a Panel of the

NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

for the National Science Foundation

National Science Foundation: Use of Cooperative Agreements to Support Large Scale Investment in Research





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December 17, 2015

National Science Foundation: Use of Cooperative Agreements to Support Large Scale Investment in Research

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The views expressed in this report are those of the Panel. They do not necessarily reflect the views of the Academy as an institution.

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FOREWORD

The National Science Foundation (NSF) was established sixty-five years ago as an independent agency responsible for promoting the nation's progress in the fields of science, technology, engineering, and mathematics. Over the past fifty years, NSF has supported transformative scientific and engineering projects that have produced path-breaking discoveries and new technologies in such areas as molecular biology and geosciences, manufacturing, computer science, and nanotechnology. NSF-supported advances in these fields continue to keep the country at the leading edge of discovery, while also enhancing the social and economic growth of the nation.

To support the scientific and engineering enterprise, NSF frequently funds the development of large-scale, multiuser scientific facilities through federal assistance awards under "cooperative agreements" (CAs). The National Science Foundation Director and the National Science Board requested that the Academy review NSF's use of cooperative agreements (CAs) to support these state-of-the-art, large-scale research facilities. The Academy Panel and study team were asked to focus on NSF's largest CAs, totaling $100 million or more, funded under the Major Research Equipment and Facilities Construction (MREFC) account.

The Academy assembled an expert Panel comprised of five Fellows and one Panel member recommended by the Foundation to conduct the eight-month study, assessing NSF's use of CAs and identifying potential improvements to the agency's processes that support large-scale research facilities. The Panel conducted a comprehensive assessment with support from a professional study team. This report includes a series of Panel recommendations intended to support NSF's use of CAs and bolster the agency's current efforts to improve oversight and project management practices for large facility construction projects.

As a congressionally chartered non-partisan and non-profit organization with over 800 distinguished Fellows, the Academy brings seasoned experts together to help public organizations address their most critical challenges. We are pleased to have had the opportunity to assist NSF by conducting this review. I appreciate NSF management, Board leadership, and stakeholders who provided important insight and context needed to inform the study. Also, I thank the members of the Academy Panel, chaired by Earl Devaney, who provided invaluable expertise and thoughtful analysis to this effort, and the professional study team, led by Cynthia Heckmann, that provided critical support to the Panel.

Dan G. Blair
President and Chief Executive Officer
National Academy of Public Administration

ACRONYMS AND ABBREVIATIONS

A&O	Audit and Oversight
AAG	Award and Administration Guide
AOAM	Agency Operations and Award Management
ATST	Advanced Technical Solar Telescope
BFA	Budget, Finance, and Award Management
BOE	Basis of Estimate
BSR	Business Systems Review
CA	Cooperative Agreement
CAAR	Cost Analysis and Audit Resolution Branch
CDR	Conceptual Design Review
CEH	Committee on Education and Human Resources
CFO	Chief Financial Officer
CPP	Committee on Program and Plans
CPRD	Cost Proposal Review Document
CRS	Congressional Research Service
CSA	Cooperative Support Agreement
CSB	Committee on Strategy and Budget
DACS	Division of Acquisition and Cooperative Support
DARPA	Defense Advanced Research Projects Agency
DCAA	Defense Contract Audit Agency
DDLFP	Deputy Director for Large Facility Projects
DIAS	Division of Institution and Awards Support
DKIST	Daniel K. Inouye Solar Telescope
DoD	Department of Defense
DOE	Department of Energy
DRB	Director's Review Board
EC	Executive Committee
EHR	Education and Human Resources
EVM	Earned Value Management
FACA	Federal Advisory Committee Act
FAR	Federal Acquisition Regulation
FDR	Final Design Review
FFRDC	Federally Funded Research and Development Center
FRIB	Facility for Rare Isotope Beams
G/AO	Grants and Agreements Officer
GAO	Government Accountability Office
GPG	Grant Proposal Guide
GPRA-MA	Government Performance and Results Modernization Act
IPA	Intergovernmental Personnel Act
IPT	Integrated Project Team
JCL	Joint Cost and Schedule Confidence Level
LFM	Large Facilities Manual
LFO	Large Facilities Office
LFWG	Large Facilities Working Group

LSST	Large Synoptic Survey Telescope
MREFC	Major Research Equipment and Facilities Construction
NASA	National Aeronautics and Space Administration
NEON	National Ecological Observatory Network
NIH	National Institutes of Health
NRC	National Research Council
NSB	National Science Board
NSF	National Science Foundation
O&M	Operations and Maintenance
OIG	Office of Inspector General
OMB	Office of Management and Budget
OOI	Ocean Observatories Initiative
PAM	Proposal and Award Manual
PAO	Project Assessment Office
PAPPG	Proposal and Award Policies and Procedures Guide
PDR	Preliminary Design Review
PEP	Project Execution Plan
PMBOK	Project Management Body of Knowledge Guide
PO	Program Officer
R&RA	Research and Related Activities
SCF	Subcommittee on Facilities
SEI	Science and Engineering Indicators
SOG	Standard Operating Guidance
STEM	Science, Technology, Engineering, and Mathematics
WBS	Work Breakdown Structure

TABLE OF CONTENTS

EXECUTIVE SUMMARY

"It has been basic United States policy that Government should foster the opening of new frontiers. It opened the seas to clipper ships and furnished land for pioneers. Although these frontiers have more or less disappeared, the frontier of science remains. It is in keeping with the American tradition - one which has made the United States great - that new frontiers shall be made accessible for development by all American citizens."[1]

As World War II was drawing to a close, President Franklin D. Roosevelt desired to leverage the research and development process overseen by the Office of Scientific Research and Development (OSRD) for the war effort in a way that would continue to benefit the nation in times of peace. He turned to OSRD Director, Vannevar Bush, to provide guidance on what the federal government could do currently and in the future to aid research activities by public and private organizations. Bush's recommendations were featured in a report, *Science: The Endless Frontier,* describing publicly and privately supported colleges, universities, and research institutes as the centers of basic research and "the wellsprings of knowledge and understanding." The report asserted that "as long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere."

Vannevar Bush's report, along with the support of several committees advising President Harry S. Truman, following the death of President Roosevelt, led to the creation of a new and independent agency devoted solely "to the support of scientific research and advanced scientific education." In fact, Bush urged that scientific research should not be placed under an operating agency whose paramount concern is anything other than research because "research will always suffer when put in competition with operations." The National Science Foundation (NSF) was created as an independent agency to achieve this mission under the *National Science Foundation Act of 1950* (Public Law 81-507). As envisioned over sixty-five years ago, NSF continues to promote this mission in its strategic goal: "to transform the frontiers of science and engineering."[2]

State-of-the-art large facility construction projects are the highest profile efforts funded and supported by NSF and include the construction of such facilities as astronomical observatories, particle accelerators, and research vessels located worldwide. In addition to serving their primary purpose of supporting the scientific community, many of these projects have established the necessary infrastructure for other government agencies to achieve their

[1] *Science: The Endless Frontier* - A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945, Government Printing Office.
[2] National Science Foundation. *Investing in Science, Engineering, and Education for the Nation's Future: Strategic Plan for 2014-2018* (March 2014), p. 5.

missions, particularly with respect to national defense efforts.[3] NSF does not operate these facilities, but supports their development, construction and operation with federal awards that are funded through cooperative agreements (CAs). NSF currently administers 33 CAs for large facility construction or operations totaling $4.8 billion in obligations.[4] Of these, 26 CAs are for large research facilities whose construction totaled over $100 million each. As would be expected, these high dollar efforts are subject to significant attention from both the National Science Foundation Inspector General and Congress and have led to questions about the use of cooperative agreements to fund these projects and the adequacy of the management, oversight and accountability practices used to monitor them.

The NSF Director and the National Science Board (NSB) asked the National Academy of Public Administration (Academy) to review a number of issues related to findings in audits by the NSF Office of Inspector General (OIG), including NSF's cost surveillance approaches under CAs and the agency's oversight of contingency and management fee. Additional key considerations for this study came from recent congressional hearings and language removed from an earlier version of the America COMPETES Act of 2015 that would have codified a number of OIG recommendations.

The Academy Panel and study team focused on NSF's largest CAs of $100 million or more involving major research facility construction projects under the Major Research Equipment and Facilities Construction (MREFC) account and addressed issues highlighted in OIG audits as well as concerns raised during congressional oversight hearings.

The Academy Panel's findings and recommendations are presented throughout the report. Chapters 1 and 2 provide important background on the scope of the study and the organizational structure of NSF. Chapter 2 also highlights NSF's actions to date in response to OIG audit findings. Chapters 3 and 4 provide an overview of NSF policy and practices for cooperative agreements, contingency and management fee. Chapter 5 summarizes the results of a comparative analysis of NSF's project management processes and practices with those of comparator agencies—the U.S. Department of Energy, Office of Science and the National Aeronautics and Space Administration. Chapter 6 presents findings and recommendations on NSF and NSB governance and organizational issues.

Overall, the Academy Panel found that cooperative agreements are the appropriate mechanism to support the development of large-scale research facilities. The Panel also recognized the tremendous efforts NSF has undertaken over the past year to implement new policies and practices that respond to OIG and congressional concerns. It is clear that, in the past, NSF has prioritized the innovative scientific aspects of large facility construction projects; the agency now needs to apply equal emphasis on increased internal management of the business practices critical to enhanced oversight and project success. In doing so, the Panel believes that

[3] Interview Notes.
[4] Document provided by NSF, Awards over $50 million, 2015.

NSF and NSB will enhance the agency's ability to fulfill its mission of supporting groundbreaking science. The Panel's recommendations are intended to support NSF's and NSB's commitment to improving core business practices and NSF's key performance goal of ensuring program integrity and responsible stewardship of major research facilities.

Panel Recommendations

The specific recommendations below appear in chapters 3, 4, and 6.

To bolster NSF's ability to detect and address potential cost proposal issues prior to the release of award funds:

3.1 NSF should require that exceptions to the recommendations from pre-award cost analyses conducted by Cost Analysis and Audit Resolution, be reviewed by the Large Facilities Office and forwarded to the Chief Financial Officer for a final determination. The results of the CFO's decision should be documented in writing and shared with the Major Research Equipment and Facilities Construction (MREFC) Panel prior to the release of award funds.

To bolster internal controls for contingency by providing additional auditability and to incentivize project managers to use the funds judiciously:

4.1 NSF should retain control of a portion of an award recipient's contingency funds and distribute them with other incremental funds as needed.

To further strengthen NSF's policy on cost estimating and ensure rigor in the process:

4.2 NSF should change current language in the Large Facilities Manual so that it is clear that award recipients are expected to follow the guidance in the Government Accountability Office's Cost Estimating and Assessment Guide and Schedule Assessment Guide when developing cost and schedule estimates.

To eliminate the additional management burdens and potential for funding inappropriate expenses posed by management fee:

4.3 NSF should eliminate the practice of including management fee in cooperative agreements in future projects.

T*o improve transparency in how NSF and NSB work together to enable mission accomplishment and perform management oversight functions, and to clarify and codify roles, responsibilities, and working relationships:*

6.1 NSF and NSB should establish and publish a joint NSF-NSB duties and responsibilities document institutionalizing roles and addressing key working relationships.

To add more rigor to the process of reviewing MREFC project readiness and performance at varying stages:

6.2 NSF should re-scope the role/duties of the MREFC Panel and amend the Panel's charge to specifically include status update reviews of projects in the development and construction phases, focusing on cost, schedule, and performance.

To help ensure that external review panels include experts with the requisite knowledge and experience to assess cost and schedule estimates and project performance on large facilities projects:

6.3 NSF should identify requirements for project management and financial management expertise related to large facilities projects and explicitly add the requirements to the criteria for selection of external reviewers.

To provide the NSF Director direct access to independent project and cost estimating expertise for reviewing MREFC projects:

6.4 NSF should establish a Federal Advisory Committee Act (FACA) advisory committee for the Director to use as a sounding board for objective insight on large research projects.

To further build capacity in the Large Facilities Office and to clarify the role, authority and accountability of the Head of the Large Facilities Office on the MREFC Panel:

6.5 NSF Director should (1) authorize the LFO to hire two additional FTEs and (2) direct the MREFC Panel charter be revised changing the status of the LFO Head from a nonvoting member to a full member with voting rights.

To reassess the need for a separate Facility Plan and if validated, provide clarity on its: (1) purpose and uses, (2) target audience, and (3) key roles/responsibilities for its development:

6.6 NSF should evaluate how it develops and uses the NSF Facility Plan (processes, form and format) and how it aligns with the agency's current budget and strategic planning processes.

To develop and strengthen project management skill capabilities across the agency:

6.7 NSF should identify project management skill requirements by role and develop/implement required corollary role-specific project management training/workshops.

To ensure that award recipients have the requisite project management experience and knowledge to successfully lead a MREFC project:

6.8 NSF should require award recipient project managers be certified in project management. NSF should also specify the minimum project management experience thresholds for project positions in the programmatic terms and conditions of the cooperative agreement.

To facilitate project management knowledge sharing across the agency and with award recipients:

6.9 NSF should formally establish communities of practice to share best practices and implement a "lessons learned" requirement for all MREFC projects.

CHAPTER 1: INTRODUCTION

Unlocking the secrets of science and pushing forward the frontiers of innovation are the visionary goals that guide the National Science Foundation (NSF) in carrying out its mission. Created by the *National Science Foundation Act of 1950* (Public Law 81-507), the Foundation is an independent federal agency whose mission is to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure national defense; and for other purposes." The 1950 Act creating NSF also established a National Science Board (NSB) to set overall policies for the agency and advise the President and Congress on critical policy issues. Responsibility for day-to-day operations is vested in an appointed director who serves as the agency's chief executive officer. The statutory joint leadership authority and accountability are quite unique among federal agencies.

The Foundation funds discovery, learning, innovation and research infrastructure to boost U.S. leadership in all fields[5] of science, technology, engineering and mathematics (commonly referred to as STEM) research and all aspects of STEM education. Other federal agencies supporting research, such as the National Aeronautics and Space Administration (NASA), National Institutes of Health (NIH), Department of Energy (DOE), and Defense Advanced Research Projects Agency (DARPA) focus on specific agency missions. NSF's mission is broader and is dedicated to enabling science for the benefit of the nation as a whole. It is summed up succinctly in a far-reaching vision statement: "A nation that creates and exploits new concepts in science and engineering and provides global leadership in research and education."

To execute this ambitious vision, NSF supports fundamental research across STEM fields largely through grants and cooperative agreements—a form of assistance used when a project requires substantial agency involvement. With an annual budget of $7.3 billion in FY 2015, NSF is "the funding source for approximately 24 percent of all federally supported basic research conducted at America's colleges and universities,"[6] administering "grants and cooperative agreements to approximately 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the U.S."[7] It is the second largest source of federal funding for basic research. NSF also funds research infrastructure, such as advanced instrumentation and facilities that enable state-of-the-art research, and Arctic and Antarctic logistics and operations. With the exception of its research station on Summit, Greenland, and the U.S. Antarctic Program—each of which the agency administers through a prime logistics contract and through cost-reimbursable services from a number of government agencies—NSF does not operate its own research facilities.

[5] There is one exception—NSF does not fund medical sciences, but does fund biological sciences, NSF website, "What We Do."
[6] National Science Foundation website, "At a Glance."
[7] National Science Foundation, *Proposal and Award Policies and Procedures Guide*, NSF-15-1, (December 26, 2014).

NSF specifically seeks to support high-risk, potentially transformative projects that generate "pathbreaking discoveries and new technologies."[8] Among these transformative projects are large-scale, multiuser scientific facilities. NSF provides funding for the development, construction and operation of these facilities, referred to as Major Research Equipment and Facilities Construction (MREFC) projects, principally through cooperative agreements. MREFC projects are both high risk and high cost (generally $100 to $500 million for the construction and commissioning of the project)—and in turn, high visibility projects. They comprise a critical component of NSF's efforts which support the development of scientific research and education programs.

According to NSF officials, cooperative agreements have afforded the agency the flexibility necessary to deal with large, complex research facilities that require frequent interaction and to respond to the needs of the scientific community while also facilitating oversight. In a government-wide environment of tight budgets and increased scrutiny of federal expenditures, exercising effective oversight of MREFC projects presents a critical management challenge for the agency, given the complexity of the emerging science and the multiple players involved such as nonprofits representing consortiums of universities, other universities and government agencies and, often, international organizations.

Study Scope

The National Science Foundation Director and the National Science Board requested that the Academy review NSF's use of cooperative agreements (CAs) to support the development, construction, commissioning, and future operations of state-of-the-art, large-scale research facilities. NSF and NSB expressed their commitment to reviewing and improving core business practices in concert with the agency's strategic and performance goals as stated in the 2014-2018 NSF strategic plan.[9] "To ensure program integrity and responsible stewardship of major research facilities and infrastructure" is a key performance goal in that plan. Audit findings by the NSF Office of Inspector General (OIG), which identified weaknesses in NSF's cost surveillance approaches under CAs and the agency's oversight of contingency and management fees—together with congressional hearings and language (since removed) from the America COMPETES Act of 2015, which would have codified in statute a number of OIG recommendations—were also the key drivers for this study.

The Academy Panel and study team were asked to focus on NSF's largest CAs of $100 million or more involving major facility construction projects under the MREFC account and address both issues highlighted in OIG audits and concerns raised during congressional oversight hearings. Specifically, the Academy was asked to:

[8] National Science Foundation, "FY 2014 Performance and Financial Highlights."
[9] National Science Foundation, *Investing in Science, Engineering, and Education for the Nation's Future: Strategic Plan for 2014-2018* (March 2014).

- Address how CAs are currently used at NSF—including the effectiveness of NSF's current CA policies and the adequacy of accessibility to awardee records and documentation;
- Compare the CA mechanism with other federal funding mechanisms; and
- Identify potential improvements to the Foundation's processes that support large-scale research facilities.

The project was broken into two phases. Phase I focused on an assessment of the agency's use of CAs and the degree to which NSF was succeeding in its mission to support the scientific, educational, and other activities it sponsors. It included:

- Reviewing how NSF currently uses CAs and structures its management fees;
- Analyzing the legal and regulatory framework NSF and other agencies rely on for CAs;
- Evaluating how NSF's CA policy, procedures, and practices differed from other funding vehicles in terms of solicitation, administration, oversight, and financial oversight and auditability;
- Identifying when CAs may be the most appropriate mechanism for large-scale investments such as research facilities; and
- Reviewing the use of CAs in comparable federal agencies.

In Phase II, the focus shifted to assessing the feasibility of using other acquisition approaches to support large-scale investment, government oversight requirements and practices, recipient accountability, decision-making roles and responsibilities for key lifecycle phases (i.e., development, design, construction, operation, and termination), terms/conditions and policies/procedures, performance measures and auditability, and resource requirements including expertise and staffing implications. In addition, the Academy examined how much discretion the agency has in setting policy for the use of CAs and specifically how NSF can strengthen policies and practices for the award of contingency and management fee.

Results in Brief

NSF is an agency in transition. An exemplar agency in promoting basic research following what is often referred to as the "Gold Standard in Merit Review" for assessing the merits of the scientific research, the agency is in the midst of a culture change shifting to a more management-oriented focus in how research projects are administered to add corollary management rigor and ensure proper stewardship of federal funds. In response to OIG and congressional concerns, NSF has undertaken a wide range of actions to improve project management and oversight under cooperative agreements, by strengthening or adding specific requirements that at a minimum, address the spirit, if not the letter, of previous recommendations. Additional actions are underway or planned; however, OIG has recently raised or reemphasized concerns in certain areas. The Academy Panel has reviewed these concerns and offers recommendations and options to address those concerns—in particular, in the areas of contingency and management fee where oversight can be further strengthened.

Overall, the Academy Panel found that cooperative agreements are the appropriate mechanism to support large-scale research facilities. The mechanism is specifically designed to allow for

substantial involvement on the part of the federal agency—and substantial involvement includes oversight. The critical success factor for these types of projects is the project management discipline—and the rigor of review processes—in place along with the capacity and capability of a skilled workforce to carry out and oversee project management responsibilities. The Panel's analysis of comparator agencies provides lessons learned and identifies practices that can be adopted by NSF. In addition, the Panel has identified NSF and NSB governance issues—in terms of both structure and practices—and offers a number of suggestions for strengthening agency management practices. NSF and NSB have considerable discretion in setting policy for the use of CAs.

The government-wide environment today is one of tight budgets and intensified oversight, a condition that is not likely to change in the near future. The agency will need to make some hard funding decisions that address the demand for more rigorous accountability systems balanced against the mission to advance science. In the long run, one does not necessarily have to be at the expense of the other—but there are likely to be short-term impacts as changes are implemented and institutionalized across the science community.

Methodology

The Academy assembled an expert Panel comprising five Fellows and one panel member recommended by the Foundation, with broad federal, executive leadership, and academic experience and knowledge in financial management, acquisition management, risk management, project management, accountability mechanisms and scientific inquiry, as well as experience or familiarity with the National Science Foundation and other federal science agencies that promote research. The Academy Panel provided ongoing guidance to a study team of six who carried out the review based on a structured methodology.

The study team performed extensive research in the form of both primary and secondary data collection and analysis. Specifically, the Academy study team examined NSF's use of cooperative agreements, reviewing relevant statutes, regulations and any pending legislation; Inspector General reports addressing CAs; previous internal and external studies on large facilities construction projects; and NSF internal and external guidance on CAs and other procurement and organizational documents/materials including NSF standard operating guides (SOGs). In addition, the study team collected and analyzed government-wide guidance from the Office of Management and Budget (OMB) such as OMB Circular A-11 and the Uniform Guidance, Government Accountability Office (GAO) best practice guides on cost and schedule estimating for large capital projects and relevant audit reports, and records of congressional hearings and other documents that shed light on past congressional activity with respect to NSF's use of CAs. The team also performed a literature search and examined related materials on procurement, CAs, project management and earned value management (EVM). And, the study team reviewed documents and guidance from benchmark/comparable agencies including the National Aeronautics and Space Administration (NASA), Department of Energy (DOE), and Department of Defense (DoD) to glean lessons learned and practices that might be instructive and transferable to NSF.

The study team conducted structured interviews with NSF management and NSB leadership and with other key stakeholders including award recipient organizations and experts from across the government including representatives of the central management/oversight agencies and representatives from other federal agencies who fund large-scale research projects. All interviews were conducted on a not-for-attribution basis. In identifying key findings and developing recommendations aimed at improving processes that support large-scale research facilities, the study team also looked at management/reporting structures in agencies that similarly operate with a board that sets policy and oversees the agency and where the board has been identified as the "head of agency" (with the Office of Inspector General reporting to it) for management practices that might be helpful.

CHAPTER 2: BACKGROUND

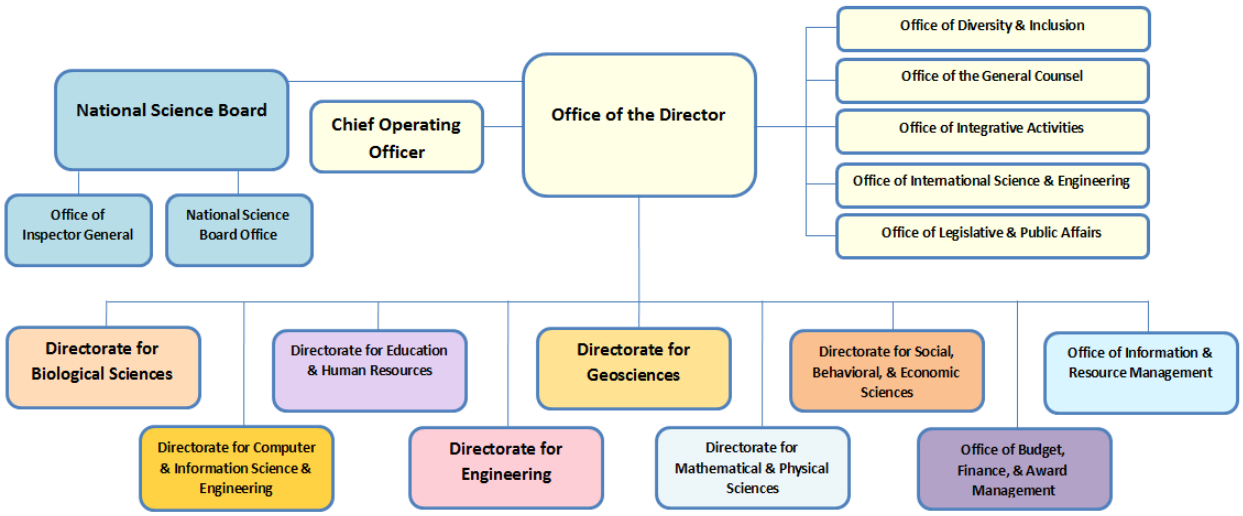
The National Science Foundation holds a rather unique position among federal science agencies. The 1950 Organic Act establishing the agency created an independent agency—NSF—that promotes and supports (nonmedical) fundamental research and education across all fields of science and engineering, and a National Science Board as the independent governing body that oversees the agency and advises the President and the Congress on critical science policy issues. A presidentially appointed director serves as the agency's chief executive officer while a Board, whose members are also appointed by the President, is responsible for setting overall policies and approving the agency's budget. This unique joint leadership authority was crafted in part to insulate science and engineering from politics.[10]

NSF was born out of the desire to have partnerships between the federal government and research institutions to advance the frontiers of science—which was, in turn, influenced by the nation's experience with the tremendous contributions of scientific research during World War II. An earlier legislative bill in 1947 to establish a board-controlled science foundation, whose members would represent the science community and not be "otherwise connected to government" and would appoint the agency head—much like a traditional board of directors—was passed by Congress but vetoed by President Truman. That legislation was crafted based on recommendations in a report originally commissioned by President Roosevelt, *Science: The Endless Frontier*.[11] President Truman, however, felt that a central science agency should have a single director accountable to the President—an agency responsible for the expenditure of public funds needed to be part of the "regular machinery of government."[12] The compromise bill signed into law on May 10, 1950—the National Science Foundation Act of 1950—established the structure NSF essentially has today with both a presidentially appointed director and a board serving for six year terms. Fittingly, among NSF's core values are a commitment to:

- *Scientific Excellence* – engaging the vision and expertise of staff with that of the scientific community to create a portfolio of awards that support transformation and innovation.
- *Accountability for Public Benefit* – operating with integrity and transparency and maintaining the highest standards of performance in administration, business processes, management, and oversight, thereby providing the best value to the U.S. taxpayer.

[10] Gonzalez, Heather, Congressional Research Service, *The National Science Foundation: Background and Selected Policy Issues*, Summary (June 5, 2014).
[11] National Science Board, "*The National Science Board: A History in Highlights 1950-2000.*"
[12] Ibid.

Current Organizational Structures



National Science Foundation

NSF is comprised of the Office of the Director; seven science, engineering, and education directorates; five staff offices; and two administrative support offices. The Office of the Director includes the Director and Chief Operating Officer along with several senior advisors who perform a variety of roles including representing the Office on various internal committees. A Deputy Director position is currently vacant; the Chief Operating Officer, who was recently nominated by the President for the Deputy Director position, essentially carries out that role. Both the Director and Deputy positions are presidential appointments requiring Senate confirmation.

With its seven science directorates—together with subordinate divisions/offices—NSF is organizationally structured much like a university; the directorates align with various academic disciplines and fields of science, engineering, and education and report to the NSF Director. The directorates are:

- Biological Sciences
- Computer and Information Science and Engineering
- Education and Human Resources
- Engineering
- Geosciences
- Mathematical and Physical Sciences
- Social, Behavioral, and Economic Sciences

Each directorate is led by an assistant director who is typically a rotator, i.e., a scientist usually from academia on a 4-year appointment under the Intergovernmental Personnel Act (IPA). Program divisions and offices within the directorates are responsible for the scientific, technical, and programmatic review and evaluation of proposals and for recommending proposals for approval. A designated NSF program officer, considered a subject matter expert,

monitors the scientific, engineering and/or educational aspects of an award. They typically report to an NSF division director who is responsible for long-range planning, contributing to the achievement of NSF strategic goals and objectives; providing stewardship for budgetary and other resources; and overseeing merit review of proposals and the award process. In addition, expert advisors from the scientific and engineering communities assist the agency in evaluating proposals through participation in review or advisory committees or as ad hoc proposal reviewers. Program officers and division directors may or may not be rotators. However, for Major Research Equipment and Facilities Construction (MREFC) projects (high risk, high cost projects between $100 to $500 million), program officers must be federal employees.

NSF's staff offices—Office of the General Counsel, Office of Integrative Activities, Office of Legislative and Public Affairs, Office of Diversity and Inclusion, and Office of International Science and Engineering—and administrative offices—Office of Budget, Finance and Award Management (BFA) and Office of Information and Resource Management—provide critical services to the science, engineering, and education directorates, as well as NSF leadership, in carrying out the agency's mission. Of these offices, BFA and its subordinate units play a particularly critical role in the development, evaluation, funds approval and oversight of cooperative agreements. Those units with salient roles for MREFC projects include:

- Division of Acquisition and Cooperative Support (DACS): DACS is responsible for the solicitation, negotiation, and administration of complex cooperative agreements and contracts for NSF research facilities and programs. DACS also oversees NSF procurement systems, contracts policy, processes, and guidance.[13]
    - Cooperative Support Branch: The Cooperative Support Branch is responsible for the award and administration of cooperative agreements for NSF research facilities, research tools, and selected science, technology, and education center programs.[14]
- Division of Institution and Awards Support (DIAS): DIAS is responsible for providing financial and administrative assistance to awardees to enable the effective stewardship of federal funds awarded by NSF to support science, technology, and engineering research.[15]
    - Cost Analysis and Audit Resolution Branch (CAAR): CAAR performs several types of pre-award and post-award cost reviews to ensure that awardees are able to effectively administer NSF-awarded funds.[16]
    - Policy Office: The Policy Office is responsible for developing, implementing, and issuing proposal and award policy for NSF programs.[17]

[13] National Science Foundation Website: http://www.nsf.gov/bfa/dcca/index.jsp.
[14] National Science Foundation Website: http://www.nsf.gov/bfa/dcca/cao/index.jsp.
[15] National Science Foundation Website: http://www.nsf.gov/bfa/dias/.
[16] For a complete list and description of the various types of pre-award and post-award reviews conducted by CAAR, please see: http://www.nsf.gov/bfa/dias/caar/index.jsp.
[17] National Science Foundation Website: http://www.nsf.gov/bfa/dias/policy/index.jsp.

- Large Facilities Office (LFO): LFO is NSF's primary resource for all policy or process issues related to the development, implementation, and oversight of MREFC projects and serves as a project management resource for NSF.[18]

National Science Board

NSB comprises 25 members, including the NSF Director (an ex officio voting member), and is led by a Chair and Vice Chair elected by the members. Appointments are staggered so that one-third of the Board is appointed every two years; members' appointments may be renewed for a second 6-year term. The Board generally meets four to five times a year. The Chair has the authority to appoint NSB staff, and the "NSB Office" is headed by a Board Executive Officer.

Members are selected on the basis of their distinguished service in science and engineering and are eminent in their particular field of research or education. They are drawn from universities and industry—the vast majority are from academia—and represent a variety of geographic areas in addition to STEM disciplines. As a part-time Board, responsibilities are ancillary for members who retain their full-time employment.

NSB identifies issues critical to NSF's future, approves NSF's strategic budget direction, approves annual budget submissions to the Office of Management and Budget, ensures balance between initiatives and core programs, and approves new major programs and awards. In 1988, amendments to the Inspector General Act of 1978 established the NSF Inspector General and assigned responsibility for appointing and supervising the Inspector General to NSB as the "head" of the agency. In 2002, Congress gave NSB increased authorities to appoint its own staff, manage its own budget, and approve projects funded out of the MREFC account.

Most of the work of the Board is carried out through standing committees and subcommittees, task forces and ad hoc committees. There are currently six standing committees; those pertinent to this study include:

- Executive Committee: During the interim period between Board meetings, the Executive Committee acts on behalf of the Board on grants, contracts, or other arrangements and other instances where an immediate decision is required, exercising any functions as delegated by the Board.[19]
- Audit and Oversight (A&O): A&O has three main functions: 1) general supervision of the NSF Inspector General, as delegated by the Board; 2) oversight of major agency administrative processes and principal administrative systems; and 3) informing the Board of problems in the administration of NSF programs and operations, and any need for corrective action.[20]

[18] National Science Foundation Website: http://www.nsf.gov/bfa/lfo/index.jsp.
[19] National Science Foundation Website: https://www.nsf.gov/nsb/committees/execcmte.jsp. Members of the Executive Committee include the NSF Director, who serves as Chair, and four other elected members from the Board.
[20] National Science Foundation Website: https://www.nsf.gov/nsb/committees/auditcmt.jsp.

- Committee on Program and Plans (CPP): CPP provides oversight, guidance, and advice on major policy, process, and operational issues related to NSF's research portfolio—including the formulation of programs, large awards, MREFC projects,[21] and polar programs. CPP regularly engages in strategic planning discussions in addition to reviewing and approving large awards.[22]
- Committee on Strategy and Budget (CSB): CSB advises on NSF strategic direction and regularly reviews budget submissions and strategic plans.[23] CSB analyzes NSF's budget and strategic plans to ensure alignment with the agency's long-term objectives.

Of the five existing NSB subcommittees, task forces, or ad hoc committees, two have a specific role in MREFC projects:

- Subcommittee on Facilities (SCF), Committee on Strategy and Budget: The SCF assists the Board in strategic budget planning for NSF's research equipment and facilities portfolio. SCF supports NSB decision-making and strategic planning through an annual review of the research equipment and facilities portfolio.[24]
- Ad Hoc Task Force on National Ecological Observatory Network (NEON) Performance and Plans: The Ad Hoc Task Force on NEON Performance and Plans is a new task force established in response to cost and performance issues raised by the Inspector General and Congress on the NEON Project. The Task Force is charged with overseeing and monitoring NEON-related activities and materials in conjunction with NSF leadership, offices, boards, and committees; it does not serve as a decision-making body.[25]

Strategic Goals

The National Science Foundation has identified three strategic goals[26] in its current 2014-2018 strategic plan that guide the agency in carrying out its mission.

1. Transform the frontiers of science and engineering;
2. Stimulate innovation and address societal needs through research and education; and
3. Excel as a federal science agency.

[21] CPP has the "primary responsibility for the Board's statutory obligations to approve the MREFC projects and their priority." https://www.nsf.gov/nsb/committees/cppcmte.jsp.
[22] National Science Foundation Website: https://www.nsf.gov/nsb/committees/cppcmte.jsp.
[23] National Science Foundation Website: https://www.nsf.gov/nsb/committees/stratcmt.jsp.
[24] National Science Foundation Website: https://www.nsf.gov/nsb/committees/subcom_scf.jsp.
[25] "The Task Force does not serve the role of approving or denying NSF actions, or making decisions on behalf of the Board, and will exist until discharged by the Board Chair." https://www.nsf.gov/nsb/committees/tskforce_neon.jsp.
[26] National Science Foundation, *Investing in Science, Engineering, and Education for the Nation's Future: Strategic Plan for 2014 – 2018* (March 2014), p. 5.

The first two goals, as articulated in the strategic plan, represent the dual nature of NSF's mission—advancing the progress of science while benefitting the nation—and reflect the primary means by which NSF ensures the preeminence of the research and development (R&D) enterprise that is essential to the nation's future. The third goal, to "excel as a federal science agency," is management-focused and directs NSF to hold itself accountable for achieving excellence in how it carries out its mission. NSF's policies and procedures maintain an open system of competition that identifies and enables pursuit of the most promising ideas for major scientific and engineering advances. Each strategic goal is supported by strategic objectives, performance goals—including designation of agency priority goals consistent with the Government Performance and Results Modernization Act of 2010—and performance indicators.

Strategic Objectives**:** Each strategic goal has specific strategic objectives. The following goals and objectives are relevant to MREFC projects and the agency's use of cooperative agreements.

- Strategic Goal 1: Transform the Frontiers of Science and Engineering
  - *Strategic Objective 3*: Provide world-class research infrastructure to enable major scientific advances.

Infrastructure projects are expected to meet extremely high standards of scientific merit and broader impacts, along with comparable standards of project planning and execution. NSF recently undertook a number of actions, including an update to the Large Facilities Manual (LFM) which delineates NSF policy on planning and managing large facilities, and clarified project roles and responsibilities, in an effort to strengthen procedures and practices related to managing large facilities projects under this objective.

- Strategic Goal 3: Excel as a Federal Science Agency
  - *Strategic Objective 2*: Use effective methods and innovative solutions to achieve excellence in accomplishing the agency's mission.

NSF is addressing management challenges identified by the Inspector General related to the construction and operation of large research infrastructure projects under this goal/objective. The key pertinent management challenge is "establishing accountability over large cooperative agreements."

Performance Goals**:**[27] Further cascading from NSF's strategic goals and objectives are ten performance goals and three agency priority goals. While agency priority goals do not directly track to large research facilities construction projects, there is a key relevant performance goal:

- Research Infrastructure Investments: Ensure program integrity and responsible stewardship of major research facilities and infrastructure.

[27] National Science Foundation, *FY 2014 Performance and Financial Highlights*, (February 2015), p. 4.

NSF has reportedly tracked the performance of its construction projects as a performance goal for over a decade. The FY 2014 performance report cites that the target measures were achieved—five of five MREFC projects under construction that were over 10 percent complete, were within the goal of keeping cost and schedule variance at or below 10 percent. Evaluation was based on data from the projects' earned value management (EVM) systems used to monitor cost and schedule performance. The target was similarly met in FY 2011, but not in FY 2010, 2012, or 2013. The agency updated its performance goals for FY 2015 and 2016, but did not change the goal statement and targets for major research facilities and infrastructure.

Budget

The NSF budget consists of four NSF specific accounts—Research and Related Activities (R&RA), Education and Human Resources (EHR), Major Research Equipment and Facilities Construction (MREFC), and Agency Operations and Award Management (AOAM)—and separate line-item accounts for the National Science Board and the Office of the Inspector General. The total appropriation for FY 2015 was $7,344 million and the estimate for FY 2016 is $7,724 million. The following NSF table provides a breakout of the agency's budget by appropriation.

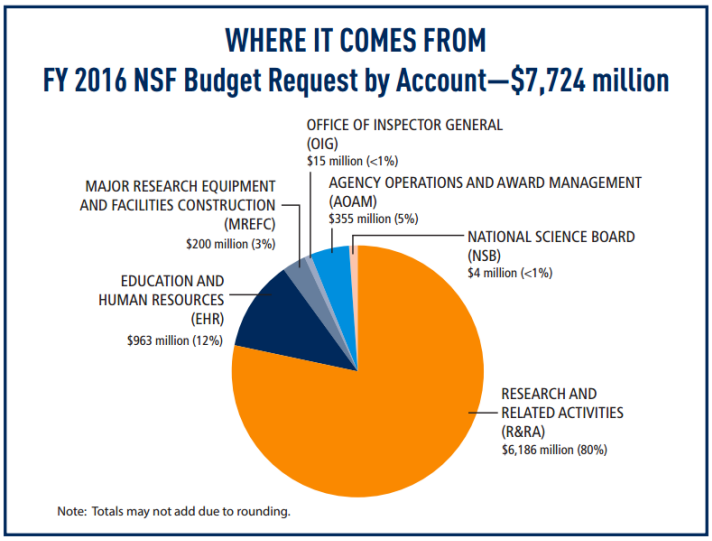
National Science Foundation
Summary Table
FY 2016 Request to Congress
(Dollars in Millions)

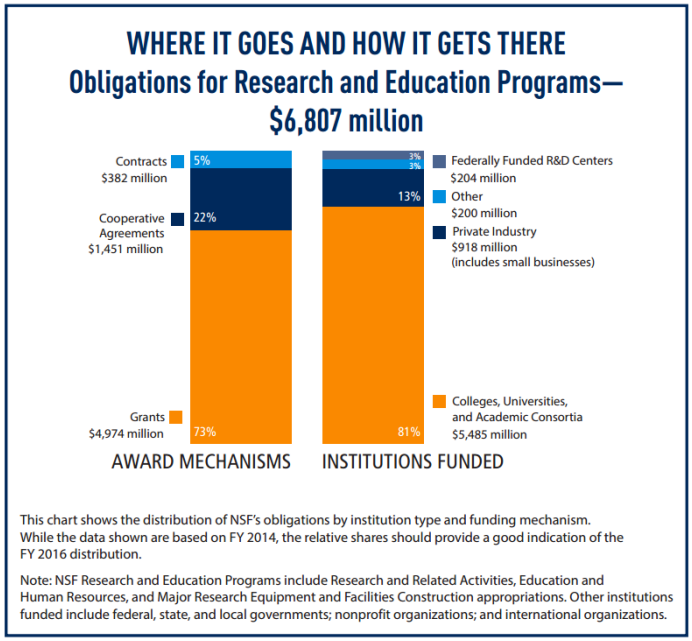
NSF by Account	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request over: FY 2014 Actual Amount	FY 2014 Actual Percent	FY 2015 Estimate Amount	FY 2015 Estimate Percent
BIO	$720.84	$731.03	$747.92	$27.08	3.8%	$16.89	2.3%
CISE	892.60	921.73	954.41	61.81	6.9%	32.68	3.5%
ENG	833.12	892.31	949.22	116.10	13.9%	56.91	6.4%
Eng Programs	*673.13*	*715.20*	*754.86*	*81.73*	*12.1%*	*39.66*	*5.5%*
SBIR/STTR	*159.99*	*177.11*	*194.36*	*34.37*	*21.5%*	*17.25*	*9.7%*
GEO	1,321.32	1,304.39	1,365.41	44.09	3.3%	61.02	4.7%
MPS	1,267.86	1,336.72	1,366.23	98.37	7.8%	29.51	2.2%
SBE	256.84	272.20	291.46	34.62	13.5%	19.26	7.1%
OISE[1]	48.31	48.52	51.02	2.71	5.6%	2.50	5.2%
IA[1]	433.12	425.34	459.15	26.03	6.0%	33.81	7.9%
U.S. Arctic Research Commission	1.30	1.41	1.48	0.18	13.5%	0.07	5.0%
Research & Related Activities	**$5,775.32**	**$5,933.65**	**$6,186.30**	**$410.98**	**7.1%**	**$252.66**	**4.3%**
Education & Human Resources	**$832.02**	**$866.00**	**$962.57**	**$130.55**	**15.7%**	**$96.57**	**11.2%**
Major Research Equipment and Facilities Construction	**$200.00**	**$200.76**	**$200.31**	**$0.31**	**0.2%**	**-$0.45**	**-0.2%**
Agency Operations and Award Management	**$305.95**	**$325.00**	**$354.84**	**$48.89**	**16.0%**	**$29.84**	**9.2%**
National Science Board	**$4.25**	**$4.37**	**$4.37**	**$0.12**	**2.8%**	**-**	**-**
Office of Inspector General	**$13.84**	**$14.43**	**$15.16**	**$1.32**	**9.5%**	**$0.73**	**5.1%**
Total, NSF	**$7,131.39**	**$7,344.21**	**$7,723.55**	**$592.16**	**8.3%**	**$379.34**	**5.2%**

Totals may not add due to rounding.

[1] This table reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering (OISE) and Integrative Activities (IA) as separate budget activities. All data are presented in the FY 2015 structure for comparability.

How those dollars break out by funding is illustrated in the two charts below.





MREFC Account Projects

MREFC projects—major research facilities and equipment that provide unique capabilities at the frontiers of science and engineering—are supported principally by two funding accounts: (1) the MREFC account supports acquisition, construction, and commissioning and (2) the Research and Related Activities (R&RA) account funds initial planning, post-construction operations, and maintenance.

The MREFC account is an agency-wide account created in 1995 with Congressional approval. It provides funding to support major science and engineering infrastructure projects that would exceed 10 percent of a science directorate's annual budget, or roughly $100 million or greater. It is intended to prevent large periodic obligations from distorting the budgets of NSF directorates and program offices and ensure availability of resources to complete large projects that are funded over several years. The MREFC account represented 2.9 percent of NSF's FY 2014 appropriation. Estimates for FY 2015 and FY 2016 are 2.7 percent and 2.6 percent, respectively, of NSF's total budget.

NSF currently administers 33 CAs for facility construction projects or operating facilities over $50 million each, totaling $4.8 billion in obligations.[28] Of these, 26 CAs are for large research facilities over $100 million; the majority of these CAs fund operating facilities. Facilities range from research vessels to astronomical observatories, particle accelerators, and seismic observatories, among others. NSF does not construct or operate the facilities directly, but

[28] Document provided by NSF, Awards over $50 million, 2015.

retains oversight responsibilities. Projects funded through a cooperative agreement and currently in the construction phase during FY 2015 and FY 2016 include:

- Daniel K. Inouye Solar Telescope (DKIST);
- Large Synoptic Survey Telescope (LSST); and
- National Ecological Observatory Network (NEON)

The MREFC appropriation provides a separate budget account for each major research equipment and facilities project in construction. Once the construction award is established, no other funding can be commingled with the MREFC funds. Operating funds for large facilities are funded under a separate award, and the recipient/awardee is required to segregate MREFC from operations accounts to avoid the commingling of MREFC funds with other appropriations under NSF assistance awards. Separate cooperative support agreements with specific terms and conditions are issued for facility construction and operations activities.[29]

NSF's Response to Inspector General Concerns

The NSF Office of Inspector General (OIG) has issued a number of audit reports, alert memos and audit escalation memorandums, as well as testified at Congressional hearings, on NSF's oversight and accountability practices for managing large research facility construction projects under cooperative agreements. OIG has stressed the importance of strong cost surveillance controls over the lifecycle of high-risk, high-dollar projects. In fact, this was one of six major management challenges that OIG identified in its annual statement to NSF and NSB for FY 2015.[30] Specifically, OIG underscored NSF's need to: (1) strengthen the proposal review process; (2) enhance post-award cost surveillance mechanisms; (3) improve policy on development, use and management of budget contingency; and (4) develop a more robust control environment for management fee.

NSF has undertaken an ambitious approach to address concerns in these four areas by initiating and implementing a wide range of actions within the past year. (See **Table 2.1** for additional detail.) OIG has acknowledged NSF's progress in improving policies and practices for large facility construction projects, but continues to identify areas that can be further strengthened. After careful review of these recent initiatives and actions, the Panel believes that they are a step in the right direction and has provided additional recommendations throughout this report to further bolster NSF's efforts to improve oversight and project management practices.

[29] National Science Foundation*, Proposal and Award Policies and Procedures Guide*, NSF-15-1, (December 26, 2014).

[30] National Science Foundation, OIG Memorandum to Dr. Dan Arvizu, NSB Chair and Dr. France Córdova, NSF Director, "Management Challenges for NSF in FY 2015," October 23, 2014.

TABLE 2.1 NSF OIG CONCERNS AND RECOMMENDATIONS AND CORRESPONDING NSF ACTIONS

Proposal Review
OIG Concern NSF's review of proposals for large facility projects is not adequate. OIG audits found: 1) a large amount of unallowable or unsupported costs in project proposals; and 2) some awardees' accounting systems were not sufficient to manage large CA projects. OIG Recommendation Obtain updated cost estimates and audits of award recipient's proposed budget and accounting system/practices at the pre-award stage for CAs valued at more than $50 million, although OIG is open to a dollar threshold greater than $50 million. OIG would also support the use of an independent cost estimate instead of a proposal audit for awards that exceed the threshold. NSF Completed Actions: • NSF has revised its Large Facilities Manual (LFM) to strengthen procedures for analysis of awardee cost proposals for large facility construction and operations to include the following provisions: — Use one of the following methods to review a proposer's cost estimate (in addition to existing internal and external reviews): o an independent audit of proposed costs (e.g., through the Defense Contract Audit Agency, DCAA) o previously developed audit information o one of GAO's "eight types of independent cost estimate reviews" to help determine whether the estimate is well documented, comprehensive, accurate, and credible o projection of the organization's cost trends for elements of cost based on current and historical cost information o an NSF cost analysis following each stage-gate review during the project's design stage (see below) • NSF's internal standard operating guidance (SOG), issued June 30, 2014 and updated on September 15, 2015, includes the requirement to ensure the adequacy of large facilities' accounting systems prior to entering construction or operations CAs, including whether an audit is necessary based on review of available information. The SOG also contains a requirement to coordinate with the Cognizant Federal Agency Official (CFAO) responsible for CAS administration when required.[31] — *Cost Proposal Review Document*s (CPRDs) will be developed to ensure full documentation of the agency's review of proposals and awardees' accounting systems. CRPDs will address all elements of cost as well as other pre-award determinations necessary to determine that the organization is eligible for the award, including that the organization has an adequate accounting system. • NSF will now require audits of awardees' accounting systems/practices before the award is made for CAs valued at $100 million or more (if NSF is the cognizant agency and if such an audit has not been performed within the past two years).[32]

[31] National Science Foundation, "Process Improvement Plan: FY 2014 Financial Statement Audit Report," p. 9.
[32] National Science Foundation, DACS SOG BFA 2015-2, "CBS Standardized Cost Analysis Guidance," Section 6.12, September 15, 2015.

Post-Award Processes

OIG Concern

NSF does not have adequate financial reporting requirements to ensure effective cost surveillance for large facility projects.

OIG Recommendation

- NSF should require annual incurred cost submissions and incurred cost audits for CAs totaling $50 million or more (OIG is willing to consider a higher dollar threshold).
- NSF and OIG should be able to access information needed for adequate oversight of these projects after an award has been made.

NSF Completed Actions

- NSF will use risk analysis to determine whether it is necessary to obtain incurred cost audits on a project-by-project basis.
- "Internal Management Plans" for large facility projects should now include: 1) post-award cost monitoring activities; and 2) an analysis of the need for annual incurred cost audits, as well as testing of an awardee's accounting system.
- NSF will now conduct, at a minimum, a final review of incurred costs at project completion for large facility construction projects in excess of $100 million. NSF will also complete an annual review of awards over $100 million to determine if an incurred cost audit may be necessary during performance based on risk.
- NSF prepared a policy on project cost book preparation and revised LFM draft sections 4.2.1 through 4.2.4 on construction and operational budgets ready for internal NSF review and clearance.[33]
- NSF prepared strengthened policy on the use of auditing and other techniques in overseeing and closing out large facility construction and operations awards that is included in "DACS Standard Operating Guidance 2014-1, DACS CBS Guidance on Pre and Post Award Cost Monitoring Procedures" effective June 30, 2014 and updated September 15, 2015.
- NSF has applied strengthened procedures for major facilities operations awards already in process.

NSF Actions Still in Process

- NSF conducted a study to identify cost reporting requirements at other agencies that utilize financial assistance awards and is currently developing a draft award provision specifying the format and detail of incurred cost information to be maintained by award recipients. NSF will seek OMB clearance for these new reporting requirements (estimated completion date is 12/31/15).
- NSF plans to conduct a third-party review on NSF's strengthened "end-to-end cost surveillance policies and procedures" (planned for FY 2017).

Contingency

OIG Concerns

- Supporting documentation for cost (budget) contingency estimates is not adequate.
- NSF does not have sufficient internal control of the use of contingency.
- Contingency estimates include funding for unforeseeable events ("unknown unknowns") which is not allowed.

OIG Recommendations

- NSF should require award recipients to properly account for contingency consistent with their estimates and separately track budgeted versus actual contingency expenditures.

[33] National Science Foundation, "Process Improvement Plan: FY 2014 Financial Statement Audit Report, Significant Deficiencies on Monitoring of Construction-Type Agreements and Grant Accrual Accounting Estimation Process" (August 28, 2015), p. 9.

OIG Recommendations Cont'd

- NSF should ensure that internal contingency policies reflect OMB cost principles and retain control over contingency budgeted for unforeseeable events.
- NSF should remove unallowable contingency from proposed budgets and ensure that internal contingency policies and procedures reflect OMB cost principles.
- NSF should review Change Control Board controls and thresholds to determine need for additional accountability strengthening and tracking.

NSF Completed Actions

- NSF revised the LFM to strengthen the process for managing the use of contingency, including requiring recipients to report contingency in monthly financial reports and/or in monthly project reports. Recipients are also required to document and trace the justifications for Change Control Board decisions to a project's risk register and work breakdown structure (WBS).[34]
- NSF uses broadly accepted methodologies to estimate contingency and revised its policy guidance to strengthen risk management (LFM Section 5.0); the documentation of contingency in the proposal budget for large facility projects (LFM Section 4.2.2 *Cost Estimating and Analysis for Construction Awards*); and the planning and use of budget contingency for construction (LFM Section 4.2.5 *Budget Contingency Planning for the Construction Stage*).
- NSF's policy on contingency is in compliance with OMB guidance. The policy clearly states that budget contingency estimates can only include funding for "known unknowns." Funding for "unknown unknowns" is not allowable under NSF policy. NSF conducted an internal review with program officials on the Change Control Board controls and thresholds.[35]

Management Fee

OIG Concerns

- Some awardees receiving management fee are not solely dependent on NSF for financial viability.
- Some of the factors NSF considers in determining whether to award a management fee are not consistent with the historical purpose of management fee.
- NSF views the use of management fees as "entirely discretionary" (analogous to "profit").

OIG Recommendation

- NSF should consider other sources of income in determining the amount of management fee to award.
- NSF should include an explicit statement that management fee is not tantamount to profit.

NSF Completed Actions

- NSF has revised its policy on management fee. The final updated management fee policy has been incorporated in the updated LFM and:
  - Recognizes the historical rationale for management fee, including working capital, facilities capital, and other ordinary and necessary expenses not otherwise reimbursable under the governing cost principles.
  - Includes a list of prohibited uses of management fee.
  - States that "unexplained failure to reasonably adhere to planned uses of fee will result in reduction of future management fee amounts under the award."
  - Creates an audit trail for management fee by requiring prior approval of management fee as well as documentation of the use of management fee.

[34] National Science Foundation, "Process Improvement Plan: FY 2014 Financial Statement Audit Report, Significant Deficiencies on Monitoring of Construction-Type Agreements and Grant Accrual Accounting Estimation Process" (August 28, 2015), p. 8.
[35] Ibid.

CHAPTER 3: USE OF COOPERATIVE AGREEMENTS TO SUPPORT CONSTRUCTION AND OPERATIONS OF LARGE SCALE RESEARCH FACILITIES

NSF uses cooperative agreements (CAs) to fund the construction and operation and maintenance (O&M) of large-scale research facilities. The primary basis for NSF's use of CAs for large facility projects is that it does not construct or operate the facilities directly (with a notable exception, facilities in the Antarctic), but does retain oversight responsibilities. Furthermore, NSF is providing federal assistance awards to recipients to conduct efforts that are not done for the benefit of the agency, but rather the scientific community at large.

Statutory Authority for Using Cooperative Agreements: Intent and Uses

For the past five years, the NSF Inspector General has focused significant attention on agency accountability over its high-dollar, high-risk cooperative agreements for construction of large scale research facility projects, emphasizing a need for improved internal controls, award terms and conditions, and overall monitoring of these CAs. The Office of Inspector General's (OIG's) assessment that CAs are not subject to the same rigor and reporting mechanisms as a contract prompted internal agency discussions as to whether procurement contracts would be a better option.[36] However, federal legislation supports NSF's use of cooperative agreements and clearly distinguishes federal assistance relationships from federal procurement relationships. Congress passed the Federal Grant and Cooperative Agreement Act ("Grant Act," P.L. 95-224) in 1978 to standardize the use and clarify the meaning of legal instruments that reflect such relationships—cooperative agreements, grants, and procurement contracts.

The Grant Act provides "uniform statutory guidelines" to guide government agencies in their use of federal funds. Under the Grant Act, procurement contracts are to be awarded when a federal agency is acquiring something such as a product or service. Both grants and cooperative agreements are awarded when a federal agency is providing assistance—the latter involving a greater degree of participation and oversight by the agency. The Grant Act requires that executive agencies use cooperative agreements when the "principal purpose" of the relationship between the agency and a non-federal entity is to "transfer a thing of value" to the non-federal entity "to carry out a public purpose of support or stimulation authorized by a law of the United States," and "substantial involvement is expected" between the agency and the non-federal entity in carrying out the activity contemplated by the agreement. The Grant Act does allow agencies to use procurement contracts in circumstances where the agency "decides in a specific instance that use of a procurement contract is appropriate."

The National Science Foundation Act of 1950 ("Organic Act," P.L. 81-507) establishes both the "principal purpose" and "substantial involvement" that support NSF's use of CAs under the Grant Act. A "principal purpose" of NSF's relationship with recipients under the Organic Act is to

[36] National Science Foundation, Office of Inspector General Alert Memo, Report No. 12-6-001, "NSF's Management of Cooperative Agreements," September 28, 2012.

fund and facilitate scientific and engineering research and education programs, and to appraise the impact of research upon industrial development and upon the general welfare. This includes providing federal assistance awards that facilitate the development of large facility projects by award recipients. Therefore, NSF is directed to provide federal award funds for building research facilities ("transfer a thing of value") to award recipients that include nonprofit organizations and universities ("non-federal entities") to assist NSF in carrying out its mission to initiate and support scientific and engineering research under the Organic Act ("a public purpose of support or stimulation authorized by a law of the United States").

The second consideration in determining whether to use a CA under the Grant Act is whether the awarding agency will have "substantial involvement" in the effort being funded. Under the Organic Act, NSF's charge is to retain responsibility for overseeing the development, management and successful performance of projects, but not directly construct or operate the facilities it supports.[37] NSF's Proposal and Award Policies and Procedures Guide (PAPPG) provides additional agency guidance on "substantial involvement" stating that substantial NSF involvement may be necessary when an activity is technically and/or managerially complex and requires extensive or close coordination between NSF and the awardee.[38] It further states that NSF will use cooperative agreements when accomplishment of project objectives requires substantial ongoing agency involvement during the project's performance period. The PAPPG also provides examples of projects which might be suitable for cooperative agreements when there will be substantial agency involvement, including research centers, large curriculum projects, multi-user facilities projects which involve complex subcontracting, construction or operations of major in-house university facilities, and major instrumentation development.

The Grant Act also provides a clear distinction between cooperative agreements and procurement contracts that further supports NSF's use of CAs. Procurement contracts differ from CAs in terms of their "principal purpose" in that they generally do not involve the "public purpose[s] of support or stimulation," but rather the acquisition, "by purchase, lease, or barter," of "property or services for the direct benefit or use of the United States Government."[39] The Federal Acquisition Regulation (FAR) contains similar language and states that "contracts shall be used only when the principal purpose is the acquisition of supplies or services for the direct benefit or use of the Federal Government." Because the Organic Act explicitly states that NSF "shall not, itself, operate any laboratories or pilot plants," NSF is not acquiring property or services for the direct benefit of the Federal Government. The FAR also states that "grants or cooperative agreements should be used when the principal purpose of the transaction is to stimulate or support research and development for another public purpose."[40] NSF's large facility projects are generally intended to serve the public purpose of building an infrastructure within the science community that is critical to supporting innovation across government and the nation as a whole.

[37] National Science Foundation Act of 1950 ("Organic Act," P.L. 81-507).
[38] National Science Foundation, *Proposal and Award Policies and Procedures Guide* (PAPPG).
[39] 31 U.S.C. §6303(1).
[40] FAR, Section 35.003.

While there is precedent for NSF using procurement contracts for large facility projects, the agency has done so in accordance with the provisions of the Grant Act and the FAR. NSF chose a procurement contract to fund the Antarctic Program because the U.S. government retains ownership of that facility and it directly benefits the U.S. government under the terms of the Antarctic Treaty.[41] The National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE) typically use procurement contracts for large facility projects for the same reason. Their projects are primarily for the benefit and use of the U.S. government, and contracts are often with large commercial entities. DOE's Office of Science has one large facility construction project that operates under a cooperative agreement—Facility for Rare Isotope Beams (FRIB). DOE used a cooperative agreement for that particular project rather than a procurement contract because the project was awarded to a university. Had FRIB been awarded to a laboratory, as is traditionally the case for large facility construction projects at DOE, a procurement contract would have been used.[42]

Federal Compliance Requirements and Oversight through a CA

OIG has raised concerns as to whether cooperative agreements are subject to adequate robust cost surveillance. Just as procurement contracts are subject to audit requirements under the FAR, CAs are subject to audit requirements under the Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards ("Uniform Guidance," 2 CFR § 200) which agencies were directed to implement by December 26, 2014. The Uniform Guidance is a single, comprehensive policy guide that provides a government-wide framework for grants management resulting from the Office of Management and Budget's (OMB's) consolidation and streamlining of federal requirements and guidance previously found in separate OMB circulars. Specifically, the guidance supersedes and streamlines requirements in OMB Circulars A-21, A-87, A-110, and A-122; Circulars A-89, A-102, and A-133; and guidance in Circular A-50 on Single Audit Act follow-up. Similar to the FAR, the Uniform Guidance is part of a larger federal effort to more effectively focus federal resources on improving performance and outcomes, while ensuring the financial integrity of taxpayer dollars. Through close and sustained collaboration with federal and non-federal partners, this OMB guidance was developed to ensure that discretionary grants and cooperative agreements are awarded based on merit; that management increases focus on performance outcomes; and that rules governing the allocation of federal funds are streamlined and administrative burden reduced for non-federal entities, while also minimizing the risk of waste, fraud and abuse through a better-focused single audit oversight tool.[43] NSF has incorporated the Uniform Guidance requirements into its policy guidance on cooperative agreements including the requirement that "federal awarding agencies have a framework in place for evaluating the risks posed by applicants for competitive grants and cooperative agreements before a recipient can receive a federal award."[44]

[41] Interview Notes.
[42] Interview Notes.
[43] 78 FR 78589.
[44] Uniform Guidance, Section 200.205(b).

CAs are subject to several requirements under the Uniform Guidance that would be analogous to the FAR, with the CA structure allowing for additional oversight and accountability mechanisms to be built directly into cooperative agreements. For example, the programmatic and financial terms and conditions identified in the CA establish compliance requirements for awardees. The CA instrument also affords flexibility to tailor project-specific requirements and performance metrics. Unlike a contract modification, these can be readily adjusted as needed to ensure the appropriate rigor in oversight with relatively minimum administrative and time burdens.

NSF has developed policies and procedures in its Large Facilities Manual (LFM) to guide NSF staff and external parties engaged in planning and managing large facilities.[45] The new structure of the LFM has allowed NSF to bolster and strengthen its policies in a fairly seamless and timely manner in response to OIG concerns. This includes providing a strengthened control environment and improved cost surveillance strategies for cooperative agreements. NSF designed the LFM to serve as an "evolving set of accompanying modules keyed to life-cycle stages" of a project. Entry and exit from each stage is clearly defined and scientific and technical experts, in addition to NSF management, are engaged in the review process. Once an award is made, annual reporting by awardees is required to assess the status of technical performance, cost schedules, and management performance. This is in addition to the business system reviews (BSRs) conducted by the Large Facilities Office (LFO) to obtain reasonable assurance that an award recipient's business systems and related policies and procedures are capable of administratively supporting large facilities, and that an awardee is in compliance with award terms and conditions.[46]

BSRs are an integral part of NSF's advanced monitoring (i.e., oversight) program. While NSF previously required that BSRs be conducted on a 5-year cycle, NSF recently changed the requirement. Going forward, the annual BSR planning process for NSF large facilities will be based on identified project risks and in coordination with the appropriate Office of Budget, Finance and Award Management (BFA) units and the program (i.e., the science directorate or office).[47] NSF has developed a structured approach for this activity that includes a team of NSF personnel, supplemented with contractor support staff, with expert knowledge in specific subject areas tied to the BSR scope. The LFO has the lead role coordinating the assessment and evaluation of a large facility award recipient's business management practices; key NSF

[45] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 1.1.1 (June 2015).
[46] Ibid. Section 2.1.6.1
[47] National Science Foundation, Office of Budget, Finance, and Award Management Division of Grants and Agreements, Standing Operating Guidance, "Annual Planning Process for Business System Reviews," September 10, 2015. Units involved include Division of Acquisition and Contract Support (DACS), Division of Financial Management (DFM)/Cash Management Branch (CMB), Division of Institution and Award Support (DIAS)/Cost Analysis and Audit Resolution (CAAR).

stakeholders in these assessments include program officers as well as staff in other BFA divisions.[48]

Although NSF has improved many of its policies and procedures for reviewing large facility projects, an area that warrants additional attention is the pre-award cost analysis conducted by BFA's Cost Analysis and Audit Resolution (CAAR) branch in the Division of Institution and Award Support (DIAS). Currently, CAAR's Cost Analysts' reports and analyses, which identify areas of concern prior to award, are advisory only and done at the request of the Division of Acquisition and Cooperative Support (DACS). The cost analysis is reviewed by the grants and agreements officer (GA/O) in discussion with the program officer; however, if the GA/O decides not to accept recommended actions prior to award, the GA/O documents the rationale for the record. Given the issues that OIG has raised, a document for the record does not appear sufficient from a cost surveillance perspective. In the event of a disagreement between the GA/O and CAAR, the LFO should be tasked with independently assessing the results and the LFO Head should sign a statement indicating concurrence or non-concurrence; this would, in turn, be forwarded to the NSF CFO as the accountable official for final disposition. The review results and approved action, documented in writing, would be shared with the Major Research Equipment and Facilities Construction (MREFC) Panel prior to the release of award funds. This would provide NSF with an additional tool for ensuring accountability as well as a clear audit trail.

How CAs Compare with Contracts

In response to a February 2014 request by the NSF Director for an analysis comparing cooperative agreements with contract funding mechanisms, BFA's Division of Institution and Award Support prepared a document highlighting key issues surrounding accountability for high-risk, high-investment projects. In comparing the use of cooperative agreements with procurement contracts, DIAS examined the implications of using a traditional contract business model for funding large facilities. The analysis addressed OIG concerns about NSF's use of cooperative agreements and the need for additional pre- and post-award surveillance,[49] and the impact that transitioning to procurement contracts would have on NSF from an operational standpoint. It provided the history and rationale for NSF using CAs, described NSF's oversight processes in place (which have since been further strengthened), and discussed what it would mean from a staffing and acquisition management perspective. Essentially, the document affirmed the use of CAs based on statutory authority and intent, and underscored the costs—in terms of administrative processes and resources—that would be required if the agency were to move to a procurement contracting model.

After reviewing the DIAS document and considering discussions with representatives of the Government Accountability Office (GAO), various Offices of Inspector General and OMB, the

[48] National Science Foundation, Office of Budget, Finance, and Award Management Division of Grants and Agreements, Standing Operating Guidance, "Annual Planning Process for Business System Reviews," September 10, 2015.

[49] Internal document provided to the study team.

study team found that the overall analysis was sound. As highlighted above, CAs are the appropriate mechanism for NSF and are wholly consistent with federal regulations and guidelines. Shifting from a federal assistance award model to a procurement contract model would introduce additional challenges in terms of resource needs and administrative requirements and processes. Procurement contracts involve a significant overhead component in terms of staffing and requirements for handling contract modifications and change orders. Such a transition would also alter the level of agency staff involvement and, importantly, the relationship between NSF and the recipients/awardees, without necessarily improving accountability or oversight. There is a common perception that procurement contracts have more defined processes and rigorous requirements under the FAR than CAs, but agencies using procurement contracts also struggle with implementing adequate accountability measures for high-risk, high-investment projects. For example, NASA, DOE, and the Department of Defense (DoD) are on GAO's high-risk list for procurement and contract management. NASA was designated high-risk in 1990 because of a history of persistent cost growth and schedule slippage in the majority of its major projects resulting from antiquated financial management systems, poor cost estimating, and underestimating risks associated with the development of its major systems. The current project management processes in place at NASA, and described later in this report, reflect the agency's significant efforts to shore up accountability processes and practices for managing high-risk capital investment projects. This example further underscores the fact that procurement contracts are subject to the same management and oversight challenges as cooperative agreements.

CA Instruments

There are two types of CA instruments used by NSF—the single award CA and the master or umbrella (governing) CA with accompanying cooperative support agreements (CSAs). Typically, CSAs include notation of specific subawardees. Under a master CA, CSAs are within the scope and terms and conditions of the master agreement, but have their own terms and conditions as well. Each CSA has its own distinct award number and funding based on its approved budget; no funding is attached to the master CA.[50] NSF negotiates and establishes the CA programmatic and financial/administrative terms and conditions with the award recipient, specifying funding, fees, CSAs and accountability/reporting.

Under MREFC CSAs, subawards that will be managed by the CA primary award recipient are identified to support specific segments of the project during the construction phase; NSF approval is required and the subawardees are subject to audit. Commonly, these subawards are contracts—rendering the CA/CSA instrument a hybrid CA-contract vehicle in practice. A key distinction is that contracts let by the primary award recipient under the CSA are not subject to the FAR but rather the procurement rules of the award recipient's organization.

[50] National Science Foundation, *Proposal and Award Manual* (PAM), Chapter 1, Section B2, (2014).

NSF does not have the same level of direct engagement with subawardees under a CSA because these interactions are facilitated by an awardee recipient's governance organization, precluding direct oversight by NSF. The lack of a direct reporting relationship with subaward recipients may present an oversight issue with respect to NSF's ability to manage subawardee performance. Therefore, how CAs and CSAs are structured, particularly with respect to the terms and conditions provided in the agreements, is especially important for effective oversight and governance.

Panel Recommendation 3.1

Objective: To bolster NSF's ability to detect and address potential cost proposal issues prior to the release of award funds.

Recommendation: NSF should require that exceptions to the recommendations from pre-award cost analyses conducted by CAAR be reviewed by the LFO and forwarded to the CFO for a final determination. The results of the CFO's decision should be documented in writing and shared with the Major Research Equipment and Facilities Construction (MREFC) Panel prior to the release of award funds.

Implementation Steps:

- *The responsible BFA units should work together to establish the specific policy and procedures for implementing these additional requirements.*

CHAPTER 4: CONTINGENCY AND MANAGEMENT FEE POLICY AND PROCESSES

Contingency and management fee are two elements of NSF cooperative agreements that have attracted significant NSF Inspector General and congressional attention since 2012 as a result of management concerns brought to light by audit findings in reviews of the Ocean Observatories Initiative (OOI), Advanced Technology Solar Telescope (ATST), the Large Synoptic Survey Telescope (LSST) and the National Ecological Observatory Network (NEON) projects.[51] Concerns with respect to contingency were raised in a 2015 congressional hearing on NSF's budget request.[52] The hearing focused on whether NSF needed to strengthen the accountability of its high-dollar, high-risk cooperative agreements for large facility projects, including better oversight and monitoring of contingency. The adequacy of NSF's policy on management fee has been challenged in recent OIG reviews and congressional hearings on NEON's projected cost overruns and use of management fee to cover questionable expenses.[53] In response to OIG and congressional concerns, NSF has developed more robust policies on contingency and management fee.

NSF Contingency Definition, Policy and Processes

Contingency represents funding needed for mitigating identified risks in complex projects. NSF includes contingency in awards for large facility projects; it is a commonly accepted business and project management practice. The Uniform Guidance defines contingency as "that part of a budget estimate of future costs (typically of large construction projects, IT [information technology] systems, or other items as approved by the Federal awarding agency) which is associated with possible events or conditions arising from causes the precise outcome of which is indeterminable at the time of estimate, and that experience shows will likely result, in aggregate, in additional costs for the approved activity or project." This language forms the basis for NSF's revised policies on contingency and risk management which are included in the key management principles and requirements for large facilities in NSF's Large Facilities Manual (LFM).

The LFM delineates NSF policy for three categories of contingency which must be included in the project execution plan (PEP) submitted by proposers:[54]

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[51] National Science Foundation, Office of Inspector General Alert Memo, Report No. 12-6-001, "NSF's Management of Cooperative Agreements," September 28, 2012.

[52] United States. Cong. House. Committee Commerce, Justice, Science Appropriations Subcommittee. 114th Cong. *Hearing on NSF's FY 2016 Budget Request*, Mar. 26, 2015.

[53] United States. Cong. House. Committee on Science, Space, and Technology and Subcommittees on Oversight and on Research and Technology. 114th Cong. *Hearing on NSF's Oversight of the NEON Project and Other Major Research Facilities Developed Under Cooperative Agreements*, Feb. 13, 2015 and United States. Cong. House. Committee on Science, Space, and Technology and Subcommittees on Oversight and on Research and Technology. 114th Cong. *Hearing on NEON Warning Signs: Examining the Management of the National Ecological Observatory Network,* Sep. 18, 2015.

[54] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 4.2.5 (June 2015).

- **Budget Contingency**: An amount added to a baseline budget to allow for identified items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in the aggregate, in additional costs.
- **Schedule Contingency:** The amount added to a baseline schedule estimate to allow for identified delays, conditions or events for which the state, occurrence, or effect is uncertain and that experience has shown will likely result, in the aggregate, in additional project duration.
- **Scope Contingency:** Scope included in the project baseline definition that can be removed without affecting the overall project's objectives, but may still have undesirable effects on facility performance. Identified scope contingency should have a value equal to at least 10 percent of the baseline budget.

At NSF, contingency is considered a critical component of the comprehensive planning and execution of the construction of large research facilities.[55] The agency recently revised the LFM to buttress and tighten requirements for contingency in response to OIG's concerns in the following three areas: (1) the development of contingency estimates; (2) the management of contingency budget use; and (3) the traceability of contingency allocation. For example, the LFM includes a new section on budget contingency planning for the construction stages with processes and requirements for managing budget contingency. Additional provisions for proposed budgets are provided in NSF's Proposal and Award Policies and Procedures Guide (PAPPG), including the Grant Proposal Guide (GPG) and Award and Administration Guide (AAG).[56]

NSF Policy on the Development of Contingency Estimates

OIG reviewed how contingency estimates are developed for federal awards, noting that they must be consistent with Office of Management and Budget (OMB) cost principles and supported by adequate documentation. NSF policy requires that proposed budgets comply with applicable federal regulations. Accordingly, NSF's contingency budget policy complies with OMB guidance (2 CFR § 200.433(b)) which requires that contingency amounts be: (1) estimated using broadly accepted cost estimating methodologies; (2) specified in the budget documentation of the federal award; (3) accepted by the federal awarding agency; and (4) included in the federal award. Additionally, for actual costs to be allowable, the OMB guidance requires that they comply with cost principles and be necessary and reasonable for proper and efficient accomplishment of project/program objectives. They must also be verifiable from the non-federal entity's records.[57] The LFM contains provisions to ensure compliance with each of these OMB requirements.

[55] National Science Foundation. *Large Facilities Manual*, (NSF 15-089), Section 4.2.5.1 (June 2015).
[56] Ibid. Section 4.2.1.3
[57] Ibid. Section 4.2.2.1

NSF has strengthened its methodological approach to cost estimating and analysis and updated LFM policies to reflect these efforts. Both budget (cost) and schedule contingency are developed using accepted cost estimating standards in accordance with OMB Circular A-11 and Government Accountability Office (GAO) best practices guidance on developing and managing large capital efforts. These practices focus on building accountability and ensuring proper stewardship of federal funds through effective project management and define key elements for doing so. Additionally, the LFM states that recipients should "strongly consider following the GAO Cost Estimating and Assessment Guide[58] and GAO Schedule Assessment Guide[59] when developing cost estimates in support of budget requests." Applying the GAO Cost Estimating and Assessment Guide and the Project Management Body of Knowledge Guide (PMBOK), NSF's risk analysis for cost estimates includes a combination of expert judgment and a risk matrix for identifying risk, the probability that risks will be realized, and their impact.[60] NSF policy states that analysis of contingency amounts proposed will be accomplished through an independent cost assessment or other technical evaluation coordinated and obtained by the Large Facilities Office.[61] Technical evaluations are required to determine: (1) whether the award recipient's assessment of the risks identified, including their magnitude and probability of occurrence, are reasonable and (2) that statistical techniques have been properly employed.

Once estimated, budget and schedule contingency are added to the baseline estimate for a project to address identified risks. Estimates are developed following a probabilistic approach using a confidence level at the 70-90 percentile based on the particularities of the project and the inherent ability to descope.[62] Baseline and contingency estimates are required to be complete and have a sound, supportable and well-documented basis of estimate, consistent with the objectives of each phase. At a minimum, during the conceptual design phase, a top-down, non-site specific, parametric cost estimate is required of recipients. At the preliminary design stage, a site specific, risk-adjusted, bottom-up, probabilistic cost estimate is required; including adequate contingency to cover all foreseeable risks. The estimate is further refined and perfected during the final design phase.

NSF established a "No Cost Overrun" policy in FY 2009 with the expectation that contingency estimates will be sufficient to manage all foreseeable risks. Directorates are responsible for the first 10 percent of cost overruns that exceed the National Science Board's approved total project cost. Project cost increases that exceed the budgeted contingency require descoping of the project to ensure the project is able to stay within its approved budget allocation. A descoping plan (at least 10 percent of the project performance baseline) is established prior to the preliminary design review. The NEON project is currently in the process of descoping per these policy provisions.

[58] The LFM directly references the GAO-09-3SP March 2009, or subsequent revision.
[59] The LFM directly references GAO-12-12OG May 2012, or subsequent revision.
[60] National Science Foundation, Office of Budget, Finance, and Award Management Standard Operating Guidance, "DACS Cooperative Support Branch Standardized Cost Analysis Guide," (SOG 2015-2) (September 15, 2015), p. 16.
[61] Ibid.
[62] National Science Foundation. *Large Facilities Manual*, (NSF 15-089), Section 4.4.5.1 (June 2015).

OIG expressed concern that NSF was providing contingency funding for unforeseeable events (commonly referred to as "unknown unknowns").[63] NSF refers to this type of funding as "management reserve" and describes it as money added to a baseline estimate to address unforeseeable events. NSF does not allow management reserve nor does it have a mechanism for holding it. In order to provide clarity on this issue, the LFM clearly states that only contingency, which covers "known unknowns," is allowable, while management reserve for "unknown unknowns" is not.[64] In fact, the independent technical evaluations required for contingency estimates must include an analysis verifying that amounts for major project scope changes, unforeseen risks, or extraordinary events are not included.[65]

NSF Processes for Managing Budgeted Contingency Usage

To execute oversight and assurance roles, NSF uses a combination of internal and external experts with specific roles and responsibilities in executing conceptual design reviews (CDR), preliminary design reviews (PDR), and final design reviews (FDR). Potential award recipients are responsible for developing and updating cost estimating plans and construction cost reports for each review. The cost reports include construction cost book reports; the results of MREFC Panel and other panel reports done for the CDR, PDR, and FDR; and other supporting documentation. Project managers (i.e., the award recipients) and their Change Control Boards have the authority to approve contingency requests under an approved NSF threshold currently up to $150,000, depending on the project, while those over this amount must be submitted to NSF at the program officer level or higher for approval. Award recipients are required to report contingency in their monthly financial reports to NSF program officers as well as in monthly project reports.[66,67]

Award recipients must follow a formal change control process to manage contingency. Written change requests must be submitted to project managers, and a Change Control Board (that includes senior project managers) reviews the requests and makes recommendations.[68] All change requests must be documented and archived and change request documents are expected to meet the minimum content requirements. Additionally, recipients are required to

[63] The term "management reserve" has various meanings across government and industry. NSF defines management reserve as a funding source for unforeseeable events ("unknown unknowns"), which it expressly does not allow.
[64] National Science Foundation*, Large Facilities Manual*, (NSF 15-089), Section 4.2.5.1 (June 2015).
[65] National Science Foundation, Office of Budget, Finance, and Award Management Standard Operating Guidance, "DACS Cooperative Support Branch Standardized Cost Analysis Guidance," (SOG 2015-2) (September 15, 2015) p. 16.
[66] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), (June 2015).
[67] Ibid. Section 4.2.5.8.
[68] NSF recently conducted a review of the controls used by the Change Control Board as well as thresholds to determine if there is a need for additional accountability, strengthening and tracking.

document and trace the justifications for Change Control Board decisions specific to contingency to the project's risk register and work breakdown structure (WBS).[69]

The NSF OIG has acknowledged that identifying funds (contingency) for uncertainties that arise during the conduct of complex projects is an important part of a project. However, OIG has recommended that recipients not manage those funds. Rather, NSF should retain contingency funds and release them when verifiable cost data can be provided by the recipient. NSF's position on retaining and managing funds budgeted for contingency ("known unknowns") is that they are an important part of project management with respect to risk mitigation and should be retained and managed by recipients. However, it is common practice at other federal agencies, including the Department of Energy (DOE) and National Aeronautics and Space Administration (NASA), to hold either all or a percentage of contingency funds. At DOE, the use of contingency is managed by the government, i.e., the federal project director holds and approves the use of contingency funds. To use contingency, awardees submit requests to the agency. Additionally, DOE has a Change Control Board responsible for reviewing contingency requests. DOE does provide for management reserve which the agency defines as "an amount of the total contract budget withheld for management control purposes by the contractor."[70] Management reserve is not part of the performance measurement baseline and must only be used for expenses within the scope of the project. Contingency funds can be assigned to management reserve and management reserve is held and managed by the award recipient. Therefore, a percentage of contingency is technically within the control of the awardee.[71] The federal project director, who is at the agency level, has access and oversight of management reserve funds and awardees are required to report the use of management reserve to the agency as part of their monthly reports.

NASA refers to contingency as "unallocated future expenses" (UFE) and these funds are held entirely by the agency at three different levels—the mission directorate level, the program level, and the project level. (Note: All three levels are federal employees—see Appendixes D and E for a description of DOE's and NASA's processes for managing large capital investment research projects.) UFE funds are managed by directorates at headquarters, while program and project funds are managed in centers located in the field. The percentages of UFE funds held at each level are determined based on the joint cost and schedule confidence level (JCL) analysis. Risks identified during this process must be reasonably likely to occur and represent costs that are allowable, allocable, and reasonable.[72] To access the UFE funds at the directorate level, program/project managers must seek approval from the directorates.[73] This structured

[69] National Science Foundation, "Process Improvement Plan: FY 2014 Financial Statement Audit Report, Significant Deficiencies on Monitoring of Construction-Type Agreements and Grant Accrual Accounting Estimation Process" (August 28, 2015).
[70] U.S. Department of Energy, *Change Control Management Guide*, DOE G 413.3-20, July 29, 2011.
[71] Interview Notes.
[72] Interview Notes.
[73] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014).

approach was developed to allow NASA to more effectively manage funds for unanticipated future expenses.[74]

By holding at least a percentage of contingency funds, NSF would have an additional and significant accountability measure in place for managing them. Under the current system of releasing control of all contingency funds with the federal award, recipients do not have a compelling incentive to preserve contingency funding. The study team was told repeatedly in interviews that contingency funds are typically "always spent."[75] In recognition of this historical practice, the recently revised LFM points out that it is possible that properly managed contingency "will remain" at the end of a project and highlights that any unused contingency—"residual funds"—should be returned to NSF for possible reallocation to other agency priorities.[76] To increase the likelihood of contingency savings, the Academy Panel recommends that NSF consider adopting NASA's structured approach and hold a certain percentage of contingency at the directorate, program and project level for its highest dollar projects and hold contingency at the program and project level for smaller dollar projects. This approach would signal that these funds are intended to be spent judiciously. NSF has the systems in place to hold contingency funds as well as the capability, through incremental funding, to release them in a timely manner when requested by award recipients.[77] Moreover, NSF has past experience holding contingency on projects where there were performance issues and is presently considering doing so for the NEON project.[78]

Tracking of Contingency Funds

NSF does not separately track contingency expenditures by award recipients, and OMB does not require that contingency funds be tracked once expensed. Other federal agencies interviewed by the study team do not track contingency separately either. However, OIG expressed concerns that there is a lack of visibility into contingency expenditures because they cannot be identified in accounting/financial systems as a contingency cost once expensed. While NSF does not track contingency expenditures separately, these funds can be traced to the work breakdown structure (WBS)[79] for every project. As described in the GAO Cost Estimating and Assessment Guide, a WBS defines in detail the work necessary to accomplish a project's objectives. NSF policy requires that a WBS include estimates with clear traceability including WBS sub-element costs that are readily mapped to NSF budget categories. In addition, NSF has strengthened and standardized the monthly reporting format that award recipients must follow for improved consistency, clarity and oversight of contingency. The report now requires a summary table of contingency allocations and a clear tie to the WBS and realized

[74] Interview Notes.
[75] NSF reports funding returned to the MREFC account from the South Pole Station Modernization Project and Earthscope.
[76] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 4.2.5-4 (June 2015).
[77] Interview Notes.
[78] Interview Notes.
[79] Interview Notes.

risk.[80] NSF needs to ensure it is monitoring compliance with these requirements closely as cost tracking provided by the WBS should verify that contingency funds are being spent appropriately and provide a clear audit trail.

Panel Recommendation 4.1

Objective: To bolster internal controls for contingency by providing additional auditability and incentivizing project managers to use the funds judiciously and return unused funds for reallocation to other agency priorities.

Recommendation: NSF should retain control of a portion of an award recipient's contingency funds and distribute them with other incremental funds as needed.

Implementation Steps:

- *NSF should (1) establish a trigger based on total project cost that will determine whether contingency will be held at three approval levels or two and (2) determine the appropriate percentage at each level based on a project's risk assessment. For projects over the threshold (e.g., projects totaling more than $100 million), contingency should be held at the directorate, program, and project (award recipient) level. Under this model, for example, 35 percent of contingency could be held at both the directorate and program level and 30 percent could be held at the project level. For projects under the threshold, contingency would be held at only two levels with, for example, 50 percent held at the program level and 50 percent held at the project level.*
- *The responsible BFA office should coordinate with all offices responsible for the management, review, and approval of contingency fund expenditures to develop the policy and process for holding and distributing funds to the recipient and the attendant audit trail requirements for documenting requests and tracking use to the project's work breakdown structure.*
- *NSF should leverage current systems for managing funds to ensure that contingency funds can be distributed in a timely manner.*

Panel Recommendation 4.2

Objective: To further strengthen NSF's policy on cost estimating and ensure rigor in the process.

Recommendation: NSF should change current language in the LFM so that it is clear that award recipients are expected to follow the guidance in GAO's Cost Estimating and Assessment Guide and Schedule Assessment Guide when developing cost and schedule estimates.

[80] National Science Foundation, "Process Improvement Plan," August 8, 2015.

Implementation Steps:

- *The LFO should work with stakeholders to identify and establish factors (e.g., risk, cost) that afford the flexibility to scope and scale the guidance based on what would be most appropriate for an individual project.*

Management Fee Definition, Policy, and Processes

NSF includes management fee in several of its cooperative agreements for large facilities to cover business expenses related to construction or operations that would otherwise be non-reimbursable under governing cost principles. The primary justification for this practice is that the majority of NSF large facility award recipients are nonprofits that operate on limited resources and may need to incur costs that benefit a supported project but for which they could otherwise not be reimbursed. The approach is intended to support the financial viability and operational stability of recipients by ensuring that costs directly related to an NSF-funded project will be covered by the award and ultimately enhance the likelihood of a project's success. However, express authority to include management fee in a cooperative agreement is lacking and clarity on what expenses should be classified as "appropriate" business expenses covered by the fee is confusing at best. The issue is further compounded by revisions to NSF's management fee policy that include examples of potentially appropriate expenses that appear to overlap with allowable costs such as indirect costs. These include "educational and outreach" activities which are not clearly distinguishable from "advertising and public relations which are allowed under the Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards (Uniform Guidance/2 C.F.R. Part 200). The Uniform Guidance governs cooperative agreements and does not address "management fee." These issues have prompted additional auditing from the NSF Inspector General and inquiries from Congress, as well as changes by NSF to its management fee policy.

Background on Management Fee

The federal government introduced management fee for federally funded research and development centers (FFRDCs) following World War II in an effort to continue its success partnering with laboratories to develop technologies that assisted with the war effort.[81] The justification for such a fee was based on a recognition that these centers, primarily nonprofit entities, might need to incur costs that could not be reimbursed as either direct or indirect costs, but were still considered "ordinary and necessary" business expenses.[82] Therefore, these costs were treated as "allowable" and could be paid for with management fee. This practice

[81] National Science Foundation, Office of Inspector General, "White Paper on Management Fees," Nov. 24, 2014, p. 2.

[82] National Science Foundation, Office of Inspector General, "Observations on NSF's Proposed Management Fee Policy," Jan. 29, 2015, p. 2.

continues for FFRDCs supported by several agencies that are in operation today, including five that are sponsored by NSF.[83]

Management fee is often considered as representing "profit" because it is used for items outside of "cost" and the concept of fees is more common in the context of federal procurement contracts.[84] The Federal Acquisition Regulation (FAR) expressly authorizes the payment of fees—as an allowance for profit—to contractors working under cost-reimbursement contracts.[85] For example, for similar experimental, developmental, or research work performed under a cost-plus-fixed-fee contract as opposed to a cooperative agreement, the fee can be up to 15 percent of the contract's estimated cost, excluding fee.[86] By contrast, there are no provisions in the Uniform Guidance governing cooperative agreements that reference either the types of fees recognized by the FAR or "management fee." This may be due in part to the results of a recent OMB survey that revealed NSF is the only agency that uses the term "management fee" in the context of federal awards.[87] While it does identify specific costs that are generally unallowable under federal assistance awards, the Uniform Guidance does not appear to expressly bar the payment of a fee, in addition to costs, under a cooperative agreement. In fact, it contains a provision stating that "a non-Federal entity may not earn or keep any profit resulting from Federal financial assistance, unless expressly authorized by the terms and conditions of the Federal award."[88] This language was intended by OMB to allow for agencies to determine whether to include management fee in federal assistance awards, however, the reference to "profit" supports the association of management fee with profit and raises a "red flag" inviting additional scrutiny. The absence of explicit government-wide guidelines specific to management fee in cooperative agreements is a major reason for continued debate as to its allowability. Not surprisingly, the lack of guidance on management fee and the additional scrutiny it invites have led some agencies to explicitly prohibit its use in federal awards. For example, NASA published a final rule in a November 2014 Federal Register notice that it would prohibit profit or fee for recipients of grants or cooperative agreements effective December 15, 2014.[89]

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[83] A full list of the 41 FFRDCs currently in operation can be found at http://www.nsf.gov/statistics/ffrdclist/.

[84] National Science Foundation, Office of Inspector General, "White Paper on Management Fees," Nov. 24, 2014, p. 10.

[85] United States. Cong. House. Committee on Science, Space, and Technology and Subcommittees on Oversight and on Research and Technology. 114 Cong. *Hearing on NSF's Oversight of the NEON Project and Other Major Research Facilities Developed Under Cooperative Agreements* Feb. 13, 2015. (statement for Kate M. Manuel, Legislative Attorney, Congressional Research Service).

[86] FAR Part 15.404-4(b)(4)(i)(A).

[87] Interview Notes.

[88] United States. Cong. House. Committee on Science, Space, and Technology and Subcommittees on Oversight and on Research and Technology. 114 Cong. *Hearing on NSF's Oversight of the NEON Project and Other Major Research Facilities Developed Under Cooperative Agreements* Feb. 13, 2015. (statement for Kate M. Manuel, Legislative Attorney, Congressional Research Service), p. 3.

[89] 79 Fed. Reg. 67347 (Nov. 13, 2014). NASA's rule defines "profit or fee" (including management fee) as amounts above allowable costs.

NSF Policy on Management Fee

The majority of NSF award recipients for large facilities are nonprofits. NSF includes management fee in its cooperative agreements and cooperative support agreements to cover an award recipient's expenses that would otherwise be non-reimbursable under governing cost principles.[90] Management fee is provided in excess of allowable costs that are typically captured under direct or indirect costs and generally fall within a 1 percent range of total project costs. NSF policy states that management fee is appropriate in limited circumstances recognizing that the awardee would only incur such expenses as a result of its support of the NSF-funded activity. Therefore, management fee may not be used to cover expenses incurred as a result of the awardee's support of activities that are conducted for other organizations and that do not benefit NSF.[91]

At a recent congressional hearing on NEON, NSF offered several agency supported uses of management fee by NSF award recipients: [92]

- An amount for working capital that may be necessary to ensure a level of retained earnings available to the organization in order to secure credit and borrowing to assure the financial health of the organization.
- Allowances for facilities capital that may be necessary for an organization to acquire major assets and address expenses that require immediate substantive financial outlays but that are only reimbursed by the government through depreciation or amortization over a period of years.
- Amounts for other expenses that are necessary to support completion of a project but that are not otherwise reimbursable. Examples of potential appropriate needs of an organization include contract terminations and losses, certain appropriate educational and public outreach activities, and providing financial incentives to obtain and retain high caliber staff.

NSF believes that performance by nonprofits operating and managing large, complex programs under a cooperative agreement entails business risk akin to those under execution of a procurement contract. Many expenses covered under a management fee "are appropriate for the normal conduct of business, such as certain types of equipment purchase, meeting interest payments on some forms of debt, paying certain legal expenses, financing of essential facilities deemed necessary to operations, and other purposes."[93]Seven NSF award recipients received

[90] National Science Foundation, Office of Inspector General, "White Paper on Management Fees," Nov. 24, 2014.
[91] National Science Foundation, Division of Acquisition and Cooperative Support, Cooperative Support Branch, Standard Operating Guidance (SOG) 2015-1, August 31, 2015, p. 2.
[92] United States Cong. House. Committee on Science, Space, and Technology and Subcommittees on Oversight and on Research and Technology. 114 Cong. *Hearing on NSF's Oversight of the NEON Project and Other Major Research Facilities Developed Under Cooperative Agreements* Feb. 13, 2015. (statement for Dr. Richard O. Buckius, Chief Operating Officer, National Science Foundation).
[93] Ibid.

management fee over the past five years for multiple projects: the National Ecological Observatory Network (NEON) Inc., SRI International, Associated Universities, Inc., Association of Universities for Research in Astronomy, Inc., Incorporated Research Institutions for Seismology, University Corporation for Atmospheric Research, and UNAVCO Inc. The combined management fee for the 13 awards represented by these recipients is 0.4 percent ($18 million) of the cumulative award amount ($4.7 billion).[94] Additionally, the management fee for any individual project did not amount to more than 0.87 percent of a total award.[95]

OIG and Congressional Concerns on NSF's Use of Management Fee

NSF policies and use of management fee in cooperative agreements became the subject of a two-part analysis/review by NSF's OIG.[96] The results of the first part were presented in a November 2014 white paper addressed to NSF's Chief Financial Officer (CFO).[97] The primary concerns presented in the document included indications that NEON, a MREFC-funded large facility project, had paid for potentially inappropriate costs with management fee under its cooperative agreement with NSF.[98] Initial observations presented in the white paper also addressed OIG's concern that some of the factors NSF considered in determining whether to award a management fee (i.e., using management fee as a performance incentive or to attract qualified organizations) "appear to be inconsistent with the historical purpose of such fees."[99] While the white paper acknowledged that based on historical precedent, management fee is warranted in order to help ensure the financial viability of an organization with limited sources of revenue, it highlighted certain NSF projects where awardees receiving management fee had alternative income sources.[100] The information was based on Single Audit report (A-133) data for FY 2013 showing "each awardee had multiple income sources, including, in many instances, income from other government agencies and/or non-governmental sources."[101]

OIG observations led to a hearing before the House Subcommittees on Oversight and on Research and Technology, Committee on Science, Space, and Technology in February 2015 on NSF and major research facilities developed under CAs. Congress focused primarily on the use of management fee in CAs and whether NSF had the proper policies and procedures in place to ensure that they are spent appropriately. A subsequent hearing was held by the Subcommittees titled, "NEON Warning Signs: Examining the Management of the National Ecological Observatory Network." The purpose of the second hearing was to review NSF's

[94] Two awards totaling $244 million are not included in the total award amount because management fee was still being negotiated at the time of this report.
[95] NSF Document.
[96] National Science Foundation, Office of Inspector General, "White Paper on Management Fees," Nov. 24, 2014, p. 6.
[97] Ibid.
[98] Ibid. Footnote 22 states that in FY 2013, NEON used such fees for, among other things, an office Christmas party ($25,000), coffee services ($11,000), $3,000 for Board of Directors dinners (including alcohol), and lobbying contracts ($112,000).
[99] Ibid. p. 9.
[100] Ibid. p. 9.
[101] Ibid, p. 9.

planned de-scoping of the project to ensure it remains on budget and on schedule following NSF's discovery of potential cost overruns of the project by the managing organization, NEON, Inc. Following the first congressional hearing on management fee in February 2015, the Office of Executive Councils, Chief Financial Officers Council issued a "Controller Alert" urging federal awarding agencies to carefully consider whether there is an appropriate justification for allowing management fee or profit in the terms and conditions of a federal award. This includes having agency controls, policy or guidance for federal award officials to consult when determining whether management fee is appropriate.[102]

Congress has also developed legislation that would impact NSF's policy on management fee. The America COMPETES Reauthorization Act of 2015 (the Act), passed by the U.S. House of Representatives (H.R. 1806), includes language allowing NSF to provide fees under an award if the awardee has demonstrated that it has limited or no other financial resources available to cover the expenses for which the fees are sought. This provision is in line with OIG's recommendation that a recipient's financial resources be provided to NSF before a decision to include management fee in a cooperative agreement is made. An earlier version of NSF's new management fee policy included this provision, but it was removed in the final policy that is now part of the Large Facilities Manual (LFM).[103] NSF's policy now provides closer monitoring for the use of management fee to ensure it is only used for ordinary business expenses related to the funded project.

Recent Changes to NSF's Management Fee Policy

NSF responded to concerns raised in Congressional hearings, as well as those raised by OIG, by developing more robust policy guidance on management fee that includes prohibited uses. Policy provisions were posted in the Federal Register for comments on December 30, 2014, and the finalized provisions were added to the June 2015 LFM clarifying what may be allowed and what is not allowed. Specifically the LFM:

- Identifies the "limited" circumstances in construction or operations of a large facility where the recipient is likely to incur certain legitimate business expenses that may not be reimbursable under governing cost principles but are considered as "potentially appropriate" for management fee. (Some examples include working capital necessary to fund operations to secure credit; facilities capital to acquire major assets or address expenses that would only be reimbursed through depreciation/amortization over time; and expenses related to educational outreach).

[102] Office of Executive Councils, Chief Financial Officers Council, Controller Alert: "Management Fees or Profit under Federal Assistance Awards," April 2015.

[103] Comments from award recipients in response to NSF's proposed management fee policy changes posted in the Federal Register on December 30, 2014, included concerns that such a requirement would introduce an administrative burden that is outweighed by the fact that management fee typically reflects less than 1 percent of the total amount of a federal award.

- Specifies prohibited uses such as alcoholic beverages, meals or social activities for non-business purposes, personal items, and lobbying as set forth in the Uniform Guidance and the FAR.
- Establishes NSF reviews of the use of management fee.
- Requires recipients to provide information on management fee use (usually) annually.
- Provides for a reduction of future management fee amounts under an award for unexplained failures to reasonably adhere to the planned uses of fee.[104]

In addition to the LFM, internal guidance from NSF's Division of Acquisition and Cooperative Support (DACS), Cooperative Support Branch (CSB) provides additional specifications in its recently revised (August 31, 2015) standard operating guidance (SOG) on the negotiation, award and payment of management fee in cooperative agreements for the design, construction and operation of NSF-sponsored large facilities. The revisions reflect the final changes to NSF's management fee policy [105] and are based on public comments on these policy changes and OMB's review. The SOG specifically states that management fee may be awarded to organizations in the limited circumstance of construction or operation of a large facility under an NSF assistance award[106] with the caveat that management fee amounts shall not be based solely on a percentage of the estimated costs. Twelve additional examples of inappropriate uses of management fee are provided in addition to the eight that are included in the LFM along with sixteen examples of appropriate uses of management fee. The LFM is silent on examples of permitted uses for management fee.

While acknowledging that enhancements NSF made to its management fee policy have strengthened the control environment,[107] OIG recently raised additional policy considerations in a September 2015 alert memo.[108] These included the potential overlap of appropriate expenses that would qualify as "ordinary and necessary" with allowable costs. OIG is concerned that this conflicts with NSF's current policy that proposed management fee elements cannot include costs incurred under the award that are otherwise allowable under governing cost principles. The two examples provided by OIG include "educational and outreach activities" and "financial incentives to obtain (and retain) high caliber staff." If there are reasonable circumstances when management fee would be needed to cover otherwise allowable cost, NSF must provide clear guidelines as to how and when this would be permitted. OIG also highlighted that NSF's current management fee policy does not include specific language as to the frequency of reviews for management fee expenditures and who will conduct them. NSF's policy language should be explicit on these two points and include exceptions to when such reviews will not be required (i.e., if no management fee expenditures are made within a given program year).

[104] The draft version of the policy conditioned such action on "repeated failures."
[105] National Science Foundation, Division of Acquisition and Cooperative Support, Cooperative Support Branch, Standard Operating Guidance (SOG) 2015-1, August 31, 2015.
[106] Ibid. p. 1.
[107] National Science Foundation, Office of Inspector General Alert Memo, p. 1, September 11, 2015.
[108] Ibid.

Most examples of costs covered by management fee that NSF and award recipients have provided seem to be costs that could be covered under indirect costs or contingency.[109] Despite recent changes that NSF has made to its policy to provide greater clarity on appropriate and inappropriate uses of management fee, OIG continues to have concerns. Further compounding the issue is the fact that efforts by OMB and the Congressional Research Service (CRS) have not resulted in greater clarity on the most controversial aspects of management fee. For these reasons, the Panel recommends that NSF discontinue the practice of including management fee in federal awards. The Panel believes that the indirect cost category and other non-federal sources of funding, if appropriate, could provide the necessary flexibility for recipients to cover many of the expenditures for which management fee is currently being used. For example, the Altacama Large Millimeter/Submillimeter Array (ALMA) project in Chile illustrates a cost that could have been covered under contingency or indirect costs instead of management fee. During a government shutdown, management fee funds were used to pay Chilean employees in accordance with Chile's labor laws. This event can be treated as a "known unknown" given experience with the likelihood of federal government shutdowns, making contingency an appropriate resource for covering this obligation. However, should NSF determine that award recipients encounter significant ordinary and necessary business expenses that do not clearly qualify as indirect costs, the agency should identify these categories of expenses and seek specific legislative authority for including funds for such costs in its federal awards.

Panel Recommendation 4.3

Objective: To eliminate the additional management burdens and potential for funding inappropriate expenses posed by management fee.

Recommendation: NSF should eliminate the practice of including management fee in cooperative agreements in future projects.

Implementation Steps:

- *The appropriate BFA office should develop NSF policy clarifying that management fee will no longer be included in federal awards.*

[109] Interview Notes.

CHAPTER 5: MANAGING COMPLEX RESEARCH PROJECTS—A COMPARISON OF NATIONAL SCIENCE FOUNDATION, DEPARTMENT OF ENERGY AND NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PRACTICES

As noted in the preceding chapters, NSF has undertaken a range of actions to improve project management and oversight under cooperative agreements (CAs) by strengthening its policies, procedures and practices. To benchmark NSF's efforts, the Panel and study team identified comparator science agencies whose large capital investment projects most closely align with NSF and reviewed their project management practices to identify approaches and lessons learned that may be transferrable to NSF. This chapter provides a comparative analysis of project management policies and practices at NSF, Department of Energy (DOE) Office of Science, and National Aeronautics and Space Administration (NASA), highlighting fundamental project management practices that NSF can use to supplement its current efforts. Detailed descriptions of each agency's practices are provided in Appendixes C (NSF), D (DOE), and E (NASA). Although DOE and NASA fund and manage their large-scale research projects principally through contracts,[110] the projects are reasonably analogous to NSF's projects in terms of scope, size and complexity.

A common theme emerged from the study team's document review process and conversations with DOE and NASA—project management is more critical to project success than the funding instrument used. This view was further validated through conversations with Department of Defense (DoD) officials, representatives from the Government Accountability Office (GAO) and Office of Management and Budget (OMB), and other agencies included in the study team's outreach efforts. GAO's high-risk list is populated with agencies—including NASA, DOE, and DoD—where GAO has identified procurement and contract management deficiencies. The DOE Office of Science was removed from the list as a result of its progress in improving project management while the rest of the agency remains on the list. Establishing strong, rigorous project management processes and procedures is essential for both the agency and the award recipient to ensure that projects meet their objectives and federal funds are appropriately spent with checks and balances in place to monitor progress. Officials from DOE and NASA noted that they apply the same project management requirements irrespective of procurement tools and view project management as a continuous improvement, agency-wide high priority; they have made progress but continue striving to improve their project management practices.

[110] The DOE Office of Science research facility construction projects are principally funded through contracts, with one notable exception. The *Facility for Rare Isotope Beams* (FRIB), which is analogous to NSF's MREFC projects, is funded through a CA. NASA will use a CA in certain cases where the agency wants to be more involved. Facility construction projects are strictly done under contracts.

Roles and Responsibilities

All three agencies have project management guidance that clearly defines the roles and responsibilities of agency staff involved in project management and oversight. The responsibilities of various individuals and organizations can be generally grouped into four categories: line management, institutional support, coordinating and advisory bodies, and governing bodies (see Table 5-1 below).

Table 5.1 Roles and Responsibilities

	NSF	DOE Office of Science	NASA
Line Management	**NSF Directorates** • Program officers (PO)—exercise day-to-day project oversight. A PO is appointed by the senior management of the originating directorate.[111] • Division directors—exercise oversight for projects within the division. • Assistant directors—exercise oversight on projects within the directorate and develop and manage the directorate's strategic plan and budget. **NSF Director**— has oversight responsibility for all projects within the agency and proposes new projects to the NSB, OMB, and Congress. **NSB**—reviews/approves MREFC projects and budgets.	**Office of Science** • Federal project directors (FPD)—exercise day-to-day project oversight. A FPD is appointed by the acquisition executive. • Program managers—are the headquarters point of contact for projects. • Project owners (associate directors)—exercise broad project leadership and guidance. • Acquisition executives — provide project management authority.	**Program Authorities** (Mission Directorates) • Project managers—are responsible for all issues related to project formulation and implementation. For projects over $1 billion, project managers are recommended by the center director and appointed by the mission directorate associate administrator (MDAA); for other projects, project managers are appointed by the center director, with concurrence from program managers.[112] • Program managers—exercise overall program oversight. Program managers are appointed by the MDAA. • MDAA—oversees all programs and projects within the directorate. • NASA Associate Administrator—has approval authority for all programs and projects over $1 billion.

[111] Senior management of originating directorate: a section head, Division Director, or Assistant Director, depending on the administrative structure of the directorate.
[112] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 140.

	NSF	DOE Office of Science	NASA
Institutional Support	**Office of Budget, Finance, and Award Management** • Grants and agreements officers from the Division of Acquisition and Cooperative Support are responsible for awarding, administering and monitoring CAs. • The Cost Analysis and Audit Resolution Branch conducts cost reviews (FL-99 reviews) for all projects over $10 million. • The Large Facilities Office (LFO) serves as the agency-wide resource for project management assistance and assurance; LFO liaisons provide direct project management support to program officers.	**Office of Science, Office of Project Assessment** (OPA) provides project and cost management support to all Office of Science projects. **DOE** Project Management Oversight and Assessment (PMOA) serves as the department-level project management support office. **Contracting Officer** assists projects in developing solicitations and awards, administers, and monitors contracts.	**Mission Support Directorate** oversees the agency's critical support functions (human capital management, procurement, etc.). **NASA Centers** support the implementation of programs/projects. **Technical Authority** Three offices—Office of the Chief Engineer; Office of Safety and Mission Assurance; and Office of the Chief Health & Medical Officer—provide independent oversight of technical activities of programs and projects. **Office of Evaluation** (reports to the Chief of Staff): • Cost Analysis Division develops the agency's cost estimating policy; provides cost analysis models and tools; develop cost estimates for potential programs. • Independent Program Assessment Office (IPAO) convenes and supports lifecycle reviews for all programs and selected projects over $250 million.[113]
Coordinating and Advisory Bodies	**Integrated Project Team (IPT)** is chaired by the program officer and consists of members from the sponsoring directorate, BFA, and Office of the Director and focuses on all project-related issues.	**Joint Project Team** is co-chaired by the federal project director and awardee project manager and focuses on all project-related issues.	**NASA Advisory Council**, consisting of 10-20 members, provides advice and recommendations to the NASA Administrator on a variety of issues (e.g., agency programs and projects, research activities and facilities, policies, and strategic plans).

[113] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 330.

	NSF	DOE Office of Science	NASA
	Large Facilitates Working Group, chaired by the LFO Head, reviews and comments on draft policies on large facility projects. **Advisory Committee of Originating Directorate** serves in an advisory capacity and provides input on directorates' priorities.	**Integrated Project Advisory Team** is a cross-functional team led by the federal project director and advises on project planning and implementation issues. **Advisory Committees** provide independent advice and recommendations to the Office of Science regarding complex scientific and technical issues shaping the direction of research programs.	
Governing Bodies	**MREFC Panel,** chaired by the NSF Deputy Director, reviews MREFC proposals in each phase of the design stage. **Director's Review Board,** chaired by the Deputy Director, reviews all materials and requests to be submitted by the Director to the NSB.	N/A	**Standing Review Board (SRB)** conducts most lifecycle reviews and other special reviews to assess program/project performance. • Board members are selected from within and outside the agency based on expertise. • IPAO is responsible for SRBs for all programs and projects ≥ $250 million. **Program Management Councils** (two agency-level councils and one center-level council) focus on program technical and programmatic performance.

Lifecycle Management

To oversee the planning, development, and implementation of large, complex research projects, all three agencies have designed multi-phase lifecycle project management processes, with a formal review and approval gate at the end of each lifecycle phase. The activities and deliverables a program/project must complete in order to enter and exit from each lifecycle stage and the approval authority are clearly specified in their policy guidance.

Key program/project decisions are to be well documented. NASA's practice stands out—NASA requires all programs and projects to develop a "Decision Memorandum" to document major program/project decisions, programmatic and technical requirements, cost and schedule estimates, key assumptions, and actions. Programs and projects follow the agency's standard

template to prepare the Decision Memorandum. At every key decision point (KDP), the Decision Memorandum is signed by the decision authority and members of the Agency Program Management Council. The signatures reflect leadership's commitments to the programs/projects and enhance accountability. Table 5.2 and Figure 5.1 below summarize and compare the lifecycle management processes of NSF, DOE, and NASA.

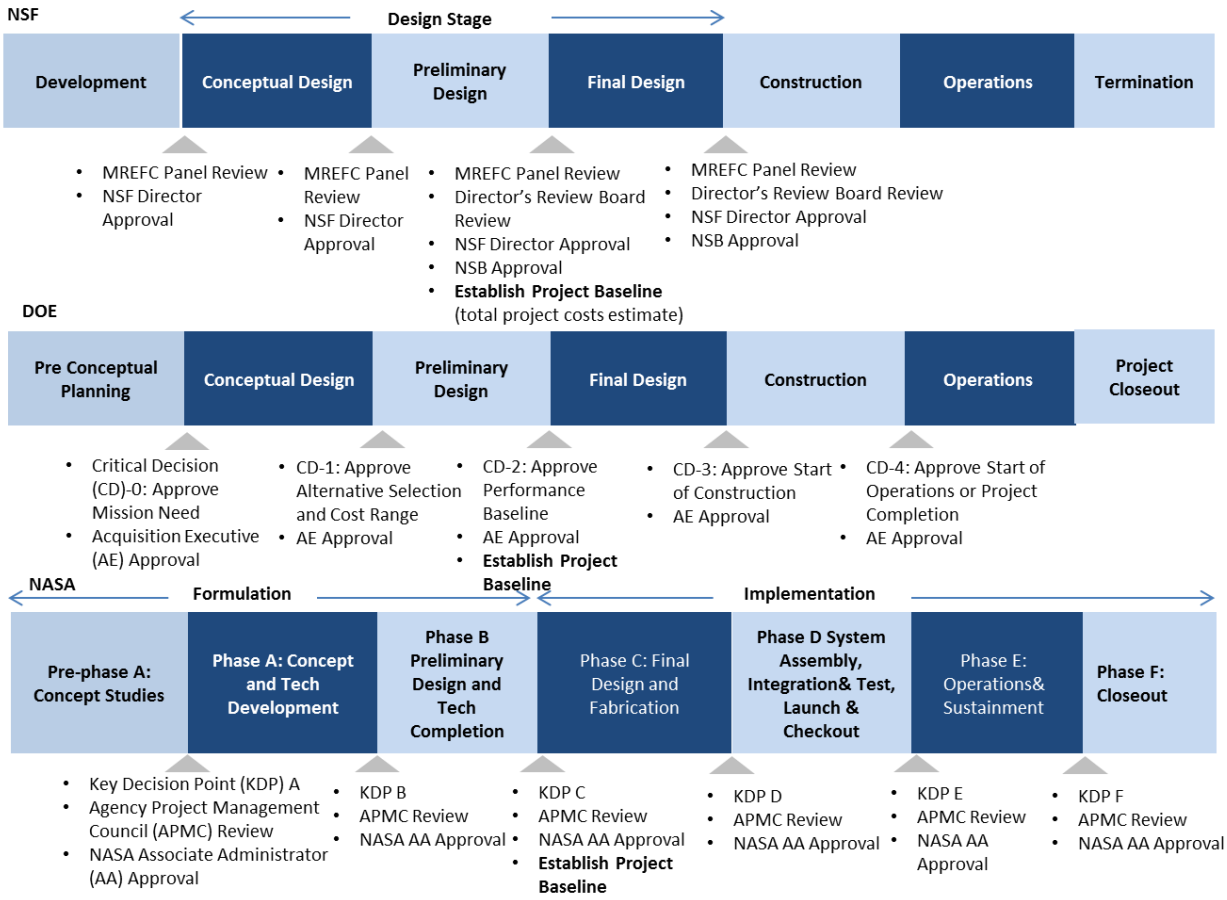
Table 5.2 Lifecycle Management

	NSF	DOE Office of Science	NASA

Process	Five lifecycle stages:
	• Development Stage
	• Design Stage
	  ○ Conceptual design phase/review (CDR)
	  ○ Preliminary design phase/review (PDR)
	  ○ Final design phase/review (FDR)
	• Construction Stage
	• Operations Stage
	• Termination Stage
		Five lifecycle/critical decision (CD) stages:
		• CD-0: Approve Mission Need (Pre-conceptual Planning).
		• CD-1: Approve Alternative Selection and Cost Range (Conceptual Design).
		• CD-2: Approve Performance Baseline (Preliminary Design).
		• CD-3: Approve Start of Construction (Final Design).
		• CD-4: Approve Start of Operations or Project Completion (Construction).
		• Project Closeout
			Two lifecycle phases, which are further divided into a number of sub-phases.
			• Formulation
			  ○ Pre-phase A: Concept Studies (KDP A)
			  ○ Phase A: Concept and Technology Development (KDP B)
			  ○ Phase B: Preliminary Design and Technology Completion (KDP C)
			• Implementation
			  ○ Phase C: Final Design and Fabrication (KDP D)
			  ○ Phase D: System Assembly, Integration & Test, Launch & Checkout (KDP E)
			  ○ Phase E: Operations & Sustainment (KDP F)
			  ○ Phase F: Closeout

Approval Authority	• **NSF Director** approves a project's readiness for entering the conceptual design and preliminary design phases; and proposes new projects for inclusion in future agency budget requests to the NSB. • **NSB** reviews and approves a project's readiness for final design phase and the construction stage; and presents new MREFC projects to Congress for funding.	• **Acquisition executives** approve project critical decisions (a project's readiness for the next lifecycle phase), and project performance baseline and funding profile.	**NASA Associate Administrator** is the decision authority for all programs and projects over $1 billion.

Figure 5.1 Comparison of Agency Lifecycle Management Processes



Project Management Skillsets and Training

Effective project management requires skilled project management staff. Consistent with OMB's requirements for federal acquisition projects, both DOE and NASA have established project management training/certification requirements for project staff. DOE federal project directors who manage projects over $5 million are required to complete project management training and be certified; at NASA, project management certification is mandatory for project managers who manage major projects valued at more than $250 million. Both agencies have well-defined project management training/certification programs. Program/project managers must meet the formal training requirements as well as complete other types of professional developmental activities to attain and maintain certifications.

While these agencies have the appropriate training programs in place, developing the capacity to implement and use project management tools is a long-standing, government-wide challenge. In fact, NASA remains on GAO's high-risk list, in part, because it lacks an adequate number of skilled project management staff.

NSF does not currently have formal project management requirements for MREFC program officers or recipients and does not offer in-house project management training that has a focus on CAs or large facilities. This issue is discussed in greater detail in Chapter 6: "Governing for Effective Stewardship of MREFC Projects."

Table 5.3 Project Management Skillsets and Training

	NSF	DOE Office of Science	NASA
Requirements	• Formal project management training or certification is not required for MREFC program officers and is not available at NSF. • NSF may send employees to outside vendors for formal project management training as appropriate. • CA recipient project managers are not required to have project management certifications.	• Project management certification is mandatory for federal project directors. ○ Four levels of certification exist, targeted by project cost thresholds: Level 1 ($5 million); Level 2 ($20 million); Level 3 ($100 million); and Level 4 ($400 million). • DOE has developed a project management training program known as the *Project Management Career Development Program.* ○ Candidates must complete required training courses and other professional development activities to obtain certifications. ○ Certified managers must complete 80 "continuous learning points" through training and other professional activities every two years. • DOE updates its PMCDP courses as needed.	• Program/project managers who manage major projects ≥ $250 million are required to be certified. • Managers who do not meet certification requirements are required to complete a set of developmental activities within an established timeframe and resubmit their portfolios for review. • Certified managers are required to earn 80 "continuous learning points" through training and professional activities every two years to maintain their certifications. • The NASA Academy of Program/Project and Engineering Leadership, operated by the Office of the Chief Engineer, provides various program/project learning opportunities.

Oversight and Accountability Process

All three agencies have implemented a variety of policy requirements and processes to strengthen their project oversight and improve accountability, including review processes. DOE and NASA have incorporated multi-level reviews into their project management processes to monitor program/project performance and progress. Most of the key reviews are organized by lifecycle phases and conducted either by an agency's project management support office or independent panels of experts.

For DOE Office of Science projects, five types of reviews are required at the Office of Science level, the department level, and the awardee level. First, design reviews are organized by awardee project managers and performed by external panels at the end of the conceptual design, preliminary design, and final design phases. At the Office of Science level, the Office of Project Assessment (OPA) conducts regular independent project reviews to assess a project's overall technical and programmatic performance (including cost, schedule and management performance). In addition, OPA assembles expert panels to perform focused, in-depth peer reviews to evaluate the technical, cost, scope and other aspects of a project. Panel members are independent of the project and are selected based on their experience and expertise. At the departmental level, the DOE Project Management Oversight and Assessment (PMOA) conducts external independent reviews (EIR) to assess the maturity of a project's design, validate project performance baseline (for projects over $100 million), and evaluate project execution readiness (for projects over $750 million) during the design stage. Although not required by the agency, some awardees conduct regular self-evaluations to ensure projects stay on track.

Similarly, NASA has implemented a series of reviews at multiple levels of the agency for each project lifecycle phase. First, the agency's Independent Program Assessment Office (IPAO) establishes a Standing Review Board (SRB) for each project to conduct lifecycle reviews, which serve as one of the agency's key checks and balance systems. NASA has developed a detailed policy to guide the selection of SRB members. As lifecycle reviews cover all aspects of program/project development, SRB members are chosen from both within and outside the agency with expertise from a variety of different disciplines, such as project management, specialized technical disciplines, etc. NASA's SRB handbook highlights the importance of having a "balanced SRB" and states "the technical and programmatic areas are covered expertly and adequately."[114] An SRB membership balance assessment is performed to address board members' skillsets, competency, and independence and serves as the basis for the SRB member selection. Second, program/project proposals are reviewed by three management councils at the center (field) level, directorate level, and agency level prior to the decision authority's KDP decision. Third, Baseline Performance Reviews (BPR), an internal senior management forum to review program/ project performance of each mission directorate, occur on a monthly basis. The BPR is chaired by the NASA Associate Administrator and Associate Deputy Administrator

[114] National Aeronautics and Space Administration, *NASA Standing Review Board Handbook*, REV A, NASA/SP-2014-3706, April 7, 2014, p. 13.

and involves agency senior leaders and center directors. NASA interviewees emphasized the value of BPRs as an important mechanism to facilitate communication and knowledge sharing across organizational boundaries within NASA. Fourth, a formal termination review process takes place to assess whether a project should be terminated before a final decision is made. NASA has also established a formal dissenting opinion process for resolving disagreements during reviews to support program/project decision-makers.

At NSF, candidate MREFC projects undergo a series of reviews during the design stage. The reviews at each design phase (CDR, PDR, and FDR) are organized and conducted jointly by the science directorate program officer and the LFO and often involve reviewers both within and outside the agency. The LFM currently states that an external panel review is required at CDR and is optional at the PDR and FDR levels. The study team was told, however, that in most cases, a MREFC project proposal is reviewed by an external panel at each phase of the design stage. It is our understanding that the next update of the LFM will further clarify the agency's requirements and ensure the consistency between actual practices and formal policies.

The emphasis of these design reviews at NSF is typically on the technical design of MREFC proposals. More recently, the agency has recognized that a similar level of rigor should be built into reviewing cost estimates. Review panel members have a strong scientific background but may not have the knowledge and expertise in cost estimating/project management. NASA's process for selecting SRB members can be adapted to assist NSF in selecting a balanced expert panel and improve the quality of design reviews.

NSF is in the process of developing policy guidance for the facility termination stage. In the revised LFM, the agency recognizes that facility termination decisions are difficult to make and emphasizes the importance of involving key stakeholders and research communities in the decision-making process. NASA's Termination Review process provides a template for NSF as it standardizes the project termination process.

Similar to DOE and NASA, NSF's large facility proposals/projects are reviewed by the agency's project management support office (i.e., the Large Facilities Office) and senior-level governing bodies (MREFC Panel and Director's Review Board reviews). Unlike DOE or NASA, NSF does not require formal directorate-level reviews. Both DOE and NASA have established a project management support office (e.g., Office of Science's OPA) or management councils at the directorate/office level to perform regular project reviews.

Table 5.4 Oversight and Accountability—Key Reviews

	NSF	DOE Office of Science	NASA
Key Reviews	**Design Reviews** • Led by the program officer (with LFO) in each phase of the design stage. • Utilize independent expert panels as well as in-house expertise. • Assess a proposal's technical design and cost/schedule estimates. **MREFC Panel Reviews** • Conducted at the end of the development stage and each phase of the design stage. • Assess a project's readiness to advance to the next lifecycle stage. **Director's Review Board Reviews** • Conducted at the end of preliminary design and final design phases. • Examine all materials that will be submitted by the Director to the NSB. **Operations reviews** • Conducted annually during construction and operations stages; • Organized by the program officer and conducted by an independent expert panel to assess project/recipient's performance. **Business Systems Reviews (BSR)** • Examine the effectiveness of business systems. • Initiated based on an LFO annual risk analysis.	**Design Reviews** • Organized by awardee project manager and conducted by an external panel prior to CD-1, 2, 3. • Review the quality of the project's technical design and budget/costs estimates. **Independent Project Reviews** • Conducted by OPA prior to CD-1, 2, 3, and 4 and annually to assess a project's technical, cost, schedule, and management performance. **Peer Reviews** • Conducted annually for all projects ≥ $100 million (CD-2—CD-4). • Organized by OPA and conducted by an independent expert panel. **Department-level External Independent Reviews (EIR)** • Conducted by PMOA • Validate performance baseline for projects ≥ $100 million in the preliminary design phase. • Review project execution readiness for projects ≥ $750 million in the final design phase. **Awardee Self-Reviews** • Conducted regularly by awardees (not a requirement for all projects).	**Lifecycle Reviews** • Convened by the IPAO and performed by the Standing Review Board in each lifecycle phase (one or multiple reviews). • Assess program technical and programmatic performance. **Management Council Reviews** • Three sequential management council reviews (center, directorate and agency) are performed in each lifecycle phase. • Focus is on program performance and its readiness to advance to the next lifecycle phase. **Baseline Performance Reviews** • Held monthly to review program and project performance in each mission directorate. ○ Chaired by the NASA Associate Administrator and Associate Deputy Administrator and involve agency senior management leaders and center directors. **Termination Reviews** • Convened by the decision authority and conducted by the Standing Review Board or an independent panel to assess whether a project should be terminated.

All three agencies have developed regular reporting requirements to monitor program/project progress. Award recipients regularly submit reports on performance data which are reviewed by the agency's program/project staff and project management support offices to identify potential issues and improve project performance. Table 5.5 provides an overview of the reporting requirements of NSF, DOE, and NASA.

Table 5.5 Oversight and Accountability—Reporting Requirements

	NSF	DOE Office of Science	NASA
Reporting Requirements	• Monthly financial and technical status reports are submitted by award recipients and reviewed by program officers and LFO liaison. • The LFO Head develops bi-monthly summary reports based on recipient reports and submits them to the NSF Director. • Award recipients submit annual progress reports to the program officer for review.	• Monthly performance data report from awardees are: ○ submitted to the agency's central system (not required for CA projects) and ○ reviewed by the federal project directors, program managers, and PMOA. • Periodic telephone discussions occur between awardees and federal project directors. • Written monthly reports from awardees are required. • Program managers provide monthly briefings to acquisition executives.	• Regular reports from programs/projects to centers on program/ project risks, status, and progress are required. • NASA Office of Chief Financial Officer collects core project data from all mission directorates quarterly. • Weekly project reports are required. • Weekly mission directorate reports are required. • NASA prepares a *Major Program Annual Report* for the Congress on projects with an estimated lifecycle cost over $250 million.

All three agencies require programs/projects to develop different types of management plans to guide program/project development and implementation activities. Key plans required by NSF, DOE, and NASA are summarized in Table 5.6 below.

Table 5.6 Oversight and Accountability—Management Plans

	NSF	DOE Office of Science	NASA
Management Plans	**Project Execution Plan (PEP)** • A draft PEP is developed during the conceptual design phase; a fully developed PEP is required for the final design review. • LFO provides a standard PEP template. **Risk Management Plan:** • Is developed as part of the PEP in the design stage and reviewed/updated by the recipient as appropriate. **Internal Management Plan:** • Is developed by the program officer during the conceptual design phase and submitted to the Large Facilities Working Group for review. • Defines how NSF oversees a large facility project, project cost estimates, risk factors, and funding strategy.	**Program Execution Plan (PEP)** • A draft PEP is developed prior to CD-1; an updated PEP is approved at CD-2. **Risk Management Plan:** • Is developed as a part of the PEP prior to CD-1 and updated regularly (at least quarterly).	**Program Plan/Project Plan** • A preliminary plan is due at KDP B, finalized at KDP C, and reviewed and updated as needed. **Risk Management Plan:** • Is developed by the first lifecycle review in Phase A and reviewed/ updated periodically.

Following OMB's guidance,[115] all three agencies require that projects develop and implement work breakdown structure (WBS) and earned value management (EVM) systems to oversee project performance. WBS is a key project management tool that defines project scope and combines project cost, schedule and scope. In all three agencies, WBS is developed as part of the design/formulation activities, and reviewed and approved by the agency.

EVM provides an integrated approach for tracking and measuring project costs and schedule performance as well as for identifying potential issues and project risks. Both DOE and NASA have well-developed EVM policies and processes in place. At DOE, projects over $20 million are required to start implementing EVM in the preliminary design phase. EVM must comply with federal standards and be certified by the agency. An EVM surveillance review is performed biannually by the agency and annually by the awardee after the project enters the construction phase. Similarly, NASA requires the use of EVM which must be in compliance with federal standards for projects valued at more than $20 million and for all single-project programs,

[115] OMB Circular A-11 requires executive branch agencies to apply an EVMS to major acquisition projects.

(NASA projects most analogous to NSF projects). The agency validates EVM compliance for contracts over $50 million. Projects (and contractors) are required to submit their EVM data on a monthly basis, and the agency conducts annual surveillance reviews to monitor the use of EVM. NSF is in the process of developing policies and guidance to standardize the use of EVM across projects.

Table 5.7 Oversight and Accountability—Work Breakdown Structure and Earned Value Management

	NSF	DOE Office of Science	NASA
Work Breakdown Structure	• Projects establish a preliminary WBS in the PEP during the conceptual design phase. • A fully developed WBS is required for the final design review.	• Projects establish a preliminary WBS as a part of the PEP in the conceptual design phase. • Projects further define the WBS through the construction phase (CD-4).	• Projects start developing the WBS in Phase A (KDP B). • A final WBS is approved at the end of Phase B (KDP C).
Earned Value Management (EVM)	• EVM is required for all MREFC projects. • Recipients submit EVM data in monthly reports. • NSF is developing EVM policies and guidance.	• EVM is required for all projects ≥ $20 million. • Projects start employing EVM during the preliminary design phase. • EVM must be in compliance with federal standards and certified by the OPA during the final design phase. • After the approval of construction, EVM surveillance review is conducted both biannually by the OPA and annually by the awardee.	• EVM is required for all single-project programs and projects ≥ $20 million. • Projects start EVM planning early in the formulation phase and start employing EVM in the implementation phase. • For contracts ≥ $20 million and ≤ $50 million, EVM must comply with federal standards; agency validation is not required. • For contracts >$50 million, EVM compliance is validated by the agency. • Projects/contractors report EVM data to the agency every month. • The agency's Integrated Surveillance Team conducts an EVM surveillance review in the formulation phase and annual surveillance reviews during the implementation phase.

Both DOE and NASA have implemented processes to document lessons learned and best practices throughout the duration of a program/project. The purpose is to provide an opportunity for the agency to identify and acknowledge achievements and pinpoint the root causes of any problems that occurred so that successes can be leveraged and problems averted in the future. DOE requires projects submit two lessons learned reports on project design activities and project execution activities. At NASA, programs/projects develop a knowledge management plan early in the formulation phase to identify strategies and processes to apply lessons learned from previous projects and capture/transfer knowledge throughout the program/project's lifecycle. NSF currently does not have formal requirements for capturing lessons learned in place. See Chapter 6 for further discussion on this issue.

Table 5.8 Oversight and Accountability—Lessons Learned

	NSF	DOE Office of Science	NASA
Lessons Learned	No formal process in place for documenting lessons learned.	**Lessons Learned Reports** • Federal project directors submit a "Lessons Learned" report on project design activities to OPA within 90 days after the CD-3 approval and another report on project execution within 90 days of the CD-4 approval.	**Knowledge Management Plans** are developed to identify strategies and processes for capturing and transferring knowledge. • A draft plan is due before the first lifecycle review in phase A; the final version is due by the second lifecycle review in phase A.

Cost Estimating and Reviews

All three agencies have mapped cost and schedule estimating requirements to program/project lifecycle phases. The degree of rigor and detail for cost and schedule estimates increase as the projects progress through each lifecycle gateway. NSF requires projects, prior to CDR, to develop parametric cost and schedule estimates, which are further refined during the preliminary design phase, and a probabilistic estimate (with a confidence level of 70-90%) of total project cost and schedule developed prior to PDR.

Similar to NSF, both DOE and NASA require programs/projects to develop project cost and schedule estimates based on rigorous risk analysis following a probabilistic approach. In addition to using a probabilistic approach, NASA's policy emphasizes the relationship between cost and schedule. Instead of developing two separate estimates (cost estimate and schedule estimate), projects are required to generate a "resource-loaded"/"cost-loaded" schedule estimate (i.e., costs are mapped to project schedule).[116] NASA has adopted a probabilistic cost

[116] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 275.

and schedule analysis tool, the Joint Cost and Schedule Confidence Level (JCL), to integrate a project's cost estimate, schedule estimate and risk factors and present a bigger picture of a project/program's chances of success. All single-project programs are required to conduct the JCL analysis to measure the likelihood of achieving their cost and schedule targets, and the agency's baseline JCL policy is to budget projects at the 70th percentile and fund to at least the 50th percentile.

All three agencies have adopted multi-level review approaches to ensure that cost estimates are accurate, comprehensive, and credible. NSF requires BFA staff (LFO, DACS, CAAR) conduct pre-award cost reviews as part of the CDR, PDR, and FDR, and hires external contractors to perform one of eight types of cost estimate reviews identified in GAO's Cost Estimating Guide. At DOE, Project Management Oversight and Assessments (PMOA) conducts multiple departmental-level independent cost estimates and independent cost reviews for projects over $100 million at various points in a project's lifecycle. Additionally, within the Office of Science, project cost estimates/performance is regularly assessed by the OPA as part of independent project reviews. For some projects, awardees conduct regular self-evaluations, and cost performance is also included in these evaluations. At NASA, cost and schedule estimates and performance are assessed as part of the lifecycle reviews and three management council reviews in each lifecycle phase. The Cost Analysis Division (CAD) of the Office of Evaluation develops cost estimates for potential future programs. All three agencies have developed formal approval processes for managing project baseline changes.

Table 5.9 Cost Estimating and Reviews

	NSF	DOE Office of Science	NASA
Cost Estimating Approach	Probabilistic approach using a confidence level of 70-90 percent. • Parametric estimates developed prior to CDR. • Probabilistic estimates developed prior to PDR.	Probabilistic approach using a confidence level of 70-90 percent. • Parametric cost and schedule estimate range developed at CD-0 and CD-1. • Probabilistic cost and schedule estimates developed at CD-2.	Probabilistic approach using a Joint Cost and Schedule Confidence Level (JCL) tool. • JCL is a probabilistic tool that integrates a project's cost estimate, schedule estimate, and risk factors. • NASA policy is to budget projects at the 70th percentile and fund at least the 50th percentile.

	NSF	DOE Office of Science	NASA

Cost Analysis and Review	**BFA Cost Reviews**
	• Conducted jointly by DACS, DIAS (CAAR), and LFO at the end of each phase of the design stage.
	
	Independent Cost Reviews
	• Conducted by external contractors.
	• The review model and timing are determined by the grants and agreement officer, LFO and program officer (usually in the preliminary design phase).
		Department-level Independent Cost Estimates and Reviews
		• PMOA conducts multiple independent cost estimates or reviews for projects over $100 million in a project lifecycle.
		
		Office of Science Independent Project Reviews
		• Conducted by the OPA
		  ○ prior to CD-1,2,3,and 4 to assess the project's readiness.
		  ○ annually to verify project's status and progress.
		• Review project's technical requirements, cost, schedule, and management performance.
			Lifecycle Reviews
			• Conducted in each lifecycle phases (one or multiple reviews) by the Standing Review Board.
			• Cost and schedule estimates are assessed as part of lifecycle reviews.
			
			Management Council Reviews
			• Conducted by three management councils (see above) in each lifecycle phase.
			• Cost and schedule estimates are assessed as part of the management council reviews.
			Office of Evaluation, Cost Analysis Division
			• Develops cost estimates for potential programs.

Documentation Requirements	The *Cost Proposal Review Document* is developed for all facility projects over $100 million to document project cost estimates and agency's cost analysis and reviews. Potential recipients prepare the *Cost Estimate Plans* and *Construction Cost Reports* at CDR, PDR, and FDR to provide a comprehensive cost estimate.	Project performance baseline is documented in the project execution plan.	• Program's cost and schedule estimates are defined in the program's *Management Agreement*, which is documented in the *Decision Memorandum*. • *Basis of Estimate* is developed to describe cost and schedule estimate ground rules and assumptions. • The *Cost Analysis Data Requirement* is developed to document project cost and schedule information and track major project changes.

	NSF	DOE Office of Science	NASA
Re-baselining	• An external baseline review is required to assess whether re-baselining is warranted. • Re-baseline requests are recommended by the program officers, authorized by the grants and agreements officers, in consultation with the IPT and directorate/division's leadership. • If project cost exceeds the approved baseline costs more than 20 percent, re-baselining must be approved by NSB, based on the recommendations from the MREFC Panel and NSF Director.	• The approving authority (DOE Deputy Secretary or Under Secretary) determines whether to terminate a project or establish a new performance baseline. • Federal project director develops a baseline change proposal; the revised baseline is reviewed by the PMOA for projects ≥ $100 million; for projects ≤ $100 million, the revised baseline is reviewed by the OPA. • All re-baseline decisions are reported to the Deputy Secretary and PMOA.	• A re-baseline review is initiated by the Decision Authority and conducted by the Standing Review Board. • An independent cost and schedule assessment is conducted; JCL is recalculated and approved. • Re-baseline requests are approved by the decision authority. • Congressional reauthorization is required for single project programs to proceed to a new baseline.

Contingency

As discussed in Chapter 3, use of contingency is a common business practice to manage project risks, and contingency estimates are a critical element of project cost estimates. All three agencies require that projects use a probabilistic approach to develop contingency estimates.

The three agencies have taken different approaches to managing contingency funds. Under NSF's current policy guidance, contingency is held by MREFC award recipients. Access to these contingency funds requires approval through a change control board. All MREFC projects are required to establish a Change Control Board (board members are award recipients' senior managers) to review all contingency requests and make recommendations to the project manager. Currently, contingency requests up to a documented threshold of $150,000 are

approved at the project (award recipient) level; requests over this threshold require NSF review and approval.

At DOE, contingency funds are held by the agency; award recipients must submit requests to the agency to use the contingency funds. DOE also has a Change Control Board responsible for reviewing contingency requests. Unlike NSF's Change Control Board, this is an internal agency board, consisting of key agency stakeholders. Contingency requests are approved by the acquisition executive (or federal project director). While contingency is managed by the agency, recipients are allowed to hold a small amount of management reserve to manage contract risks. The use of management reserve does not require the agency's approval.

Like DOE, NASA manages contingency (known as unallocated future expenses [UFE]) at the agency level and releases the funds to awardees when needed. UFE is held at three levels within the agency—the mission directorate level, the program level, and the project level. A major portion of UFE funds are managed by directorates at headquarters, while program and project funds are managed in the field. The percentages of UFE funds held at each level are determined based on the JCL analysis. To access the UFE funds at the directorate level, program/project managers must seek approval from directorates.

NSF's LFM requires projects to return unused contingency funds (based on unrealized risks) to the agency. However, there is no strong incentive in place for recipients not to use all contingency funds. Almost all NSF projects use their full cost contingency. NASA has a more centralized model to manage major projects. Funding decisions are made based on the analysis of the portfolio as a whole, rather than individual projects, and most UFE funds are held at the headquarters/mission directorates' level. Projects are managed within a program so that their unused budget and/or UFE is available to other projects in the program. This approach allows the agency to develop a more integrated resource plan and incentivizes project managers to live within a project budget and achieve savings.

All three agencies do not require recipients to track contingency funds separately in their accounting systems once expensed. Recipients are required to report the use of contingency to the agencies on a monthly basis.

Table 5.10 Contingency

	NSF	DOE Office of Science	NASA
Contingency Estimates	• Probabilistic approach using a confidence level of 70-90 percent.	• Probabilistic approach using a confidence level of 70-90 percent.	• Probabilistic approach following JCL policy to budget projects at a 70 percent JCL and fund to at least 50 percent JCL.

Control Processes	• Contingency is managed by award recipients.
	• Recipient project managers have the authority to approve contingency requests under an approved threshold.
	• Contingency requests over an approved threshold are submitted to the agency for approval.
	• A change control board (including recipient senior project managers) review all contingency requests and make recommendations.
	• All change requests are documented and archived.
	• The use of contingency is reported to the agency in the recipients' monthly reports.
	• Contingency is not tracked separately in the award recipients' accounting systems once expensed.
		• Contingency is held by the agency.
		• To access contingency, awardees submit requests to the agency; requests are reviewed by a change control board (including key agency internal stakeholders); and are approved by acquisition executives (approval authority can be delegated to federal project directors).
		  ○ Awardees hold a small amount of "management reserve" to cover risks within the contract scope.
		  ○ Awardee project managers have the authority to approve the use of management reserve.
		  ○ Awardees report their use of management reserve to the agency in their monthly reports
		• Contingency is not tracked separately in the awardees' accounting systems once expensed.
			• Contingency (known as unallocated future expenses (UFE)) is managed by the agency at the mission directorate level, program level, and project level.
			• A major portion of contingency funds are managed by directorates at headquarters; program and project funds are managed in the field.
			• The distribution of UFE funds among directorates, programs, and projects is determined based on the JCL analysis.
			• The use of UFE funds managed by directorates requires directorates' approval and amendments to the program /project's management agreement.
			• Projects are managed as part of a program (portfolio), and residual UFE funds (savings) are available to other projects.
			• UFE is not tracked separately in the awardees' accounting systems once expensed.

Management Fee

As discussed in Chapter 4, management fee is a controversial issue government-wide. NSF's recently revised LFM provides more specific guidance on the use of management fee. The new guidance identifies three expense categories considered as "potentially appropriate" for management fee and specifies the circumstances under which the use of management fee is not appropriate. Award recipients are required to report their use of management fee "usually" on an annual basis. The agency conducts reviews to examine whether the recipient's actual use of management fee is consistent with the original fee proposal.[117]

Management fee is not commonly used for DOE Office of Science projects and is generally not used in cooperative agreements. As a result of issues raised by the NASA Inspector General, NASA recently ended its practice of providing management fee under CAs.

Table 5.11 Management Fee

	NSF	DOE Office of Science	NASA
Policy	• NSF's revised policy on management fee identifies limited circumstances under which the use of management fee is considered appropriate and specifies prohibited uses of management fee. • Award recipients report on the use of management fee (usually annually); the agency reviews the use of management fee.	• Use of management fee is not common for Office of Science projects. • The Facility for Rare Isotope Beams (FRIB) project (funded under a CA) does not offer management fee.	• NASA has changed its policy and no longer provides management fee to projects under CAs.

Based on the study team's analysis, it is clear that NSF is following, or has recently adopted, promising practices in many areas related to the development of large facility projects. However, there are additional practices that NASA and DOE's Office of Science have adopted that would benefit NSF as highlighted throughout the report. Chapter 4 addressed NSF's need for a structured approach to contingency, and NASA and DOE provided useful models for the agency as it reconsiders its policy in this area. The agencies' approach to management fee, which is also addressed in Chapter 4, is similarly instructive for NSF. Chapter 6, which follows, highlights governance issues and offers a number of recommendations for strengthening the effective stewardship of MREFC projects, including the need to build project management capability and enhance agency review and oversight processes.

[117] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 4.2.2-3 (June 2015).

CHAPTER 6: GOVERNING FOR EFFECTIVE STEWARDSHIP OF MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION (MREFC) PROJECTS

Ensuring proper stewardship of federal funds requires effective governance structures and processes—the internal infrastructure of an agency. The National Science Foundation's (NSF) strategic goal, to "excel as a federal agency," focuses on NSF internal management and steps, underway or planned, that the agency will take to hold itself accountable. In addressing this goal, NSF management, along with the National Science Board (NSB), has been actively engaged in assessing management and oversight processes and practices—in particular, in the area of complex, large-scale research equipment and facilities. This chapter highlights a number of governance and organizational issues involving both NSF and the Board and offers recommendations to address ambiguities and further build the agency's capacity to effectively manage these major research equipment and construction projects.

NSF and NSB Roles and Responsibilities and the Impact of a Transitional Workforce

The unique relationship between the NSF Director and the NSB, who hold joint leadership authority, presents a leadership model with both opportunities and inherent management challenges. While roles and responsibilities have evolved over time through amendments to the NSF Organic Act and through working relationships nurtured by individuals in leadership roles, the original structure established for NSF management and NSB remains essentially unchanged and highly interdependent. In an earlier study by the Academy, undertaken as a result of congressional interest for an independent assessment of NSF's organization and management, an Academy Panel recommended that the NSF Director and NSB implement a process to clarify and codify the roles and responsibilities of the Board and NSF units that routinely interface with NSB staff and members.[118] The Panel also recommended that these roles and responsibilities be made publicly available, reviewed annually, and revised as needed. Boundaries involving *oversight (*how does oversight translate into practice; what might be considered micromanagement versus appropriate monitoring) and *management* (what is the proper level—e.g., strategic versus operational) were issues examined at the time of the review. These same issues have been raised more recently as congressional and audit oversight has intensified, and both NSF leadership and the Board have taken more active roles asking questions and seeking more status updates on projects and activities.

From all accounts, the current arrangement and working relationship between the NSF Director and the Board appear to be working well. The Director was formerly a Board member and has the advantage of understanding the Board's perspective and how it operates. This rather highly cooperative relationship has not always been the case in the past. The study team was told that the personality of key leaders and Board members drives the relationship. It is working well

[118] National Academy of Public Administration, *National Science Foundation: Governance and Management for the Future* (April 2004).

today, but there is no guarantee that it will in the future. Roles and working relationships are not spelled out in a joint document, which was a recommendation made in the Academy's 2004 study. The need persists to institutionalize key elements of how NSF and the Board work together to enable mission accomplishment. By doing so, NSF management and NSB will ensure that these efforts are sustained beyond changes in leadership and Board membership. Transparency through active communications and relationship-building between NSF management and the Board are vital to sustaining effective working relations and leading the agency.

Practices instituted by the Smithsonian Institution may be instructive and offer some promising practices. The Institution, created by Congress in 1846 "as an establishment for the increase and diffusion of knowledge,"[119] has instituted a formal governance process to guide its efforts and fulfill its responsibility for agency administration which is vested in a 17-member Board of Regents. The Smithsonian Board of Regents functions more as a traditional board of directors in that the Board elects the Secretary who implements the Board's policies and priorities and is responsible for day-to-day leadership. However, there are similarities in how the Board of Regents and NSB operate. For example, the Board and Secretary work together in a partnership to carry out the agency's mission, with the Board exercising broad oversight of agency management and operations; the Board reviews and approves the agency's budget; the Board is considered the "head of agency" with the Inspector General reporting to the Board; the primary work of the Board is accomplished through committees; and Board members are part-time and meet at least four times a year. In response to congressional concerns over lax oversight and a GAO report identifying 46 reforms aimed at improving operational policies and controls, the Board of Regents adopted the *Twelve Principles of Governance that Power Exceptional Boards* by BoardSource, a national organization focused on good governance practices for nonprofits, as a benchmark to evaluate its own practices and procedures. The tenets include:[120]

1. Constructive Partnership: recognizing that the effectiveness of the board and chief executive are interdependent.
2. Mission Driven: ensuring congruence between decisions and core values.
3. Strategic Thinking: making time to continuously engage in strategic thinking to hone the organization's direction.
4. Culture of Inquiry: institutionalizing a culture of inquiry and constructive debate for sound and shared decision-making.
5. Independent-Mindedness: putting the interests of the organization above all else.
6. Ethos of Transparency: ensuring stakeholders have access to appropriate and accurate information on finances, operations, and results.
7. Compliance with Integrity: establishing appropriate mechanisms for active oversight.
8. Sustaining Resources: linking plans to financial support, expertise and networks of influence.

[119] Smithsonian Institution website: http://www.si.edu/Governance.
[120] *Governance Report*, Smithsonian Institution, June 2015.

9. Results-Oriented: measuring organizational advancement towards mission and evaluating the performance of major programs and services.
10. Intentional Board Practices: structuring the board to fulfill essential governance duties and support organizational priorities.
11. Continuous Learning: embracing a continuous learning mode by evaluating board performance and assessing the value added to the organization.
12. Revitalization: energizing the board through planned turnover, thoughtful recruitment, and inclusiveness.

In assessing performance, the Board of Regents annually reviews the roles, responsibilities and jurisdiction of its standing committees in order to best serve the Smithsonian's evolving needs and evaluates the size, structure, composition and effectiveness of the Board. The NSB uses its annual retreat to similarly address how it is organized. Publicly available on the Smithsonian's Board of Regents website are a "Duties and Responsibilities" document, as well as Bylaws and Charter Provisions documents, that make clear roles, responsibilities and working relationships. The NSB and NSF leadership would benefit from a similar statement.

The staffing composition of both the NSF and NSB also presents a challenge as they routinely experience purposeful turnover. About one-third of all management/leadership positions are temporary rotators, principally IPAs with a 4-year appointment limit. Rotators, largely from academia, afford NSF fresh experience from the research community and contemporary scientific and engineering knowledge. The downside is that rotators generally lack institutional knowledge and are not familiar with government rules and procedures, while continual changes in leadership present continuity challenges for the organization. To address these issues, NSF endeavors to pair IPAs with permanent employees (e.g., a permanent deputy with an IPA Assistant Director). Directorates differ on how they brief incoming rotating leadership at the Assistant Director and Division Director level**.** However, in an environment of heightened oversight, standard/documented policies and procedures become increasingly important, particularly where turnover of key decision-makers is the norm. The Defense Advanced Research Projects Agency (DARPA), like NSF, has a substantial number of rotators on IPA assignments; unlike NSF, DARPA has a large administrative management support structure. A small agency with about 200 staff, DARPA relies on this temporary technical staff to lead research efforts. About 50 percent of the staff are temporary IPAs and 50 percent are permanent support staff who assist the technical staff in carrying out their responsibilities.[121] The technical IPAs serve as project program managers and are responsible for the lifecycle of the research project, which generally runs from 3-5 years. The agency uses its cadre of support staff to ensure agency institutional requirements for project and acquisition management are met.

NSB members are also time limited—but their tenure is generally longer than IPAs, as members are appointed to 6-year terms that can be extended by another 6-year term. The current NSB

[121] Interview Notes.

Chair and Vice Chair are both reaching the end of two 6-year terms with the Board. In addition, the term of the Chair of the Subcommittee on Facilities is also coming to an end—these terms expire in May 2016. (As noted earlier, one-third of the Board generally rotates off every two years.) NSF will lose a great deal of institutional knowledge with their departure.

Current NSB members, like NSF rotators, are largely from academia. They have stellar science credentials but may not have a business operations or project management perspective that is becoming increasingly important in overseeing MREFC projects and agency strategic direction. Ideally, some members should have both a research and a business perspective as business/financial/project management-oriented representation would provide a needed perspective, particularly in crafting questions for assessing cost and schedule estimates, as well as evaluating construction costs, for MREFC projects.

Presently, there is a growing recognition for the need to diversify the expertise on the Board with some members who have project management experience in order to balance the science perspective when reviewing projected project outcomes. The September 2015 call for nominations for the Class of 2022 Board members identified topics for which demonstrated expertise was sought. The first bullet under "specific topics" for representation was "large/complex facility planning, construction, management and transformation;" the third bullet was "metrics and performance measurement." Moreover, the selection criteria used to evaluate nominees listed certain preferred attributes as key considerations. Among the attributes—in addition to experience with large facilities and performance metrics noted in the call for nominations—was "project management/cost analysis." The explicit identification of these topics and attributes demonstrates recognition of the need for members with project and financial management knowledge and experience who can articulate questions for assessing cost proposals, project management capabilities, and the adequacy of a MREFC project's governance structure. While the final selection of Board members is not within the control of the Board—as noted earlier, Board members are presidentially appointed—the expectation is that the current announcement will yield a pool of candidates with the desired, diversified credentials.

Panel Recommendation 6.1

Objective: *To improve transparency in how NSF and the Board work together to enable mission accomplishment and perform management oversight functions and to clarify and codify roles, responsibilities, and working relationships so that they are sustained beyond transitions that occur with leadership changes and expiration of Board members terms.*

Recommendation: *NSF and NSB should establish and publish a joint NSF-NSB duties and responsibilities document institutionalizing roles and addressing key working relationships.*

Implementation Steps:

- *NSF and Board leadership should develop a joint document highlighting key roles and responsibilities and delineating how they work together. Staff and stakeholder input should be solicited, as appropriate, prior to finalizing the document.*
- *The document should be shared with NSF and NSB staff and posted on both the NSF and NSB websites.*
- *The document should be reviewed annually and updated as necessary.*

MREFC Review Panels and Governing Bodies

A key element for effective stewardship is identifying what information needs to rise to the Director and, in turn, to the Board for informed decision making and proper oversight of major research facilities projects. As noted earlier, much of NSB's work is done through committees and much of the NSF review processes are similarly accomplished though panels and committees. Two review bodies that play important roles in the Director's oversight of MREFC projects are the MREFC Panel and the Director's Review Board. In addition, agency coordinating teams/groups and science directorates' external advisory committees and review panels play major roles at certain points in the project development and execution process.

MREFC Panel

As stated in the MREFC Panel Charter dated January 2015, the Panel's role is to provide governance of the overall MREFC process and review "specific cases" presented by the originating organization(s).[122] Acting in an advisory role to the NSF Director, the Panel makes recommendations on ongoing and candidate MREFC projects as to their readiness for advancement to subsequent project stages or design phases. The Panel is chaired by the NSF Deputy Director (currently the Chief Operating Officer) and comprises assistant directors, program office heads, the Chief Financial Officer, other senior NSF management (including representatives from the Office of the Director), and the LFO Head in a non-voting capacity. Project readiness is assessed using a ranking system developed for NSF large research facility projects by the National Academies of Sciences. In assessing project readiness, the Panel prioritizes projects based on what is referred to as the "third ranking criteria," which represents national criteria assessed across all fields.[123] Presently, as structured, the Panel usually meets

[122] National Science Foundation, *Major Research Equipment and Facilities Construction (MREFC) Panel Charter*, (January 2015).

[123] There are three ranking criteria applied to MREFC projects. The "first ranking" is scientific and technical criteria assessed by researchers in a field or interdisciplinary area (generally at the NSF division level); "second ranking" is agency-specific criteria assessed across related fields (NSF directorate level); and "third ranking" is national criteria assessed across all fields (overall NSF Level). Source: LFM, A-1. These rankings are based on recommendations in National Academies of Sciences, *Setting Priorities for Large Research Facilities Projects Supported by the National Science Foundation,* (2004), pp. 22 and 23.

on MREFC stage reviews only, although the Panel could be called upon to provide other reviews or assessments as directed by the Office of the Director.

The third ranking (national level) currently focuses on merit and science questions ensuring that projects moving through the review/approval gates have the potential to be most transformative. In both the first ranking (NSF division) and second ranking (NSF directorate), there are broad questions addressing project management capabilities and readiness; specifically:

- First Ranking: Are the project-management capabilities of the proposal team of the highest quality?
- Second Ranking: Which projects have the most readiness for further development and construction?

At the third ranking, project management capability is not referenced; however, the Panel's standard operating procedure for project advancement includes key questions on stewardship and project maturity. The MREFC charter also provides for "as needed" meetings where the panel would review status, planning and implementation issues, challenges and concerns, and any policy or budget issues.

The Director's Review Board is charged with assuring, for the Director, that all recommendations and proposed action items have undergone thorough review, assessment and discussion. It serves as the Director's forum for reviewing recommendations to the NSB on critical NSF awards, actions and items—its function includes, but also extends beyond, large facilities. Similarly chaired by the NSF Deputy Director, it includes assistant directors, the Chief Financial Officer, among others, and persons the Director may designate. Joint meetings between the Director's Review Board and the MREFC Panel are sometimes held, as membership between the two can overlap.

Of these two governing bodies, the role of the MREFC Panel is particularly important as it is, in effect, the gatekeeper for advancing projects during the design stages. As such, it is critical that the Panel have the information needed to appropriately judge whether a project is ready to advance. However, once a project is funded and moves into construction and later operations, it appears the Panel has no clear role. From an oversight perspective, NSF is missing an opportunity here. For consistent and informed oversight, the Panel should perform project oversight over the lifecycle of the project's development and implementation, reviewing project status on a set schedule. It should establish a regular, set meeting schedule (monthly or bi-monthly) for reviewing projects ready for gate reviews and status updates on projects in construction, focusing on cost and schedule performance, as well as technical performance. Concerns/issues identified through these reviews should be communicated to the Director's Review Board, which in turn would identify what needs to move forward to the NSB.

Advisory Committees/Review Boards

Advisory committees of the science directorate/office sponsoring a project provide input to the directorate's leadership concerning priorities among projects. The NSF Director requires that the originating directorate obtain an endorsement from the appropriate advisory committee prior to requesting NSB approval of a project in a future NSF budget request to Congress. In addition, when satisfied that the scientific merit of a project justifies advancement to the preliminary design phase, the directorate's assistant director/office head authorizes the designated program officer to organize an external review of the project execution plan. This external review is a critical step for a project to move forward for potential MREFC funding. In addition to assessing scientific and engineering merit, the expert panel is to review management, cost, and schedule issues. Once an award is made, an annual review panel comprising principally external experts reviews all aspects of the project, including assessing technical progress, cost, schedule and management performance. The review usually takes place on-site at the facility. An LFO liaison (representing the LFO) assists the program officer by specifying language to include in the panel's charge, recommending non-scientist panelists and assessing the completed review. Criteria for selection of the reviewers is broadly written—it includes both special and more generalized knowledge of the science and engineering subfields, basic knowledge of infrastructure of the enterprise, and diverse representation which includes organization and geographic areas.[124]

Additional requirements—explicit criteria—are not in place for MREFC projects in terms of experience with other large facilities construction projects or business, fiduciary or project management experience/expertise to assess cost and schedule estimates. A number of officials/managers that the study team interviewed noted the difficulty of assessing cost and schedule estimates and the challenge for the review panels given the time they have to evaluate a project. A 2004 National Academy of Sciences study highlighted the important role review panels play and the need for "outside persons who are experts in technical subjects that the project entails and experienced in project implementation and management."[125] It noted that panels should provide a balance of scientific and project management expertise. Given the heightened importance of the quality of reviews conducted on cost and schedule estimates and evaluations of project performance, it would be beneficial to establish more explicit requirements for project management and financial management knowledge/experience in the written criteria in the agency's guidance manuals regarding the selection of MREFC reviewers.

[124] National Science Foundation, *Proposal and Award Policies and Procedures Guide*, NSF 15-1, p. III-3.
[125] National Academies of Sciences, *Setting Priorities for Large Research Facilities Projects Supported by the National Science Foundation,* (2004), p. 42.

Internal Coordinating Committees

Internally, two formal coordinating committees play important roles—the Integrated Project Team (IPT) and the Large Facilities Working Group (LFWG). Of the two, the IPT is the most significant as it is an action team, whereas the LFWG is advisory. Both teams are new.

The IPT replaced two previous bodies (the Project Advisory Team and Business Operations Team) which were advisory only. The IPT is chaired by the program officer, but the members carry out their office's functional responsibilities. Three groups comprise the IPT:

- Science and Technical—led by the program office, which has primary oversight over the project.
- Award Management—comprised of the key BFA units responsible for assurance. They review and monitor cost, scope, and schedule and the Project Execution Plan.
- Strategic—comprised of representatives from offices in the Office of the Director. They also have an assurance role.

The intent is for each IPT to last the duration of the project. As a new approach, it is still feeling its way. It is not clear from the guidance in the LFM whether and how the IPT may link to the MREFC Panel. Given both the MREFC Panel's and the IPT's roles, this relationship needs to be articulated, particularly with respect to the information, analyses, and/or assessments to be forwarded for the MREFC Panel's review in addition to the information provided by the sponsoring directorate and office.

The Large Facilities Working Group was previously known as the Large Facilities Panel; its role is solely advisory. Its principal tasks are to review and provide comments on draft policies and procedures related to large facilities, providing input on large facilities issues and reviewing internal management plans prior to the conceptual design review.

Given the issues that have been raised by the Inspector General as well as congressional concerns on the management and oversight of MREFC projects, the question arises as to whether existing governing bodies are providing the insight needed to ensure the proper governance oversight of these complex, multi-user research facilities. An overriding theme is whether the bodies have the requisite expertise, both in-house and externally, to effectively evaluate these complex projects and ask the necessary probing questions to assess whether cost and schedule estimates are realistic, given an inherent science "can do" culture of optimism.

Currently, under the Federal Advisory Committee Act (FACA), there is an NSF Advisory Committee for Business and Operations[126] that provides advice to BFA and the Office of

[126] Currently, NSF has 14 advisory committees of external experts who provide advice and recommendations to NSF directorates and offices in the areas of research, education, and infrastructure.

Information and Resource Management on issues related to oversight, integrity, development, and enhancement for improved performance of NSF's business operations. In 2011, the Committee, whose members are a mix of academia, nonprofits and industry, conducted a study of the funding and governance of future large facilities projects. However, the committee does not serve the Director. A FACA committee for MREFC and other high visibility initiatives could provide the NSF Director with direct access to project and cost estimating expertise, affording an independent perspective that can help inform oversight actions. Revisiting the role and involvement of the MREFC Panel would also be helpful as more active involvement throughout the project's lifecycle may provide the panel with the information and knowledge needed to make more informed assessments when a project is being considered for advancement.

Panel Recommendation 6.2

Objective: To add more rigor to the process of reviewing MREFC project readiness and performance at varying stages.

Recommendation: NSF should re-scope the role and duties of the MREFC Panel and amend the Panel's charge to specifically include status update reviews of projects in the development and construction phases focusing on cost, schedule, and performance.

Implementation Steps:

- *The LFO should work with the MREFC Panel to identify the staff support and information needs, including the analyses and assessments conducted by the IPT, to execute its expanded duties.*

Panel Recommendation 6.3

Objective: To help ensure that external review panels include experts with the requisite knowledge and experience to assess cost and schedule estimates and project performance on large facilities projects.

Recommendation: NSF should identify requirements for project management and financial management expertise related to large facilities projects and explicitly add the requirements to the criteria for selection of external reviewers. The criteria should be incorporated in both the Grant Proposal Guide and the Proposal and Award Manual.

Implementation Steps:

- *The LFO should take the lead in developing the criteria based on lessons learned from past MREFC projects. The criteria should be vetted with all appropriate internal and external stakeholders.*
- *The Policy Office should incorporate the agreed-upon criteria in the Grant Proposal Guide and Proposal and Award Manual.*

Panel Recommendation 6.4

Objective: To provide the NSF Director direct access to independent project and cost estimating expertise for reviewing MREFC projects.

Recommendation: NSF should establish a FACA advisory committee for the Director to use as a sounding board for objective insight on large research projects.

Implementation Steps:

- *NSF should initiate the process for establishing a new federal advisory committee under FACA.*

Roles, Responsibilities and Placement of the Large Facilities Office

The role and placement of the Large Facilities Office has been the subject of debate for some time. Varying views on the LFO's role—oversight versus assistance—and where it should be housed, have been raised virtually since the office's inception in 2003. Some believe the LFO should organizationally sit in the Office of the Director for greater credibility, noting it should be independent of the research directorates and the Office of Budget, Finance, and Award Management (BFA) to play the role of "assistance and assurance." Others note it should remain in BFA in order to provide a coordinated assistance and assurance role and not be viewed as a separate oversight office. The version of the America COMPETES Act of 2015 passed by the House also touches upon the organizational placement of the LFO Head as it requires the NSF Director to appoint a senior official within the Office of the Director responsible for oversight of major multi-user research facilities.

NSF established the LFO in response to concerns raised in 2001 and 2002 by both the Congress and the NSF Inspector General that NSF was inappropriately combining funds from the MREFC and R&RA accounts for major facility projects. To respond to those concerns, NSF took actions to tighten oversight of MREFC projects and recruited a Deputy Director for Large Facility Projects (DDLFP) in 2003, who it also designated as the LFO Head—one individual with two titles. The LFO was placed in BFA, reporting to the Chief Financial Officer.

From the start, the LFO focused on instituting project management discipline in the oversight of large facilities projects and developing guidelines for program officers to address risk, financial management and other critical elements involved in the design, development, construction and operations of major multi-user research facilities.[127] The LFO published the Facilities and Management Oversight Guide in 2003, an early version of the Large Facilities Manual. Development of the original guide was heavily influenced by processes and practices in place in the Department of Energy's Office of Science, whose large scale research projects are viewed as

[127] National Science Foundation, *Report to the National Science Foundation on Major Multi-User Research Facilities* (March 18, 2013).

the most analogous to NSF's.[128] Revisions to the LFM over time have been made to strengthen project management practices and add more rigor to the development, review and oversight processes, by adopting key principles from the Project Management Body of Knowledge (commonly referred to as PMBOK) and GAO's best practice guidance on cost and schedule estimating. Throughout this report, we have noted activities underway by the LFO and key guidance sections delineated in the LFM that speak to NSF efforts to tighten oversight of MREFC projects.

In December 2012, the NSF Director commissioned an internal study to assess the processes, policies and mechanisms for supporting large research facilities.[129] The memorandum announcing the effort included the stated expectation that the assessment would lead to recommendations on organizational roles and responsibilities, including those of the LFO. The study noted that over its ten-year history, the LFO had taken the lead role in developing NSF's overall approach for the management and oversight of MREFC projects, working collaboratively to educate and support NSF program officers in their oversight and merit review capacity. The LFO had also worked with other BFA staff to help NSF directorates and offices, as requested, adapt MREFC review processes for other large research infrastructure projects that are funded completely from the Research and Related Activities (R&RA) account. Further, it noted that while primarily an *assistance* provider, the LFO also had an independent *assessment* function for projects in pre-construction and construction and had taken on a *planning* role preparing the annual large facilities plan for the National Science Board.[130]

The study found that performing all three functions—assistance, assessment and planning—is a challenge for a single office and recommended that NSF define these functions more precisely and assign them across the agency to more than one unit. Specifically, it recommended that NSF (1) re-focus the LFO as a Project Assessment Office (PAO) and consider giving it more stature and (2) designate a senior official for large facilities in the Office of the Director to coordinate facilities planning and oversee PAO development. Under the proposed structure, the PAO would lead project assessments while those program assistance functions (training and professional development, policy and guidelines, and sharing of best practices) designed to ensure that program officers are equipped to exercise oversight would shift to other NSF units such as the Policy Office and the NSF Academy. While the study's recommendations to shift the role of the LFO to a project assessment office and transfer assistance functions to other units were not adopted, the identification and analysis of issues influenced actions to improve coordination across the agency and to more clearly define roles and responsibilities.

[128] Interview Notes.
[129] National Science Foundation. *Report to the National Science Foundation on Major Multi-User Research Facilities* (March 18, 2013).
[130] Note: The 2013 Large Facilities Manual identified the MREFC Panel as responsible for developing the Facility Plan. The most recent version of the LFM (June 2015) identifies the LFO Head as the responsible official for the Plan. See discussion on the NSF Facility Plan, p. 70.

As noted earlier, the LFO presently defines its role as one of assistance and assurance. The office provides assistance to program officers and others in carrying out their role in the form of project management expertise, sharing practices and providing support to the program officers. It exercises assurance by actions reviewing award recipient compliance with the terms and conditions set forth in cooperative agreements, as well as the processes and procedures in place for managing and overseeing MREFC projects. It also develops and implements processes to ensure that all facility award instruments include at least four performance evaluation components: (1) clear and agreed upon goals/objectives; (2) project performance measures and performance targets, as appropriate; (3) periodic reporting; and (4) evaluation and feedback to assess performance. LFO staff are assigned as liaisons to individual project program managers and collaborate with them to plan the conceptual, preliminary and final design reviews (CDR, PDR and FDR) and independently assess the quality of the reviews; they also serve on the integrated project team throughout a project's lifecycle and exercise a primary role for oversight and project management support to the program manager. The LFO Head is a member of the MREFC Panel ensuring that MREFC processes are followed at major gate reviews; however, the LFO Head participates as a non-voting member and is the only non-voting member of the Panel.

In the study team's conversations with agency officials, many questioned how an LFO can carry out both roles and whether assurance and assistance are contradictory functions. However, assistance and assurance are not mutually exclusive concepts. While assurance is considered a form of oversight, its focus is on attaining and maintaining program quality by the systematic monitoring and evaluation of a product, service or facility to ensure that standards are met. Ensuring recipient compliance can be done in an assistance mode with the LFO providing support to program officers in project management practices—in essence, the LFO is assisting program officers as they exercise their responsibilities to ensure there is proper stewardship of federal funds and that science objectives are achieved. Assurance performed in this manner is more collaborative and is focused on agency mission. Other BFA units carry out oversight functions, as well, reviewing and monitoring various management and fiduciary elements, while managerial oversight encompasses NSF leadership and the NSB. In addition, overall program and agency oversight functions are performed by the Inspector General, GAO, and the Congress.

Typically, the science directorates have had considerable autonomy in managing projects. Given the heightened scrutiny of MREFC projects and agency efforts to respond to numerous concerns raised by the Inspector General and the Congress, it is critical that processes and practices for overseeing MREFC projects be codified and consistently applied. The LFO has a major role here working with the science directorates and program officers and has taken a number of steps to further improve project management practices. The LFO has been building its own capacity—it has hired two additional staff members who are certified project managers—and has established an internal requirement that LFO staff will be certified. Current staffing is four federal permanent employees and one rotator, who is on a visiting scientist appointment (when that appointment expires, the plan is to replace that individual with another visiting scientist to ensure that the LFO has an up-to-date perspective from the science community). The LFO Head, who had been acting for the past year and was recently appointed to the position in September

2015, is a scientist and engineer—and an experienced project manager. He appears to be well respected by colleagues internal and external to the agency, based on comments repeatedly shared with the study team. He has been working to build capacity in the LFO, actively engaging program officers and others, and cultivating strong working relationships across the agency. Effective internal coordination, clarity of processes, and consistency across the MREFC portfolio are high priorities for the office.

Given all the initiatives and activities underway—and the culture change taking place across the agency—time is needed to socialize the changes and then to evaluate, from a continuous improvement perspective, what is working and what requires further adjustments. Ultimately, where the LFO organizationally resides is not as important as clear project management roles, responsibilities, and authorities—together with leadership support. NSF needs to focus on building project management capabilities and capacity across the agency, and the LFO holds the appropriate toolkit to lead/coordinate this effort. Transferring the function to the Office of the Director could be disruptive to current efforts, create potential conflicts, and be perceived as shifting the balance of power. Moreover, LFO responsibilities better align with BFA units which form the nexus of the functions critical to support the agency's project development and execution—budget, acquisition, finance and cost analysis, project management, and audit resolution. An effective coordinated approach across these units is essential to avoid inconsistent, contradictory or duplicative processes/efforts. This is even more important today as the need for tightened oversight has intensified. The CFO is the accountable executive for these functions and plays a prominent role in the agency's governing bodies. Accordingly, the Panel is not recommending that the LFO be moved to the Office of the Director. The Panel is recommending, however, that staffing in the LFO be augmented by adding two additional FTEs. As the National Academy of Sciences noted in a 2004 report,[131] adequate staff and institutional authority are necessary to assure NSF leadership and the NSB that proper project management is in place and work is progressing on schedule and within budget. The Panel concurs with that statement and finds it as relevant today—if not more so—as it was in 2004. The Panel is also recommending that the LFO Head's authority be broadened by granting the Head full membership status on the MREFC Panel as a voting member.

Panel Recommendation 6.5

Objective: To further build capacity in the Large Facilities Office and to clarify the role, authority and accountability of the Head of the Large Facilities Office on the MREFC Panel.

Recommendation: NSF Director should (1) authorize the LFO to hire two additional FTEs and (2) direct the MREFC Panel charter be revised changing the status of the LFO Head from a non-voting member to a full member with voting rights.

[131] National Academies of Sciences, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation* (2004), p. 42.

<u>Implementation Steps:</u> NSF should initiate the process for hiring additional LFO staff and revising the MREFC Panel charter.

<u>Annual Facility Plan and Portfolio Management Process</u>

The Large Facilities Manual describes the NSF Facility Plan as a "valuable planning tool both within and outside NSF," providing a "comprehensive exposition of needs and plans to inform decision-making in the Executive Branch and Congress," and serving "as an important vehicle for communicating with research communities."[132] The intent, as stated in the LFM, is to reflect the Administration's priorities for "new start" projects, NSB priorities for NSB-approved projects, and the NSF Director's priorities for MREFC projects in the Preliminary Design Phase with ongoing MREFC projects always receiving the highest budget priority. The plan is updated annually and is a publicly available document according to the LFM. Considerable detail is provided in the LFM including descriptions of key sections of the Facility Plan. For example, the first section of the plan is to provide an extensive discussion of the "frontier" research objectives and opportunities establishing the context and compelling need for major facilities derived from workshops, advisory committees, National Research Council (NRC) reports, expertise of visiting and permanent scientific staff, and unsolicited proposals from the community. The second section provides an update on the status and progress of each MREFC project and candidate projects while mapping them to the objectives and opportunities contained in the first section. The Deputy Director for Large Facility Projects—the LFO Head—is responsible for developing and maintaining the plan which is approved by the NSF Director and submitted to the NSB in February of each year.

Although the LFM provides ample detail on the Facility Plan, the Academy's review brought to light several salient questions concerning its actual status. Specifically: (1) what is the current purpose and use of the document—is it a decision document for leadership or an information document capturing decisions essentially already made; (2) is it strategic or a combination of strategic and operational and if so, what is its relationship to the agency's current budget and strategic planning processes/documents as those processes have evolved; and (3) importantly, who is the intended audience/customer(s) today? Part of the confusion over the plan's purpose may be due to the evolving nature of the portfolio review process.

Interestingly, in discussions with NSF and NSB officials, the intent of the plan was not quite as evident as the LFM description would indicate, with questions raised as to the objective of the plan—is it strategic, an informational status update, or a review of progress and challenges? The plan's customers as currently defined are quite broad—both internal and external—leading to the question, "who is the plan serving?" Efforts to locate the current plan on the NSF website were unsuccessful although the study team was provided a copy of a briefing slide deck, entitled, "Annual Facilities Plan 2015." Some prior plans were available and variations in the structure/composition of those plans demonstrate that the document has evolved over time.

[132] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 3.2 (June 2015).

The 2007 Facility Plan and the 2008 Facility Plan, for example, are polished documents describing overall research objectives with considerable narrative detail on specific MREFC projects under construction, new starts and potential future projects. Conversely, the content of the 2012 plan provided to the study team was a set of very detailed briefing slides with notes presenting the portfolio of NSF facilities across the life cycle of the projects (including those in operations) and addressing the lifecycle stages of a facility and design phases/approval gates. We were told that the most recent version of the plan as presented to the NSB was developed based on input from the NSB working with NSF to develop a format that would be useful to all parties. It is a high-level briefing document, highlighting project stages and the MREFC process and projects in those various stages, together with projected costs.

Historically, the origins of the plan go back to 2004 and reflect NSF's response to a National Academy of Sciences review[133] and recommendation that NSF create a roadmap documenting priorities set among large facilities projects. The report also recommended that the MREFC funding request be based on this roadmap. In response to the report, the NSB and NSF developed and issued a joint report in 2005—*Setting Priorities for Large Research Facilities Projects Supported by the National Science Foundation*.[134] To implement the roadmap recommendation, NSF established the NSF Facility Plan to "report on major projects under construction and in various stages of development, together with an extensive discussion of the science objectives and opportunities at the frontiers of science and engineering that provide the context and compelling need for major facilities." At least annually, the NSF Director was to provide an update to the plan, which the NSB would review. It was envisioned that the plan would be a valuable planning tool within NSF and the Executive Branch to inform congressional decisions and communicate with the research communities. The language in the LFM describing the purpose of the plan is largely taken from the language in that joint NSB-NSF 2005 report.

More recent discussions of the Facility Plan have framed its purpose and use differently. A March 2011 report by the Business and Operations Advisory Committee, Ad-Hoc Subcommittee on Funding and Governance of Future Major Research Facilities, noted that the NSF Facility Plan identifies a small group of projects in advanced stages of development that NSF believes is ready to go to the Board for approval. The report describes the plan as representing NSF's view as the Board performs its own portfolio review, including the assessment and prioritization of projects presented by NSF.[135] It also noted that research priorities are largely established within the science directorates. The NSB's FY 2012 Annual Portfolio Review of Facilities[136] refers to the Facility Plan as a non-advocate input prepared by the NSF Large Facilities Office covering MREFC

[133] The National Academies, *Setting Priorities for Large Research Facilities Projects Supported by the National Science Foundation,* (2004), pp. 21-30

[134] National Science Board, A Joint National Science Board-National Science Foundation Management Report: Setting Priorities for Large Research Facilities Projects Supported by the National Science Foundation (September 2005).

[135] National Science Foundation's Business and Operations Advisory Committee, *Report of the Ad-Hoc. Subcommittee on Funding and Governance of Future Major Multi-user Facilities,* March 17, 2011.

[136] National Science Board, *Annual Portfolio Review of Facilities FY 2012* (NSB-12-44), July 18, 2012.

projects in planning construction and operation. It states that the Facility Plan includes current budget information and budget requests for the following year, and is used to inform the Board's annual portfolio review; the portfolio review, in turn, informs Board decision-making and guidance on project prioritization and strategic budget planning's portfolio review. Finally, the March 2013 report on Major Multi-User Research Facilities stated the NSB annual portfolio review takes place following the presentation of the Large Facility Plan and is a process that enhances the Foundation-wide *portfolio planning* function by providing an opportunity for NSF senior management to work with the Board on long-range planning and position the major multi-user research facilities portfolio at the forefront of discovery and innovation.[137]

These descriptions do not align readily with the definition in the recently revised LFM, which has retained the identical language from earlier versions of the LFM (e.g., 2013 and 2007) with one exception—responsibility for developing and maintaining the plan has shifted from the MREFC Panel to the Deputy Director for Large Facility Projects. This raises the question as to whether this is the appropriate placement of the responsibility for developing an agency roadmap as originally intended by the National Academy of Sciences study. Portfolio planning and review can occur at the division, directorate, and agency-wide levels—and the NSB has a critical role reviewing the agency's portfolio, being attentive to balance across organizations and science communities. However, most officials the study team spoke with noted that the agency did not have a consistent or institutional approach to portfolio management—it varied among NSF organizations. Effective portfolio management requires formalized processes that capture the long-term, joint NSF and NSB perspective based on input from a wide range of stakeholders. It requires frequent communications with stakeholder communities and should be a key element of the agency's strategic planning process. The fundamental question is two-fold: (1) whether the Facility Plan—and its place in agency portfolio management—is relevant today as a standalone document, particularly in light of tight budgets and the limited number of MREFC efforts currently in the budget and on the horizon and (2) only, if still relevant, should the LFO Head continue to have the lead responsibility for preparing the plan given the LFO's principal responsibilities in project management and oversight rather than portfolio planning.

Panel Recommendation 6.6

Objective: To reassess the need for a separate Facility Plan and only if validated, provide clarity on its: (1) purpose and uses, (2) target audience, and (3) key roles/responsibilities for its development.

Recommendation: NSF should evaluate how it develops and uses the NSF Facility Plan (processes, form and format) and how it aligns with the agency's current budget and strategic planning processes, assessing (1) the plan's value to both NSF and NSB decision-makers and key stakeholders, (2) whether a standalone plan is necessary or whether it can be incorporated into

[137] National Science Foundation, Report to the National Science Foundation on Major Multi-User Research Facilities (March 18, 2013).

existing budget and strategic plans, and (3) if necessary as a standalone plan, who should be the lead for developing the plan.

Implementation Steps:

- *The NSF Director and NSB Chair should establish a working group to analyze the current plan intent, key roles in the development process, and uses—and identify necessary adjustments.*
- *In assessing the NSF Facility Plan, the working group should validate who is the intended key customer(s) of the plan and seek input from both internal and external stakeholders. Assessment criteria should include determining the value (cost/benefit) of the plan and its relationship with other agency planning processes.*
- *Recommendations should be vetted with all appropriate internal and external stakeholders.*

Project Management Skills Essential for Effective Management and Oversight

Effectively implementing robust project management practices requires establishing bench strength with individuals who have solid project management knowledge credentials and experience. GAO's best practice guidance and OMB Circular A-11, Capital Programming Guide (2014), guidance address how to develop and manage large capital efforts. The guidance focuses on building accountability and ensuring proper stewardship of federal funds through effective project management and defines the key elements which can be applied to CAs, as well as contracts. The comparator agencies that we examined implemented formal project management development requirements described in Chapter 5 consistent with OMB requirements for certification of federal acquisition program and project managers. The standards were established in 2007 and updated in 2013 and delineate competencies necessary for developing skilled, professional program and project managers who are defined as essential to the success of agency missions. The role of the program and project manager is to develop project requirements, lead integrated project teams, and oversee budgeting and governance processes—all critical steps in ensuring that expected project outcomes will be achieved and mission needs fulfilled.[138] While not a requirement for managing cooperative agreements, competency elements can be adapted for staff involved in managing and overseeing these equally complex, major capital efforts—MREFC projects. To do so, involves an investment in training and development. But this investment can be scaled and scoped to meet the needs of the agency.

NSF managers (program officer through executive leadership) have especially strong science credentials; however, they are not as likely to have corollary skills and experience in project

[138] Memorandum for Chief Acquisition Officers and Senior Procurement Executives, "Revisions to the Federal Acquisition Certification for Program and Project Managers (FAC-P/PM), Office of Management and Budget, December 16, 2013. Please see Appendix F for a listing of federal project management competency requirements that apply to executive agencies. The Department of Defense is exempt as it has agency-specific guidance and training on competency requirements managed by the Defense Acquisition University.

management. As noted earlier, NSF does not currently have requirements for project management training or certification for internal NSF staff. The study team was told, by a number of officials and individuals interviewed, that historically there has been some reluctance to institute mandatory training requirements given the NSF culture and its highly educated workforce drawn largely from academia. We also learned that project management training was available in-house in the past through ESI, a project management vendor and management consultant firm, but the program was terminated due to high cost of the training. Currently, the NSF Academy—NSF's internal learning organization—offers only a Fred Pryor one-day overview course on project management primarily geared to administrative support staff. The NSF Academy has been focusing on developing mandated training courses and workshops on merit reviews[139] and on executive and managerial development offerings. A one-day course on large facilities management is listed in NSF Academy Session I materials on merit review basics as an available "classroom core program management" course offered biannually for program managers who manage large facilities or are interested in the "unique factors that must be considered in managing *grants* that fund large facilities." However, the study team was told that the course has not been offered in some time. Individual employees can seek project management training and certification on their own through external vendors if funds are available and the training approved by the appropriate NSF manager.

Efforts are presently underway in the LFO to build project management capability to provide assistance to program officers agency-wide. The Large Facilities Manual defines the LFO as the NSF-wide resource on project management. However, project management knowledge and skills are needed throughout the agency at varying levels—from program manager to the executive leadership. For some, particularly senior line managers, familiarity with project management processes and tools such as earned value management—for example, how to read an EVM report; how to assess what is reported to know whether a project is on track or about to go off the rails and need intervention—will be sufficient. For others, and specifically program officers, more detailed knowledge and experience are required. Just as importantly, project management competency must be in place in the award recipient's organization in addition to the agency as an agency can have solid processes and checks and balances in place, but if the awardee is deficient in these same areas, the project may experience significant cost overruns and schedule slippage. Currently, certification requirements are not specified in CAs for recipients. The assumption, it appears, is that the awardee will choose a highly qualified project manager to lead the effort. Grants and agreements officers and program officers have a role reviewing the proposed staffing for a project. However, requiring that awardee project staff include certified project managers with experience in leading complex research projects would help to ensure that the staff managing the on-site project have the skills necessary to deliver

[139] The NSF Academy offers a 2-day Program Management Seminar that focuses on the history of NSF and roles/ responsibilities of key offices and functions and four "Merit Review Basics" sessions that sequentially address the lifecycle of program management. Sessions I (overview, criteria, and conflict of interest) and II (review strategies, communication and fairness) are mandatory for new program managers and must be taken within the first 90 days of employment at NSF. Sessions III (recommendations, justifications and requirements) and IV (post award management, program budgets and new funding opportunities) are optional.

the project as defined by the cooperative agreement. Examining the NEON project from a "lessons learned" perspective may be an instructive learning tool for future project/program managers as issues with project management permeated the award recipient's organization and governance practices, as well as the agency's.

Formally establishing NSF communities of practice, participating in government-wide communities of practices, and setting formal processes for documenting and sharing project management lessons learned would also be helpful. The Academy's 2004 study noted that processes for sharing management knowledge and experience were lacking and recommended the creation of a knowledge-sharing program, in the spirit of a learning organization, to encourage the exchange of ideas. The study team was told that the program officers forum, organized and led by the LFO, has been recently revitalized and is considered a community of practice for internal NSF staff involved with large facilities projects (although it is open to other interested staff as well) while the annual large facilities workshop is meant to share practices among MREFC recipients. Both of these efforts have been underway with mixed results for a number of years—but feedback recently from those who have attended sessions has been positive. These efforts need to be capitalized upon and further cultivated. In addition, GAO hosts a community of practice on cost, schedule and EVM best practices. In the past, some NSF staff have attended—the meetings are open to anyone who wants to participate and includes government, nonprofit and industry individuals with interests in the area—and the study team was told that a new staff member who recently joined the LFO will be attending the meetings regularly. However, there has not been an official commitment or designation of NSF staff or offices (who attends can certainly rotate) to attend the meetings and in turn, share practices, and emerging issues gleaned during the session with the NSF community involved in overseeing major projects. The meetings also provide a valuable opportunity to network with others across government and industry with responsibilities in the lifecycle of large capital investment projects.

Finally, internal NSF processes for documenting and sharing project management lessons learned are not clearly defined. The LFM references that the LFO Head "fosters the sharing of lessons learned and the use of best practices from prior projects,"[140] but the form it takes is not specified. DOE's governing internal guidance for "Program and Project Management for the Acquisition of Capital Assets"[141] requires projects to develop "lessons learned" documentation within 90 days after the approvals of critical decision CD-3 (approve start of construction) and CD-4 (approve start of operations or project completion). While the Office of Science is actually exempt from this agency-wide requirement, its leadership chose to require lessons learned documentation on all projects, regardless of funding type, with a total project cost of $10 million or more.[142] A standard template is provided and projects are to address three major successes and three potential improvement lessons learned—so the focus is not simply on the

[140] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 2.1.6-12 (June 2015).
[141] Office of Science, Project Lessons Learned Template for Post CD-3 and CD-4, January 30, 2012.
[142] The one exception is if the duration between CD-3 and CD-4 is less than one year, then the requirement is waived.

negative or what not to do. The intent is for the document to inform agency policy and the management of future efforts. This is not unlike a post implementation review assessment for information technology projects. Similarly, NASA formally documents lessons learned and captures them in an online lessons learned information system. NASA requires that projects develop a knowledge management plan to identify strategies and processes for capturing and transferring knowledge. Instituting these type of approaches tailored specifically to NSF needs would benefit the agency.

Panel Recommendation 6.7

Objective: To develop and strengthen project management skill capabilities across the agency.

Recommendation: NSF should identify project management skill requirements by role and develop/implement required corollary role-specific project management training/workshops.

Implementation Steps:

- *The LFO should work with the NSF Academy to conduct a needs assessment to identify project management knowledge and skill requirements by role and use the results to develop and implement role-specific project management curricula.*
- *The LFO and NSF Academy should develop NSF-tailored seminars for senior leadership focused on their oversight responsibilities.*
- *The NSF Academy should explore arrangements with other federal agencies such as NASA and DOE to take advantage of established federal courses addressing project management principles for capital investments, EVM, work breakdown structure, cost estimating, and the like.*

Panel Recommendation 6.8

Objective: To ensure that award recipients have the requisite project management experience and knowledge to successfully lead a MREFC project.

Recommendation: NSF should require award recipient project managers be certified in project management. NSF should also specify the minimum project management experience thresholds for project positions in the programmatic terms and conditions of the cooperative agreement.

Implementation Step:

- *NSF program officers and Grants and Agreements Officers should work together to include project management certification and requisite experience requirements in cooperative agreements for MREFC projects.*

Panel Recommendation 6.9

Objective: To facilitate project management knowledge sharing across the agency and with award recipients.

Recommendation: NSF should formally establish communities of practice to share best practices and implement a "lessons learned" requirement for all MREFC projects.

Implementation Steps:

- *The NSF Academy should promote the formation of communities of practices and encourage staff participation.*
- *The LFO should develop a lessons learned process and template to capture instructive experiences from projects and to inform policies and practices to strengthen the management of future projects.*

The Cost of Increased Oversight—Considerations

NSF's lean mission support structure presents a challenge to efforts to augment accountability mechanisms. In FY 2014, NSF's "agency operations and awards management" account represented 4.3 percent and in FY 2015, 4.4 percent of the agency's total budget, while overall overhead represented about 6 percent. This is considerably less than other agencies, and presents resource constraints and challenges to efforts to build additional project management capacity and accountability mechanisms. In recognition of both these burgeoning oversight requirements and NSF's need for more focus on management excellence, NSF has approved the hiring of additional staff in the Office of Budget, Finance and Award Management based on BFA's evaluation of its staffing requirements within the Large Facilities Office, the Division of Acquisition and Cooperative Support and the Cost Analysis and Audit Resolution Branch. LFO has added one additional full-time-equivalent (FTE) this year and now has four permanent staff plus one rotator (a visiting scientist). DACS/CSB is adding two additional staff increasing to nine permanent FTEs. And, CAAR has added three FTEs. In addition, the LFM has been modified to read "Program Officer (or Program Officers)" recognizing the fact that some complex or challenging projects may require more support at the program level, as well.

Unfortunately, budget cuts through the appropriations process most often target internal operations and salary and expense accounts. NSF requested a 9.2 percent increase in the FY 2016 operations and awards management budget, or 4.6 percent of the total budget. While tensions and tradeoffs are inherent between the NSF mission of advancing science and instituting strengthened accountability systems—especially, within a government-wide environment of tight budgets and intensified external oversight—the agency will need to reassess priorities and make the hard budget decisions necessary for moving forward. The many agency changes and initiatives underway or about to be implemented—along with the additional hiring actions in play—make estimating potential additional costs and resource requirements in the recommendations identified throughout this report difficult at this time. As a result, the Panel is not specifying additional staff needs beyond the recommendation for two additional staff members in the LFO. NSF will need to evaluate the impact of hiring actions currently underway against workload, and develop/update workforce plans to address needs. It is likely that additional staff resources will be indicated. Additional funding will also be necessary to implement the project management training recommendations; total cost will

depend on the results of a needs assessment and the ability to leverage existing training/course materials available from other federal agencies.

Acknowledging concerns about the administrative burden placed on agencies and award recipients is a piece of the equation of balancing the requirements for increased oversight with the costs of implementing them. Two recent studies[143] (one conducted by the NSB and the other, a congressionally requested National Academy of Sciences review) highlighted concerns and issues associated with administrative and compliance requirements—specifically, federal regulations, policy and guidance—associated with federally funded research and offered a number of government-wide policy considerations and recommendations for streamlining and eliminating duplicative requirements. Both studies reinforced the need for effective oversight and ensuring accountability, performance, and proper stewardship of federal funds—and efforts to prevent fraud, waste and abuse—while also calling attention to the costs associated and the need to weigh those costs and the value of new requirements against facilitating the advancement of science. Although these studies did not specifically address MREFC projects (their focus was largely on universities and principal investigators), the question of administrative burden is not without merit. What distinguishes MREFC projects is the nature of these complex research facilities. They are high-risk, high-dollar, and high-visibility capital investment projects. It is critical that the proper degree of oversight be in place to monitor performance. Introducing rigor in governance and project management is not in conflict with good science—rather, it enables good science. Continuously reviewing oversight processes and practices to ensure they meet their intended objective and are both cost and value effective for the agency and the awardees will in the long run enable NSF to better discharge its mission to pursue transformative science.

[143] National Science Board, *Reducing Investigators' Administrative Workload for Federally Funded Research* (NSB-14-18), March 10, 2014 and The National Academies of Sciences, Engineering, and Medicine, *Optimizing the Nation's Investment in Academic Research: A New Regulatory Framework for the 21st Century, Part 1*, September 2015.

APPENDIX A: PANEL AND STAFF

PANEL

Earl Devaney* (Chair), Former Chairman, Recovery and Transparency Board and Inspector General, Department of the Interior; Inspector General, Department of the Interior; Director, Office of Criminal Enforcement, Forensics and Training, Environmental Protection Agency; various positions including as Special Agent in Charge, United States Secret Service.

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Pamela Haze,* Former Deputy Assistant Secretary for Budget, Finance, Performance, and Acquisition, U.S. Department of the Interior; former positions in the Office of Budget, U.S. Department of Interior: Director, Co-Director, and Deputy Director; Analyst, Fish and Wildlife Service; Biological Resources Manager, U.S. Geological Survey.

Sean O'Keefe,* Howard G. and S. Louise Phanstiel Chair in Strategic Management and Leadership, Maxwell School of Citizenship and Public Affairs, Syracuse University. Former Chairman and Chief Executive Officer, EADS North America; Vice President, General Electric Company; Chancellor, Louisiana State University; Administrator, National Aeronautics and Space Administration; Deputy Director, U.S. Office of Management and Budget; Louis A. Bantle Chair in Business and Government Policy, Maxwell School of Citizenship and Public Affairs, Syracuse University; Special Assistant to the Senior Vice President for Research, Dean of Graduate School, Professor of Business Administration, Pennsylvania State University; Secretary of the Navy; Comptroller and Chief Financial Officer, U.S. Department of Defense; Staff Director, Senate Defense Appropriations Subcommittee, U.S. Senate.

Beth Robinson,* Chief Financial Officer, Air Line Pilots Association, International; former Chief Financial Officer, National Aeronautics and Space Administration; Assistant Director for Budget, Budget Review Division, U.S. Office of Management and Budget; Deputy Director, Congressional Budget Office; Deputy Assistant Director for Budget Review and Concepts, and Program Examiner for Energy Issues, U.S. Office of Management and Budget; Staff Member, House Committee on Science, Space and Technology, U.S. House of Representatives; Project Director and Expert, Office of Technology Assessment, U.S. Congress; Congressional Science Fellow, Geological Society of America; Fellow, National Science Foundation; Assistant Professor of Geophysics, Stanford University.

Richard (Rick) Johnson, Chief Executive Officer and Founder, Global Helix LLC; retired Senior Partner and current Senior Counsel, Arnold & Porter, LLP; former General Counsel for International Trade, U.S. Department of Commerce; Chair or Vice Chair, Organization for Economic Cooperation and Development (OECD) committees and task forces; member of National Academy of Sciences panels and projects and university councils at Brown and Massachusetts Institute of Technology.

Academy Fellow

ACADEMY STUDY TEAM

Joseph P. Mitchell, Ph.D., *Director of Academy Programs*—leads and manages the Academy's studies program and serves as a senior advisor to the Academy's President and CEO. He has served as Project Director for past Academy studies for the Government Printing Office, the U.S. Senate Sergeant at Arms, USAID/Management Systems International, the National Park Service's Natural Resource Stewardship and Science Directorate, and the USDA Natural Resources Conservation Service. During his more than 10 years at the Academy, Dr. Mitchell has worked with a wide range of federal cabinet departments and agencies to identify changes to improve public policy and program management, as well as to develop practical tools that strengthen organizational performance and assessment capabilities. He holds a Ph.D. from the Virginia Polytechnic Institute and State University, a Master of Public Administration from the University of North Carolina at Charlotte, and a B.A. in History from the University of North Carolina at Wilmington. He recently completed a Master of International Public Policy with a concentration in American Foreign Policy from the Johns Hopkins University School of Advanced International Studies.

Cynthia Heckmann, *Project Director*—previously served as Project Director on the Academy's reviews of the Department of Justice's Civil Rights Division and the Center for Disease Control (CDC) Human Resource Process Review. Her extensive career at the Government Accountability Office includes serving as the Chief Human Capital Officer (CHCO) and Deputy Chief Information Officer. Ms. Heckmann also has executive branch experience, as well as state government experience. She has served as a strategic advisor on research studies for the Partnership for Public Service and is a CHCO SAGE—Strategic Advisor for Government Executives—for the Partnership. Ms. Heckmann holds a Masters of Public Administration from Northeastern University and a Bachelor of Arts from Simmons College. She also attended the Executive Fellows Program at Harvard University's John F. Kennedy School of Government and Yale University's School of Organization and Management.

Allison Brigati, *Senior Project Advisor*—serves as General Counsel for the Academy. An attorney since 1990, Allison has experience in legal analysis, investigative functions, and organization and management issues. She started with the Academy as a Senior Advisor in 2008, and served in that role for studies relating to the Office of National Drug Control Policy, Federal Emergency Management Agency, Government Accountability Office, and the Department of Commerce's Office of Inspector General. She became the Academy's Legal Counsel in late 2008, and manages all legal issues relating to the Academy and its daily operations, as well as serving as an advisor to the President, Directors and CFO. Prior to joining the Academy, Ms. Brigati served in a variety of legal, investigative and management roles, including various posts at the World Bank, as Senior Advisor to the Director, Senior Quality Assurance Officer, and Senior Institutional Integrity Officer for the Department of Institutional Integrity, as well as Senior Counselor for U.S. Affairs in the Department of External Affairs. She received her B.A. from the University of Notre Dame (1987), and a J.D. from Boston University School of Law (1990).

Nicole Camarillo, *Project Development Advisor*—is the Associate General Counsel and Project Development Advisor for the National Academy of Public Administration. She has a legal background in regulatory compliance and employment law issues and extensive experience working for nonprofits on a variety of advocacy issues and has federal campaign experience. At the Academy, Ms. Camarillo assists the Academy's General Counsel on all employment law and policy matters affecting the organization. She also serves as a legal advisor on Academy studies, particularly those involving legislative and regulatory matters. Ms. Camarillo assists the Director of Academy Programs with the development of Academy proposals and studies. She received her B.A. from Stanford University and her J.D. from the University of California, Berkeley School of Law.

Chloe Yang, *Research Analyst*—is a Research Analyst at the Academy. Since joining the Academy in 2009, she has worked on projects involving a range of federal agencies, including the Office of Management and Budget, Pension Benefits Guarantee Corporation, Amtrak Office of Inspector General Organization, U.S. Coast Guard, and the Government Accountability Office. These projects span the fields of budget, financial management, strategic planning, intergovernmental collaboration, and performance management. For each of the projects, Ms. Yang provided research and analytical support and was a co-author of each final report. She received her B.A. from Renmin University in China and her M.P.A. from George Mason University.

Eric Christensen, *Research Associate*—graduated from the State University of New York at Albany with a BA in Political Science. After graduation, he served as a campaign manager in a mayoral election; interned for U.S. Senator Charles Schumer and volunteered on voter outreach for City Councilman Vincent Gentile in Brooklyn. He received his MPA from Cornell University, Cornell Institute for Public Affairs and is a member of Pi Alpha Alpha national honor society for public affairs and administration. Mr. Christensen served as a consultant on Rural Regeneration in Haiti while at Cornell University. He also interned for Public Policy Solutions, Inc., in San Luis Obispo, CA and was a consultant for Tompkins County Government while at Cornell University.

He co-authored and co-edited a report on budgetary priority setting, performance measurement, shared services and charter revision for Tompkins County.

Adam Darr, *Research Associate*—recently joined the Academy as a Research Associate having previously interned in the summer of 2013. He graduated from Virginia Commonwealth University (VCU) with a B.A. in Political Science and Homeland Security and Emergency Management. Prior to joining the Academy, Mr. Darr interned with the Henrico County Office of Emergency Management as an Emergency Management Specialist where he created a countywide program to facilitate better disaster response and recovery by coordinating monthly meetings for all faith-based organizations within the county. He also spent past summers interning with the Fairfax County Public Schools in the Office of Family and Early Childhood Education. He has worked during two General Assembly Sessions within the Virginia House of Delegates under Delegate Thomas Davis Rust and Delegate Barbara Comstock, respectively.

APPENDIX B: PARTICIPATING INDIVIDUALS AND ORGANIZATIONS

(Titles and positions listed are accurate as of the time of the Academy's initial contact)

The Panel and study team met with numerous stakeholders through formal interviews, meetings, and discussion groups. The Academy would like to thank these individuals for their contributions.

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APPENDIX C: NATIONAL SCIENCE FOUNDATION PROJECT MANAGEMENT AND OVERSIGHT

NSF policies and recommended practices for award recipients and NSF staff on the development and implementation of large facility projects are delineated in the Large Facilities Manual (LFM). The LFM is considered a living document to be updated and revised periodically. It is also technically a chapter—Chapter XIII—of NSF's internal policy guide, the Proposal and Award Manual. The Large Facilities Office (LFO) is the "owner" of the manual and has the lead role in updating requirements, policies, and practices. First introduced as the Facilities and Management Oversight Guide in 2003, the LFM has been updated a number of times since then to reflect new and strengthened oversight roles, policies and procedures; the current version, published in June 2015, incorporates NSF's recent efforts to apply its processes to the entire life cycle of a project.

The key project management policies and procedures described in the LFM are highlighted below.

Roles and Responsibilities

NSF has a multi-layer oversight structure for large facility projects. Principal participants and their responsibilities are:

NSF Directorates (originating organizations)

Within NSF Science Directorates, there are three levels of line management responsibilities and authorities. Program officers (POs) have the primary oversight responsibility for all project-related issues and interact with award recipients on a daily basis. Division directors oversee the planning, funding, development, and reviews of large facility projects within the division. *Assistant directors* develop the directorate's strategic plans and budget; select and advance prospective projects based on community inputs; and oversee the development of all large facility projects within the directorates.

Institutional Support

Multiple individuals and organizations provide institutional support to large facility projects. Grants and agreements officers (G/AO) from the Division of Acquisition and Cooperative Support, BFA, are responsible for awarding, administering, and monitoring cooperative agreement (CAs) for large facility projects. The G/AO (and other BFA staff) provides a variety of services to program officers throughout the lifecycle of a project. For example, they assist with drafting program solicitations, review program solicitations, negotiate CA terms and conditions, facilitate proposal review processes, and provide advice on business requirements and agency policies.

The Large Facilities Office (LFO) serves as the "NSF's primary resource for all policy or process issues related to the development, implementation, and oversight of Major Research Equipment and Facilities Construction (MREFC) projects,"[144] providing project management assistance and assurance—ensuring compliance with policies, guidance, and best practices—to both NSF program staff and recipients. The LFO Head (who also holds the title of Deputy Director for Large Facilities Projects) reports to the Chief Financial Officer (CFO)/Head of BFA. The LFO Liaison is the designated project management advisor (i.e., the LFO staff member assigned to a project) providing policy and procedural advice to assist program officers in developing and overseeing MREFC projects.

Coordinating and Advisory Bodies

Each large facility project has an integrated project team (IPT), which is chaired by the program officer and comprises representatives from the originating organization (for scientific and technical expertise), the LFO and BFA (for business and project management expertise), and the Office of Director (for strategic direction). The IPT meets at least quarterly and serves as a coordinating body throughout the design and construction stages. The IPT is new and replaces the Project Advisory Team and the Business Oversight Team, which were more advisory in nature. The intent is for the IPT to provide a more integrated, formalized oversight and assurance project management structure.

The Large Facilities Working Group (LFWG) is chaired by the LFO Head with members appointed by assistant directors and with ex officio members from the Office of the Director, General Counsel, and BFA. It is also new, replacing the large facilities panel, and serves in an advisory capacity for reviewing and commenting on draft policies and processes related to large facilities and addressing other large facility issues.

The Advisory Committee of the Originating Directorate or Office provides input concerning priorities. The NSF Director requires endorsement of a proposed project from the appropriate Advisory Committee prior to requesting the National Science Board (NSB) approval to include the project in a future NSF budget.

Governing Bodies

Two high level panels play key governance roles in addition to the NSF Director—who is ultimately responsible for proposing new projects to the NSB, the Office of Management and Budget (OMB) and Congress and for obligating MREFC funds—and NSB, who reviews and approves MREFC budgets and large awards for funding specific MREFC projects.

The MREFC Panel is chaired by the NSF Deputy Director (currently the Chief Operating Officer serves in that role in an acting capacity) and consists of assistant directors, program office

[144] NSF website. https://nsf.gov/bfa/lfo/index.jsp.

heads, the CFO and other senior management representatives. The MREFC Panel reviews MREFC projects/proposals and assesses their readiness to advance to the next lifecycle phase/stage[145], and makes recommendations to the Director. The *Director's Review Board* (DRB) is chaired by the Deputy Director and comprised of assistant directors, the CFO, and other senior management representatives from NSF directorates and offices. It reviews and approves MREFC project proposals at the end of the Preliminary Design Review and the Final Design Review. DRB's responsibility extends beyond MREFC projects, reviewing all requests and materials to be submitted to the NSB.

Lifecycle Management

For large facility projects, NSF has developed a lifecycle management process that includes five stages:

- ***Development:*** Large facility projects are selected and prioritized at the directorate level within NSF, with inputs from the research community. Community input is collected through various methods, such as National Academy of Sciences decadal surveys, conferences, community workshops, directorate advisory committees, etc. The research communities submit proposals to NSF to request development funding for potential project ideas and concepts. NSF program staff work closely with the communities to facilitate the proposal submission, merit review, and decision-making process. The development stage can last 10 years or more. Project development activities in this phase are funded by originating organizations (that is, NSF directorates) through the Research and Related Activities (R&RA) account. At the end of this stage, the NSF Director, based on the MREFC Panel's recommendation, approves/disapproves a potential project's readiness for the formal design stage.

- ***Design:*** NSF assigns a program officer to a project to serve as the primary point of contact with the potential award recipients/proponents in the early design stage. All program officers for MREFC projects are permanent federal employees. NSF generally accepts solicited proposals for large facility projects. Before developing the solicitation, the program officer needs to consult with the GA/O to obtain advice on whether a CA is the appropriate funding mechanism for the project (i.e., whether "substantial involvement" of the agency is required). The solicitation usually specifies the funding mechanism that will be used for the project and defines the level and nature of the agency's involvement.

  The design stage, typically funded through a science directorate's R&RA account, is divided into three phases:

  - Conceptual Design Phase/Review (CDR): During this phase, projects define project scope, technical requirements, feasibility, and parametric (top down) estimates of

[145] The MREFC Panel only focuses on the development stage and the design stage.

cost and schedule, and preliminary risk analysis. At the end of CDR, the NSF Director approves/disapproves a project entering the next phase.

- Preliminary Design Phase/Review (PDR): projects further refine their project cost, contingency, and schedule estimates using probabilistic methodologies [risk adjusted, bottom-up estimates] and present them in a work breakdown structure (WBS). At the end of this phase, a total project cost estimate (performance baseline estimate and contingency estimate) is developed for the NSB's review and approval. The NSB decides whether a proposed project should be included in NSF's budget request to OMB and the Congress and be advanced to the final design phase.
- Final Design Phase/Review (FDR): projects further refine their probabilistic cost, contingency, and schedule estimates, which are presented in a detailed WBS. At the end of this phase, NSB approves/disapproves a project's readiness for construction. It generally takes about 3-5 years and 5-25 percent[146] of the total estimated construction costs to complete the design stage.

Potential recipients develop and update cost estimating plans and construction cost book reports at each review phase of the design stage (at minimum) to ensure the comprehensiveness and reliability of project cost estimates. The *Cost Book* is organized in a WBS format and specifies the cost estimate and basis of estimate for each cost item.[147]

- ***Construction*:** The construction stage is funded through the MREFC account and begins when funds are obligated fulfilling the terms and conditions set forth in the CA. It generally takes 2-6 years and costs can range between $100 million to $800 million to complete the construction of a large facility. The construction stage also includes activities to transition to operations. Projects develop a commissioning plan to guide the initial facility operations activities.

- ***Operations:*** The operations stage involves the day-to-day effort to operate and maintain research and is usually funded through a directorate's R&RA account. The operations stage may also include activities that support the transition to the Termination stage. As the operations stage usually lasts for a long time (usually 20-40 years), the agency may decide to re-compete the award for facility operation as appropriate. The program officer plans a review of an operating facility and awardee performance at least two years before the award expires. Based on the review, the originating organization (directorate/program officer) decides whether to renew or re-compete the award and makes recommendations to the NSB. The renewal or re-competition of an operating facility is approved by the NSB. The NSB's recommended policy is that all awards should be re-competed periodically. Periodic review and re-

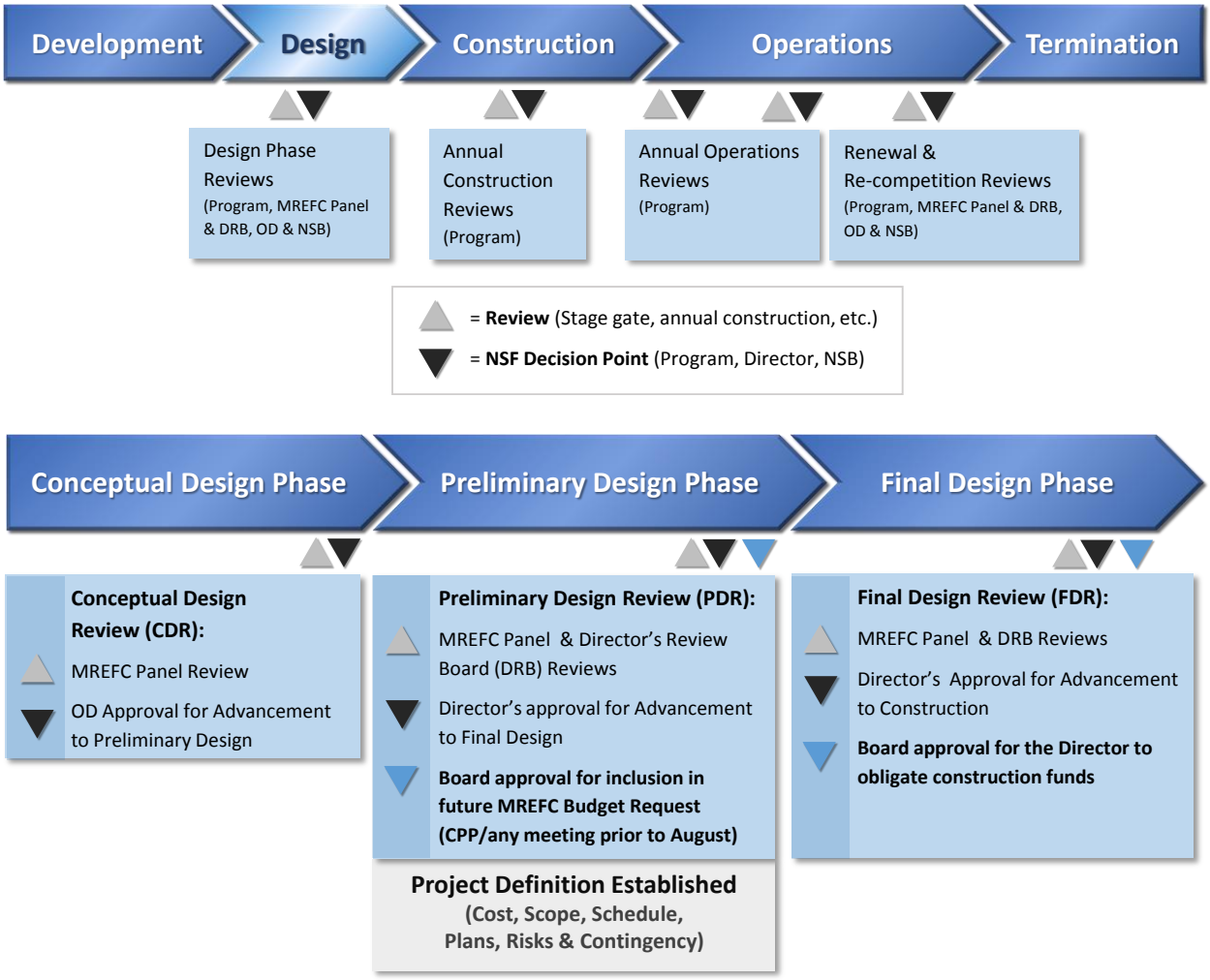
[146] National Science Foundation. *Large Facilities Manual*, (NSF 15-089), Section 2.3.1-3 (June 2015).
[147] Ibid.

competition clause is contained in the originating CAs for some projects (e.g., the Research Vessel Sikuliaq project), depending on technical details of the facility,

- ***Termination***: The termination stage occurs at the end of the operations phase when the agency decides to divest or decommission a facility. Directorates/divisions conduct periodic reviews to monitor the status of their facilities. Research communities and other important stakeholders must be involved in the decision-making process for facility termination. A transition plan is required when the agency decides to close a facility to specify termination costs and liabilities.

The five lifecycle stages of large facility projects are shown below in Figure C.1

Figure C.1: NSF Facility Lifecycle Stages[148]



[148] National Science Foundation. *Large Facilities Manual*, (NSF 15-089), Figure 2.1.3-1 & Figure 2.1.3-2 (June 2015).

Project Management Skillsets and Training

Formal project management training is not an agency requirement for staff involved in MREFC projects and is currently not available internally through the NSF Academy, the organizational unit that serves as the "hub" for learning and training. NSF sends employees who need formal project management training to outside vendors as appropriate. CA recipients are also not required to have certified project managers leading MREFC projects.

NSF is currently building project management capability in the LFO with the intent to provide assistance agency-wide. For each large facility project, an LFO liaison is designated to work closely with the program officer. The LFO also hosts (1) a large facilities workshop annually to engage facility project award recipients and discuss challenges and issues related to large scientific facilities and (2) a bimonthly program officer forum for internal NSF staff focusing on key project management issues, agency-wide policies and processes, and best practices.

Oversight and Accountability Processes

Reviews

NSF requires projects conduct a series of reviews to ensure that they meet the requirements of relevant laws and regulations and follow agency policies and procedures in addition to advancing science.

Design Reviews

The conceptual design review (CDR), preliminary design review (PDR), and final design review (FDR) are led by the program officer (in consultation with the LFO liaison) and utilize independent panels consisting of external experts, consultants and in-house expertise. The design reviews have long been focused on the quality of the technical design (the scientific side) of a proposal. The revised LFM emphasizes that these reviews are to also examine a proposal's cost schedule estimates, risk analysis and contingency estimates (e.g., assumptions, basis of estimate, and methodology). The program officer and LFO liaison assess the panel review results and make recommendations to the directorate/division leadership and the LFO Head respectively.

Cost reviews

NSF has developed a tiered review approach to assess whether a proposer's cost estimates are adequate and reasonable. The cost estimates are reviewed jointly by the Division of Acquisition and Cooperative Support (DACS), Division of Institution and Award Support (DIAS), and LFO at the end of each phase (CDR, PDR, and FDR) of the design stage at increasing levels of refinement. DIAS's Cost Analysis and Audit Resolution (CAAR) branch conducts one or more FL-99 reviews for all projects over $10 million to assess proposal budget, indirect cost rates, potential recipient organizations' accounting system, and financial capability. The G/AO (DACS)

is responsible for identifying the areas they want CAAR to review. The cost reviews follow the agency's internal Standard Operating Guidance (SOG). The agency may perform other cost reviews as appropriate based on its risk assessments to ensure cost estimates meet expectations.

In addition to the cost reviews by BFA staff, cost estimates of large facility projects are now subject to an independent review, which would be conducted by external contractors. The independent cost estimate review model (based on the eight types of cost estimate reviews identified by GAO's *Cost Estimating Guide*) and the timing of the review are jointly decided by the G/AO, LFO, and the program officer based on the specific needs of a project.[149] The review is generally conducted during the preliminary design phase to ensure the review results are available to the recipients before the final design phase starts. The results of the independent review are documented in the cost proposal review document (CPRD). The LFO has taken the lead in identifying requirements and scoping a request for proposal to secure the services of a contractor able to perform all eight types of cost estimates reviews for future independent cost assessments.

The G/AO (DACS) prepares the CPRD for all large facility projects over $100 million to document project cost estimates and the agency's review and analysis. The document is developed and approved three times during the design stage—at the completion of the CDR, PDR and FDR.

Business Systems Reviews (BSRs)

BSRs are conducted by LFO (NSF staff and contracted support) to examine whether business systems—that is, people, processes, and technologies, the critical elements for successful project management by the recipient—are sufficient to support a large facility project. The primary purpose of BSRs is to provide oversight and compliance assistance to recipients. NSF has recently revised its internal Standard Operating Guidance on BSRs. The need for a BSR is determined via a risk-based approach. According to the new guidance, at the beginning of each calendar year (the first quarter/mid-February), LFO conducts the NSF Large Facility Portfolio Survey to collect information from programs and other BFA divisions to identify potential risk areas and develop the BSR schedule for the following fiscal year (new MREFC projects are typically included in the review schedule as a priority). The revised guidance emphasizes the agency's internal coordination among LFO, programs, CAAR, DACS, and other BFA divisions/offices in conducting risk analysis and reviews.

[149] National Science Foundation, Office of Budget, Finance, and Award Management, Division of Acquisition and Cooperative Support, Standard Operating Guidance. "DACS Cooperative Support Branch Standardized Cost Analysis Guidance" (SOG 2015-2) (September 15, 2015), p. 21.

Operations Reviews

Different types of post-award reviews are performed to ensure projects stay on track. For example, NSF conducts periodic reviews (at least annually) to examine project/recipient performance during both construction and operation stages. The reviews are organized by the program officer and engage a panel of experts with knowledge and experience in science and technology, cost and schedule, and award management.

Audit Requirements

In response to issues raised by the Inspector General, NSF is developing policy guidance on the use of audits to strengthen oversight over large facility projects. For example, NSF plans to require pre-award audits of a recipient's accounting system/practices for CAs valued at $100 million or more (if one had not been performed within a 2-year window). Additionally, a final incurred cost review upon project completion, at a minimum, is required for facility construction projects of $100 million or more. The need for incurred cost audits during the construction and operations stages will be determined based on an annual, risk-based, project review by the LFO and DACS Cooperative Support Branch.

Reporting

Recipient project managers submit monthly financial and technical status reports to NSF; program officers and LFO Liaisons review the monthly reports to identify issues and help projects improve their performance. The LFO has recently implemented standard monthly report templates to achieve consistency across projects. Based on the individual project reports, the LFO Head compiles a consolidated bi-monthly report for the NSF Director. The format of this bi-monthly report is new and reflects input from the NSF Director concerning both content and presentation. For example, the July/August report included, for the first time, a table of the status of large facilities projects in the operations stage, as well as cost and schedule performance information of projects in the design and construction stages.

During the operations stage, recipients are required to submit annual reports to review progress on their performance goals identified in the annual work plans. In addition, to address OIG concerns, NSF plans to adopt a new financial reporting requirement for large facility project recipients to "maintain financial information for both direct and indirect costs incurred on a yearly basis."[150] The agency is in the process of developing guidance for implementing this requirement.

[150] National Science Foundation, Division of Acquisition and Cooperative Support. Cost Submissions for Large Facility Cooperative Agreements—Draft Award Provision (September 30, 2015).

Work Breakdown Structure

The work breakdown structure (WBS) is a fundamental project management tool that defines project scope and integrates project cost, schedule, and scope. As described in the LFM, it is "a deliverable-based and hierarchical framework structure that provides specific, manageable and schedulable baseline tasks and may be composed of products, material, equipment, engineering, services, data, support facilities, and related tasks that make up a project." [151] NSF requires projects establish a WBS in their project execution plan during the conceptual design phase. The agency encourages projects to follow the WBS guidance and examples from the Government Accountability Office (GAO), Department of Energy (DOE), Department of Defense (DoD) and other federal agencies to ensure the consistency across projects within the agency. Project cost and contingency estimates are presented using the WBS structure.

Earned Value Management (EVM)

EVM is a project management process that "combines scope, schedule, and resource measurements to assess project performance and progress."[152] The goal of using EVM is to monitor project progress in a timely and accurate manner and detect potential problems and project risks. NSF large facility projects are required to use EVM to track and measure cost and schedule performance. Recipients submit EVM data as a part of their monthly report to the agency. The agency is in the process of developing policies and guidance to standardize the use of EVM across projects. The LFO serves as program officers' primary resource for assistance with the use of EVM.

Management Plans

Project Execution Plan

The project execution plan (PEP) is the key project management document that guides facility construction and operation. Proposers are required to develop a draft PEP during the conceptual design phase and refine the plan as the project progresses through different phases of the design stage. A fully developed PEP is required for the final design review. Key components of the PEP include: project governance structure, baseline budget, budget/scope/schedule contingency, work breakdown structure, cost book and basis of estimate, risk management, and funding profile. The LFM provides a template to standardize the development of PEP.

[151] National Science Foundation. *Large Facilities Manual*, (NSF 15-089), Section 4.2, (June 2015), p. 21.
[152] Ibid. Section 8, (June 2015).

Risk Management Plan

The risk management plan is an integral part of the PEP developed by the proposers in the design stage. The risk management plan is reviewed and updated by the recipient, as appropriate, during the construction and operation stages. The plan lays out a project's risk management approach, including roles and responsibilities, process, baseline definition for calculating risk exposure and contingency needs, contingency estimates and management, and schedule, cost, and timing of risk management activities.[153]

Internal Management Plan

In response to the PEP developed by the proposer, the program officer, in consultation with the Integrated Project Team, develops an internal management plan (IMP) during the conceptual design phase. The IMP lays out how NSF will oversee a large facility project throughout the lifecycle; provides project budgetary estimates and cost monitoring activities; identifies risk factors; and develops funding strategies. After being approved within the originating organization (NSF division and/or directorate), the plan is submitted to the LFWG for review. LFWG provides written comments on the IMP.

Operations Plan

The operations plan is part of the overall project lifecycle and is required before the end of construction, ideally two years prior to the end of construction and commissioning activities. Estimates of funds for operations and maintenance should be provided in the planning stages of a facility and should follow GAO's cost estimating guidelines.

NSF Facility Plan

The purpose of the NSF Facility Plan is to provide an overview of the NSF facilities portfolio. The plan addresses current scientific research objectives and opportunities and reviews the status and progress of all current and potential MREFC projects. The Facility Plan is updated annually; it is approved by the NSF Director and submitted to the NSB every February. The LFO Head is currently responsible for developing and maintaining the plan.

Re-baselining

NSF has had a "no cost overrun" Policy in place since FY 2009. The expectation is that contingency estimates will be sufficient to manage all foreseeable risks. Cost overruns not covered by contingency must be accommodated first by reducing project scope. Projects establish a de-scoping plan prior to the PDR. Directorates are responsible for the first 10 percent of cost overruns that exceed the NSB approved total project cost.

[153] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 5.2.5-2, (June 2015).

If cost overruns cannot be addressed by using contingency or de-scoping, an external baseline review is required to assess problems and determine whether de-scoping is warranted. Re-baselining requests are authorized by the program officer after consultation with the IPT and directorate/division management. If the total project cost increases more than 20 percent of the NSB-approved baseline cost (or $10 million), re-baselining must be approved by the NSB following a recommendation by the MREFC Panel and the NSF Director.

Contingency

Contingency is a common business and project management practice for mitigating potential risks in complex projects and consists of three components: cost, schedule, and scope. Cost and schedule contingency are developed using accepted cost estimating standards and added to the baseline estimate for a project to address identified risks.

NSF's recent revisions to the LFM have tightened the requirements for the development of contingency estimates and the process for approving, managing and tracking the use of contingency budgets, building in improved traceability of contingency costs. Contingency estimates (cost and schedule) are developed following a probabilistic approach using a confidence level of 70-90 percent.

NSF's primary focus has been on cost contingency, and almost all projects use all of their cost contingency funds. The revised LFM has articulated the expectation that some cost contingency may remain at the end of a project when properly managed. "Any residual funds must be de-obligated and returned to NSF at which time NSF will request possible re-allocation of those dollars to other agency priorities."[154] The use of contingency is currently managed by recipients through a formal change control process. Written change requests are submitted to project managers (recipients), and a change control board (which includes senior project managers) reviews the requests and makes recommendations. Project managers (award recipients) have the authority to approve contingency requests under a threshold (currently $150,000).

Contingency requests above the threshold are submitted to NSF (at the program officer level or higher) for approval. All change requests must be documented and archived, and change request documents should meet the minimum content requirements. Once expensed, contingency is not tracked separately in a recipient's accounting system. The use of contingency is reported to the agency as a part of the project's monthly reports.

Management Fee

Management fee is an amount of money paid to a recipient in excess of a CA/Cooperative Support Agreement (CSA)'s allowable costs which would typically be included in direct or

[154] National Science Foundation, *Large Facilities Manual*, (NSF 15-089), Section 4.2.5-4, (June 2015).

indirect costs. Management fee has historically fallen within a 1 percent range of total project costs.

NSF recently revised its policy on management fee and added a new section in the June 2015 LFM clarifying what may be allowed and what is not allowed. The LFM identifies the “limited” circumstances in construction or operations of a large facility where the recipient is likely to incur certain legitimate business expenses that may not be reimbursable under governing cost principles but are considered as “potentially appropriate” for management fees. (Some examples include working capital necessary to fund operations to secure credit; facilities capital to acquire major assets or address expenses that would only be reimbursed through depreciation/amortization over time; expenses related to educational outreach). In addition, the revised LFM specifies prohibited uses of management fees, such as alcoholic beverages, meals or social activities for non-business purposes, personal items, and lobbying as set forth in the Uniform Guidance and the Federal Acquisition Regulations (FAR). The revised LFM requires recipients to submit information “”typically annually” on the use of management fees, which is subject to the agency review.

APPENDIX D: DEPARTMENT OF ENERGY/OFFICE OF SCIENCE PROJECT MANAGEMENT AND OVERSIGHT

Overview

The U.S. Department of Energy (DOE), Office of Science is the lead federal agency promoting the development of fundamental energy research. One of the major responsibilities of the Office of Science is to support the development, construction, and operation of "unique, open-access scientific user facilities."[155]

The Office of Science research facility construction projects are principally funded through contracts, with one notable exception. The *Facility for Rare Isotope Beams* (FRIB), which is analogous to NSF's MREFC projects, is funded through a cooperative agreement (CA).

FRIB is funded jointly by the DOE/Office of Science and Michigan State University. The project is currently in the construction phase and has a total budget of $730 million with almost $95 million in costs shared [156] by the university. Within the Office of Science, the Office of Nuclear Physics assumes the day-to-day oversight responsibility for the FRIB project. The project is being designed and built by Michigan State University.[157]

Project Management and Oversight

Project management is viewed as a high priority agency-wide. DOE has developed rigorous project management processes and procedures to strengthen project management practices and ensure project performance. With the exception of Office of Science projects, all DOE capital asset projects with a total project costs greater than $50 million are required to follow DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Asset*. The agency's program/project management guidelines may be tailored to meet the needs and requirements of specific projects.

The Office of Science is not subject to DOE Order 413.3B because of the project management systems the Office of Science has institutionalized in place and its proven track record of delivering desired project performance. However, Office of Science project management processes and procedures are generally consistent with the requirements delineated in the agency-wide policy.

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[155] DOE Office of Science website: http://science.energy.gov/about/.
[156] U.S. Department of Energy, Office of Science, Nuclear Physics FY 2016 Budget Request to Congress. .
[157] Nowak, Tom, FRIB Project Overview for Good Morning Livingston. http://howell.org/wp-content/uploads/2015/03/2015-03-10-Howell-Chamber-final.pdf (March 10, 2015).

Similarly, while the FRIB project funded under a CA is exempt from some general project requirements typically defined for contracts, FRIB follows similar project management processes and practices as those for projects funded through contracts.

Roles and Responsibilities

Various individuals and organizations are involved in managing large-scale capital asset projects. The roles and responsibilities of key managers and project management entities are described below.

Federal Project Line Management

There are four levels of line management responsibilities and authorities for projects funded through a contract or financial assistance award (CA) within the Office of Science:

1) *Federal Project Directors* (FPDs) are the first line of federal accountability with awardees and oversee projects on a day-to-day basis. For the FRIB project, the FPD resides in the DOE Chicago Office and reports to the Manager of the Chicago Office.

2) *Program Managers* are housed at the DOE headquarters (HQ) and serve as the HQ point of contact for projects. Program managers are responsible for directing project initial development, monitoring project performance, and representing the projects in the agency's program budget formulation. The Program Manager for Major Initiatives, Office of Nuclear Physics is the responsible program manager for the FRIB project.

3) *Project Owners* are the Office of Science associate directors who ensure projects are funded and have the resources for success and provide broad project leadership and guidance. In the case of FRIB, the Associate Director of the Office of Nuclear Physics serves as the Project Owner.

4) *Acquisition Executives* are the top-level of project management authority, approve project lifecycle critical decisions and project performance baseline, appoint Federal Project Directors, and monitor their performance. The acquisition executive level varies depending on the project's total costs. The Deputy Director of Science Programs within the Office of Science is the acquisition executive for FRIB.[158]

Project Management Support Offices

The Office of Science's project management office—the Office of Project Assessment—provides project and cost management support and conducts independent project reviews of all Office

[158] The Deputy Director of Science Programs within the Office of Science is the Acquisition Executive for all projects with a total cost of $400 million to $750 million.

of Science projects. The Office of Project Assessment has been in place since the agency was first established in 1977.

In addition, the DOE Office of Project Management Oversight and Assessments (PMOA) is the departmental-level project management support office and conducts independent cost reviews or independent cost estimates for projects of $100 million or more funded through contracts. To enhance the agency's management of projects, DOE has established, within the past year (12/01/14), a departmental project assessment office reporting to the appropriate Under Secretary who does not have line management responsibility for project execution.

Project Advisory Bodies

DOE advisory bodies provide coordination, assistance, and advice to the agency and awardees to facilitate the successful completion of projects.

1) Integrated Project Team (IPT) is a cross-functional advisory group led by the federal project director and consists of members with technical, budgetary, and project management experience from both the agency and the awardee. IPT is involved in all phases of a project and supports the federal project director by performing periodic assessments of project performance; reviewing project design packages, deliverables, and change requests; and reviewing project completion and closeout documents.

   The FRIB project has established two advisory teams to assist the federal project director—a Joint Project Team and an Integrated Project Advisory Team. The Joint Project Team is co-chaired by the federal project director and the awardee project manager and includes members from both the agency (e.g., DOE program manager) and the awardee (e.g., the awardee associate project manager). Other stakeholders, such as the DOE contracting officer and the agency/awardee executive leadership, may be called upon to attend meetings to resolve specific issues. The Joint Project Team meets weekly to discuss project-related issues, such as project performance and status; project critical decision packages; and project change requests.

   The Integrated Project Advisory Team is a cross-functional team led by the federal project director and consists of selected DOE employees, such as the DOE program manager, contracting officer, legal counsel, etc. The membership of the Integrated Project Advisory Team may change over time depending on the needs of the project. The Integrated Project Advisory Team supports the federal project director by providing a wide range of knowledge, skills, and experience to ensure effective project planning and implementation.

2) Federal Advisory Committees**.** The Office of Science consists of six program offices, each of which has established a federal advisory committee. The six advisory committees provide objective advice on scientific and technical issues affecting the

development and implementation of research programs. Committee members are appointed by the Secretary of Energy and mainly selected from universities, national laboratories and industries based on their professional expertise. The agency emphasizes the value of obtaining a diverse membership with "a balance of representation across disciplines, institution types, regions, and demographics."[159] Each advisory committee meets two or three times every year.

Awardees

Along with the federal project director, each project has an awardee (a contractor or CA award recipient) project manager, who carries out the awardee's project management responsibilities. For FRIB, the project manager is the Michigan State University Project Manager.

Lifecycle Management

The Office of Science has a well-defined project lifecycle management process. Projects progress through five critical decision (CDs) stages, including:

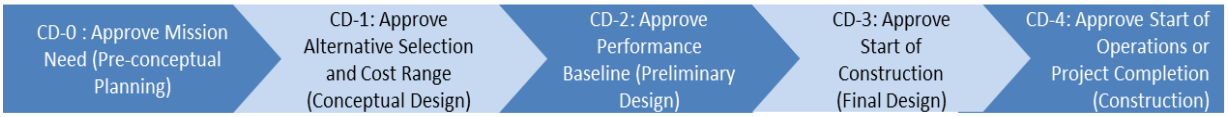
- **CD-0**: **Approve Mission Need (Pre-conceptual Planning).** During this phase, projects perform pre-conceptual design planning activities to examine the agency's mission-related needs and develop high-level project parameters, including a preliminary cost estimate range. The federal program manager takes the lead in conducting a *Mission Validation Independent Review* to validate the mission need and preliminary cost range. An independent cost review is conducted by the DOE Office of Project Management Oversight and Assessments for major system projects of $750 million or more. A *Mission Need Statement* is approved prior to CD-0 (the approval authority varies depending on the size of the project).
- **CD-1: Approve Alternative Selection and Cost Range (Conceptual Design).** This phase is an iterative process to analyze and define project elements with the conceptual design being reviewed by reviewers external to the project. Prior to CD-1, the project's *Acquisition Strategy* and preliminary *Project Execution Plan* are reviewed by the Office of Science's Office of Project Assessment and approved by the acquisition executive. Projects develop three cost estimates in this phase 1) preliminary design cost estimates; 2) lifecycle cost of alternatives under consideration; and 3) the total project cost range estimate, a schedule range estimate, and annual funding profile of the selected alternative.[160] The CD-1 approval represents the completion of the project conceptual design. Funding up to this stage is provided through operating funds.
- **CD-2**: **Approve Performance Baseline (Preliminary Design).** At the end of this phase, projects are required to establish a performance baseline, defining total project costs

[159] U.S. Department of Energy, Office of Science website: http://science.energy.gov/sc-2/federal-advisory-committees/.
[160] U.S. Department of Energy, *Cost Estimating Guide*, DOE G 413.3-21 (May 9, 2011), p. 15.

(including contingency and management reserve), key performance parameters, and the schedule baseline (project milestones and completion dates). Cost and schedule estimates are risk-adjusted and presented as single point estimates. An updated *Project Execution Plan*, including a funding profile to support the performance baseline, is approved by the acquisition executive prior to CD-2. The project's preliminary design is reviewed by a panel external to the project. Project engineering and design (PED) funds are used to support the activities in this phase.

- **CD-3**: **Approve Start of Construction (Final Design).** An external panel reviews the project's final design (or determines that the design is sufficiently mature to start procurement or construction) and funding is provided through both PED funds and construction funds. Cost estimates are updated as necessary and may include some actual bids from contractors.[161] At the CD-3, the project is ready to start procurement and construction.
- **CD-4**: **Approve Start of Operations or Project Completion (Construction).** Prior to CD-4, projects verify achievements of key performance parameters, conduct operation readiness reviews, and issue *Project Transition to Operations Plans*. Funding for this phase is provided through operating funds.
- **Project Closeout:** After a project is complete, projects are required to conduct a series of administrative and financial closeout activities. All CD documents are submitted to the DOE *Office of Project Management Oversight and Assessment*. Projects develop and submit a *Lessons Learned Report* and an initial *Project Closeout Report* within 90 days after the CD-4 approval. A final Project Closeout Report is required "after all project costs are incurred and all contracts are closed."[162]

Figure D.1 DOE Office of Science Project Lifecycle Phases



Project Management Skillsets and Training

At DOE, project management training is mandatory for federal project directors and is available, but not required, for federal program managers. DOE has developed a well-defined project management training program called the *Project Management Career Development Program* (PMCDP). PMCDP has four levels of certification targeted by total project cost thresholds: Level 1 (greater than $5 million); Level 2 (greater than $20 million); Level 3 (greater than $100 million); and Level 4 (greater than $400 million). All federal project directors are expected to be certified to appropriate levels as specified in agency guidelines.

[161] U.S. Department of Energy, *Cost Estimating Guide,* DOE G 413.3-21 (May 9, 2011), p. 16.
[162] U.S. Department of Energy, *Project Completion/Closeout Guide,* DOE G 413.3-16A (October 26, 2011), p. 26.

To attain certifications, candidates must complete required training courses, together with work and developmental activities, and demonstrate their knowledge and skills in key project management areas, such as scope management, cost and schedule management, risk management, and the like. PMCDP-certified federal project directors are required to complete 80 "continuous learning points" through training and other professional activities every two years to maintain their certifications.

DOE updates its PMCDP courses as needed to meet the changing requirements of project management. For example, to strengthen its project management training, the agency has recently added new courses in Earned Value Management, Cost and Schedule Estimation, and Earned Value Analysis.

Oversight and Accountability Processes

The Office of Science is a reasonably mature organization with well-established project oversight and accountability policies and procedures. GAO specifically removed the Office of Science from the High Risk List (while keeping other DOE units on the list) based on its progress in project management processes and practices.

Reviews

Reviews are an essential element of project management to keep projects on track. The following sections describe the Office of Science's review requirements for its projects.

Design reviews

The conceptual design review, preliminary design review, and final design review are organized by the awardee project manager and conducted by staff external to the project to assess the quality of the design and project's budget and costs.

Independent Cost Estimates/ Independent Cost Reviews, External Independent Reviews, and Independent Project Reviews

The DOE Office of Project Management Oversight and Assessments (PMOA) conducts a series of *Independent Cost Estimates/Reviews* for projects valued at more than $100 million. It also conducts *External Independent Reviews* to validate the project baseline for projects over $100 million and review project execution readiness for projects over $750 million. Additionally, the Office of Science's Office of Project Assessment (OPA) conducts independent technical, cost, schedule, and management reviews for projects within the Office of Science. The agency's requirements for Independent Cost Estimates/Reviews, External Independent Reviews, and Independent Project Reviews are summarized in the following table.

Critical Decisions	Requirements
Prior to CD-0	PMOA conducts an Independent Cost Review for projects ≥ $750 million.
Prior to CD-1	PMOA develops an Independent Cost Estimate and/or Independent Cost Review for projects ≥ $100 million (as appropriate)
	OPA conducts an Independent Cost Review for projects ≤ $ 100 million
Prior to CD-2	PMOA conducts *External Independent Reviews* to validate the Performance Baseline for projects ≥ $100 million and develops an Independent Cost Estimate for projects ≥ $100 million to support the Performance Baseline validation.
	OPA conducts Independent Project Reviews to validate the Performance Baseline for projects ≤ $100 million.
Prior to CD-3	PMOA conducts *External Independent Reviews* to review project execution readiness for all projects ≥ $750 million and develops an Independent Cost Estimate for projects for projects ≥ $100 million (as warranted)
	OPA conducts Independent Project Reviews to review project execution readiness for projects ≤ $750 million
Prior to CD-4	OPA conducts Independent Project Reviews for all projects

Peer Reviews

From the CD-2 through the CD-4, an annual peer review is required for all projects totaling $100 million or more.[163] These in-depth reviews are organized by the Office of Project Assessment and conducted by independent experts with relevant knowledge and expertise.

Lessons Learned

DOE requires projects to capture lessons learned and best practices throughout the project. The federal project director submits the *Lessons Learned* report on project planning and design activities to the Office of Project Assessment within 90 days after the CD-3 approval. The second Lessons Learned report on project execution and construction is submitted within 90 days of CD-4 approval.

Review Requirements for CA Projects

Projects funded under CAs follow most of the agency's review requirements. Major reviews required for the FRIB project include: 1) Independent Project Reviews conducted by the OPA prior to CD-1, 2, 3, and 4 to assess the project's readiness and 2) Peer reviews organized by the

[163] U.S. Department of Energy. *Program and Project Management for the Acquisition of Capital Assets*. DOE O 413.3B (November 29, 2010), Appendix C-21.

awardee project office focusing on specific topics as needed. Additionally, OPA performs an annual Independent Project Review (including cost reviews) to verify the project's status and progress, while the awardee—Michigan State University—has four standing committees that conduct self-evaluations/reviews of the FRIB project every six months (note: this is not a requirement for all projects).

Reporting and Assessments

Starting at CD-0, projects valued at more than $10 million submit their project data to the agency's Project Assessment and Reporting System, DOE's central program performance data collection system[164] every month. The federal project directors, program managers, and PMOA perform project assessments based on the awardee's monthly performance data. PMOA coordinates the assessment results with programs and reports to the Deputy Secretary on the 25th business day of every month.[165]

The FRIB project is not required to submit performance data to the agency's central system. For the FRIB project, the awardee project manager has periodic telephone discussions with the agency to review project status and submits written progress reports to the agency every month. The federal program manager conducts a monthly briefing to the acquisition executive on the project's status, and the federal project director assists in the preparation of the monthly briefing.

Work Breakdown Structure

The Work Breakdown Structure (WBS) is a program/project management tool that defines program/project scope and serves as the basis for planning, executing and evaluating program/project activities. A preliminary WBS is defined prior to CD-1 and further refined through CD-4.[166] The WBS is developed by the federal project director as a part of the Project Execution Plan.

Earned Value Management System

The Earned Value Management System (EVMS) is a critical component of the agency's risk management approach and is required for all projects over $20 million. Projects start employing EVMS during the Preliminary Design Phase (prior to CD-2). An awardee's EVMS must be in full compliance with federal guidelines and validated by the agency. For the Office of Science's projects, EVMS compliance is certified by the OPA during the final design phase (prior to CD-3). After the approval of CD-3, an EVMS surveillance review is conducted both biannually

[164] The Project Assessment and Reporting System (PARS) II is DOE's central system for collecting key project performance information.
[165] U.S. Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*. DOE O 413.3B (November 29, 2010).
[166] U.S. Department of Energy, *Work Breakdown Structure Handbook* (August, 16, 2012), p. 19.

by the Office of Project Assessment and annually by the awardee to ensure the certified EVMS remains in compliance with federal standards.

In the case of FRIB, EVMS was fully implemented after the approval of CD-2, and surveillance audits are conducted annually. The project's EVMS compliance was certified against federal guidelines by the awardee (with the help from external experts), and certification results were reported to the agency federal project director.

DOE has undertaken actions to enhance its EVM training to help employees develop the skills to use EVM appropriately. Employees are encouraged to take federal EVMS training and pursue EVM certifications. The agency has established an Earned Value (EV) Training Snippet Library, which is available to the entire agency and awardees, to improve the common understanding the use of EVM. New EVM courses have been incorporated into the federal project management training and certification program (i.e., the PMCDP program) noted above.

Management Plans

Project Execution Plan

The project execution plan (PEP) is a core project management document and developed by the federal project director (the federal line program manager performs the role of project director until the project director is appointed at CD-1). Prior to CD-1, projects develop a preliminary project execution plan, which appoints the federal project director, establishes the integrated project advisory team, and develops a risk management plan. An updated Project Execution Plan is approved at CD-2. Key elements of a project execution plan include: key performance parameters, management structure, roles and responsibilities of major participants, project performance baseline, a funding profile to support the execution of performance baseline, the change control process, and the risk management approach. The project execution plan is reviewed annually and revised as needed throughout the project.

Risk Management Plan

The risk management plan is the governing document that guides the project risk management process and addresses how risks will be managed and who will manage them throughout the project. The Risk Management Plan ties together all key elements of risk management, such as risk planning, risk assessment, risk identification, risk analysis, risk monitoring, risk documentation and communication, and other risk data and information. The Risk Management Plan is developed as a part of the preliminary Project Execution Plan prior to CD-1.

A risk register, a complementing document to the risk management plan, serves as a project risk information repository and is a daily risk management tool for a project. The Risk Register documents project risks in a standard format. For each identified risk, the risk register documents the risk category, risk owner, assumption, probability of occurrence, consequence

of risk occurrence, causes, and trigger events.[167] An initial Risk Register is established prior to CD-1 and examined/updated regularly (at least quarterly).

Performance Baseline Estimates

Project cost and schedule estimates are developed and updated throughout the lifecycle of a project. The cost and schedule estimates requirements for each project phase are described in the "Lifecycle Management" section. Depending on project scope, maturity, and data availability, a project may choose different methods and techniques to estimate project costs. For example, a parametric model is often used during the early phase of project development (i.e., CD-0 and CD-1) when the project scope is not well defined. As projects evolve, cost estimates become more definitive, and more detailed estimating methods (e.g., activity based/unit cost estimate[168]) are used when project activities and tasks are well defined.

Project performance baselines are developed based on rigorous analysis of project risks. DOE's policy requires that performance baselines of capital asset projects be estimated at a confidence level of 70-90 percent. The specific confidence level for each project is determined by the federal project director and approved by the acquisition executive.

Performance Baseline Change Control Process

The performance baseline approved and documented at the CD-2 represents the "Department's commitment to Congress to deliver the project's defined scope by a particular date at a specific cost."[169] When a performance deviation occurs, the approving authority determines whether the project should be terminated or a new performance baseline should be established. The DOE Deputy Secretary is the approving authority for project scope/performance changes that affect the ability to satisfy mission needs or project cost growth that exceeds the original cost baseline by 50 percent or $100 million. The Under Secretaries are the approval authorities for baseline changes below the Deputy Secretary approval level.[170] In the case of the FRIB project, the approval authority is delegated to the acquisition executive level (i.e., the Deputy Director of Science Program).

If the approving authority decides that a new performance baseline should be established, the federal project director prepares and submits a baseline change proposal that specifies the revised performance baseline (total project cost, CD-4 date, project scope and minimum key performance parameters). For projects over $100 million, the revised performance baseline

[167] U.S. Department of Energy, *Risk Management Guide*, DOE G 413.3-7A (January 12, 2011), p. 15.
[168] Activity based cost estimate: each activity is decomposed into detailed items so that labor hours, material costs, equipment costs, and subcontract costs are itemized and quantified. U.S. Department of Energy. *Cost Estimating Guide*, DOE G 413.3-21 (May 9, 2011), p. 18.
[169] U.S. Department of Energy, *Program and Project Management for the Acquisition of Capital Assets*. DOE O 413.3B (November 29, 2010), Appendix C-3.
[170] The approval authority may be delegated to a lower level executive/manager.

must be validated by the DOE Office of Project Management Oversight and Assessment; for projects valued at less than $100 million, the revised performance baseline is validated by the project management support offices (within the Office of Science, it is the Office of Project Assessment). All performance baseline change decisions are reported to the Deputy Secretary and the Office of Project Management Oversight and Assessments.[171]

Contingency

Contingency, consisting of three components—cost contingency, schedule contingency, and scope contingency—is used to cover the risks within the project performance baseline. To illustrate the valid use of contingency, the DOE *Change Control Management Guide* provides some examples of events where contingency may be used, such as changes in scope and unusually severe weather.[172] Application of contingency usually requires a contract modification. Contingency is a component of project cost estimate directly related to project risks and is determined via a probabilistic approach using a 70-90 percent confidence level.

Cost Contingency

Cost contingency is used to cover risks within the total project cost or to cover the costs of optimizing scientific capability of the facility. Cost contingency is established when the project performance baseline is developed (CD-2).

The use of contingency is managed by the government (i.e., the federal project director holds and approves the use of contingency funds). DOE has a standard change control process to manage the use of contingency. To use contingency, awardees submit baseline change proposals to the agency. The proposals are reviewed by a change control board, consisting of representatives from all major internal stakeholder groups. Based on the board's assessment, the approval authority reviews and approves the requests. Acquisition executives are the approval authority for the use of contingency, and the authority may be delegated to federal project directors. Contingency is not tracked separately as "contingency." It is expensed as a part of the total project cost.

The FRIB project's budgeted contingency fund is $170 million (against a total project cost of $730 million). At the beginning of each fiscal year, contingency funds are designated for Michigan State University and held by the agency. The use of contingency is approved at the federal project director level.

[171] U.S. Department of Energy, *Program and Project Management for the Acquisition of Capital Assets,* DOE O 413.3B (November 29, 2010), Appendix A-19.
[172] U.S. Department of Energy, *Change Control Management Guide*, DOE G 413.3-20 (July 29, 2011), p. 11.

Schedule Contingency and Scope Contingency

In addition to cost contingency, there are two other types of contingency, including schedule contingency and scope contingency. Schedule contingency covers time-related risks and project uncertainties. For FRIB, an 18-month schedule contingency has been established. Scope contingency represents the difference between the threshold key performance parameters and objective key performance parameter. The FRIB project has a small amount of scope contingency—$10 million.

Management Reserve

After the contract or cooperative agreement is awarded, the awardee is required to establish a performance measurement baseline to define the project scope along with a management reserve, separate from the contingency funds, to manage the risks/changes within the project's scope. Management reserve is not part of the performance measurement baseline and is held for management control purposes by the awardee. Some examples of the events where management reserve may be used are unfavorable market conditions and design development.[173]

The FRIB project maintains a small amount of management reserve ($500,000 to $1 million). According to the FRIB project execution plan, management reserve funding can come from savings. Some contingency funds can also be assigned to the management reserve account if approved by the federal project director.[174]

Management reserve is held and managed by the awardee. In the case of FRIB, the Michigan State University project manager manages the management reserve funding. To use management reserve, the awardee Control Account Manager prepares a Baseline Change Control package and submits it to the project manager (awardee), who has the authority to approve/disapprove the request. Awardees are required to report the use of management reserve to the agency as a part of their monthly reports.

Management reserve is a key component of project cost estimate and is estimated using a risk-based, quantitative approach.

Management Fee

The use of management fee is not common for Office of Science projects. Management fee is used in other DOE contracts depending on the particular project and consistent with the Federal Acquisition Regulations, but is generally not used in cooperative agreements.

[173] U.S. Department of Energy, *Change Control Management Guide*, DOE G 413.3-20 (July 29, 2011), p. 11.
[174] In practice, contingency funds have not been assigned to the FRIB management reserve account to date.

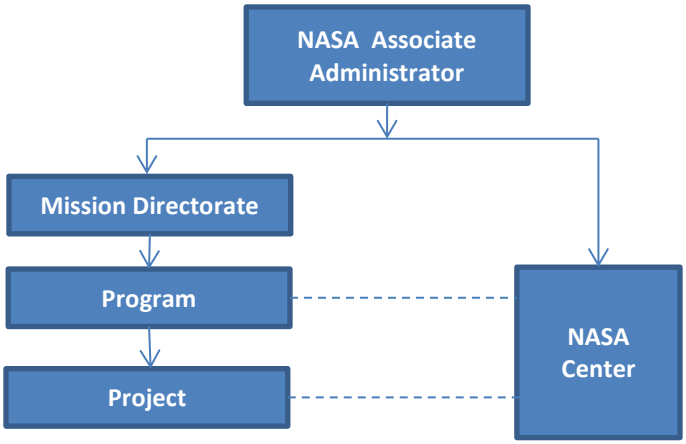
APPENDIX E: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PROJECT MANAGEMENT AND OVERSIGHT

Overview

The National Aeronautics and Space Administration (NASA) was established in 1958 to "drive advances in science, technology, aeronautics, and space exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth."[175] To carry out its mission, NASA organizes its work among four mission directorates: the Aeronautics Research Mission Directorate, the Human Exploration and Operations Mission Directorate, the Science Mission Directorate, and the Space Technology Mission Directorate. In addition, NASA has ten centers and other major facilities across the country to implement the agency's mission activities. All mission directorate associate administrators and center directors report to the NASA Associate Administrator.

At NASA, space flight programs and projects are highly-visible and complex strategic investments. NASA primarily uses contracts to carry out these initiatives. Programs and projects represent two different levels of activities and focus. A program is a strategic investment initiated by a mission directorate to address the agency's strategic goals and critical needs, and often includes one or more projects. A project represents a specific investment initiated by a program as a part of the program's overall strategy and objectives.[176] Programs and projects are generally carried out at NASA centers.

Figure E.1 below depicts the organizational hierarchical relationship among mission directorates, programs, and projects.[177]



[175] National Aeronautics and Space Administration, *NASA Strategic Plan 2014*, NP-2014-01-964-HQ.
[176] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook*, NASA/SP-2014-3705 (September 2014), p. 6.
[177] Ibid.

NASA's programs have different scientific goals and objectives, and therefore require different program lifecycle management approaches. The agency divides its space flight programs into 3 categories:[178]

- "Tightly Coupled Programs" comprise multiple projects that execute a portion of the mission. Multiple centers typically contribute to the program, and no single project is capable of implementing a complete mission.
- "Loosely Coupled Programs" address specific objectives through multiple space flight projects of varied scope. The individual projects have an assigned set of mission objectives, architectural and technological synergies that benefit the program (e.g., Mars) as a whole.
- "Single-Project Programs" generally have long development and/or operational lifetime, require the investment of a large amount of agency resources, and involve contributions from multiple organizations, agencies, and/or countries.

Single-Project programs are the most analogous to NSF's MREFC projects, and an example of single-project programs is the James Webb Space Telescope Project, a collaborative effort among NASA, the European Space Agency, and the Canadian Space Agency. Single-project programs go through similar lifecycle review and management processes as projects, and follow one of two management structures—either a separate program and project management organization or a combined program and project management structure.

Project Management and Oversight

NASA has evolved its project management practices strengthening insight into project performance throughout a project's lifecycle. The roles, responsibilities, processes and requirements described below apply to single-project programs. The agency's project management requirements can be tailored to—"adjust or seek relief from a prescribed requirement" [179] such as programmatic requirements or institutional requirements"—to accommodate the program's unique features and needs to achieve mission success. Organizations that established the policies and requirements are responsible for approving the tailoring requests.

[178] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook*, NASA/SP-2014-3705 (September 2014), p. 21.
[179] Ibid, p. 263.

Roles and Responsibilities

A number of agency officials and entities across the agency play key roles in project management and oversight of the agency's programs and projects.

Programmatic Authority *(Mission Units)*

Individuals with key programmatic authority, including the NASA Associate Administrator, the mission directorate associate administrator, the program manager, and the project manager, are principally responsible for ensuring that programs/projects achieve their goals and objectives (i.e., programmatic requirements).

The NASA Associate Administrator is the decision authority for single-project programs and is responsible for approving key program cost and schedule estimates and making Key Decision Points (KDP) decisions on whether the program is ready to proceed to the next lifecycle phase. The mission directorate associate administrator is responsible for managing the directorate's program portfolio and oversees the implementation of programs and projects within the directorate. The program manager has the primary responsibility for ensuring the program's technical, cost, and schedule performance; developing program cost estimates, budget, and funding requirements; developing/implementing the program plan; and overseeing project implementation. The program manager is recommended by the center director and approved by the mission directorate associate administrator. The project manager reports to the program manager and is responsible for all issues related to project formulation and implementation (e.g., project technical integrity, mission success, and cost and schedule performance).

Institutional Authority *(Mission Support)*

Institutional authority focuses on the agency's internal operational standards and procedural standards which are independent of any particular program/project. Key institutional authority responsibilities reside within the Mission Support Directorate and NASA centers.

The Mission Support Directorate provides institutional support to the whole agency and oversees critical mission support functions, such as human capital management, procurement, strategic infrastructure, shared services, protective services, and headquarters operations.[180] The Mission Support Directorate Associate Administrator is responsible for establishing mission support policies and procedures.

NASA programs/projects are carried out in NASA centers, and center directors are responsible for developing and maintaining the center's institutional capabilities—such as policies and structures, human capital, facilities, and infrastructure—to ensure that programs/projects are

[180] NASA website: http://www.nasa.gov/msd/aboutus.

executed properly. Center directors do not have the authority to provide programmatic direction to programs/projects.

Technical authority, as a part of the NASA's governance structure, plays an important role in the agency's "checks and balances" and oversees technical activities of programs and projects. Technical authorities are mainly provided by the Office of Chief Engineering, Office of Safety and Mission Assurance, and Office of Chief Health and Medical Officer.

NASA's Office of Evaluations is responsible for providing "objective, transparent and multidisciplinary analysis of NASA programs and projects to inform agency decision making." The Office of Evaluations is comprised of two divisions: (1) the Cost Analysis Division, which develops the agency's cost estimating policy, provides cost analysis tools, and develops cost estimates for potential programs and (2) the Independent Program Assessment Division (IPAO), which convenes and supports lifecycle reviews for all programs and selected projects (over $250 million) to support the agency leadership's approval decisions.

Standing Review Board

An independent Standing Review Board, consisting of a chair, a review manager, board members, and expert consultants, conducts most lifecycle reviews and other special reviews to evaluate the status and performance of a program/project. Board members and consultants are selected based on their knowledge and experience from both within and outside the agency. The board is usually convened by NASA's Associate Administrator, the Chief Engineer, the Director of the Office of Evaluation, and the responsible center director. The board chair, members, and consultants are selected by the agency's Independent Program Assessment Office, the mission directorate, and the responsible center. With no official voice, the program/project manager is also involved in the process of selecting board members.

Management Councils

Program management councils focus on program technical and programmatic performance (e.g., cost, schedule, risk, and risk mitigation). NASA has management councils at the agency-level and the center-level. There are two agency-level management councils: 1) the Agency Program Management Council (APMC) is chaired by the NASA Associate Administrator and consists of senior managers and center directors. The APMC is the governing management council for all programs and conducts program evaluations to support KDPs. 2) The Mission Directorate Program Management Council (MDPC) is chaired by the mission directorate associate administrator and includes senior executives within the directorate. MDPC focuses on program performance within the directorate and conducts regular (monthly) and critical decision program assessments. At the center level, the Center Management Council, chaired by the center director, provides oversight over all programs within the center and serves as advisors to the center director. The Center Management Council conducts program evaluations to ensure that the program executes its program plan properly and follows the center's technical and management best practices. Additionally, the Center Management Council makes

recommendations to the program manager on a variety of issues, such as programmatic requirements, budget, and schedule.

Advisory Council

The NASA Advisory Council comprises 10-20 members who meet three times every year to provide independent advice and recommendations to the NASA Administrator on agency programs and projects, research activities and facilities, policies, strategic plans, and financial management. Council members are appointed by the NASA Administrator and serve two-year terms. The Advisory Council has five standing committees (i.e., the Aeronautics Committee, Human Exploration and Operations Committee, Science Committee, Technology, Innovation, and Engineering Committee, and Institutional Committee), as well as one Ad Hoc Task Force on Science, Technology, Engineering, and Mathematics Education.[181]

Lifecycle Management

Single-project programs have two lifecycle phases—"Formulation" and "Implementation," and progress through seven Key Decision Points (KDPs). The goal of the Formulation phase is to develop a cost-effective program to address the agency/directorate's critical needs and mission. During Formulation, the program establishes its technical approach, programmatic requirements, acquisition strategy, performance metrics, preliminary cost and schedule estimates, annual funding levels, and implementation plans. Formulation is an iterative process and consists of three sequential sub-phases, including:

Formulation

- **Pre-phase A**: Concept Studies (KDP A). During this phase, a program is required to establish its mission objectives, ground rules, and assumptions, preliminary lifecycle cost range estimate (a low estimate and a high estimate), schedule range estimates, staffing requirements, and potential risk factors. The program starts developing a *Formulation Agreement* to document the resources, schedule, and funding requirements for the Formulation phase. To proceed to the next phase, the program should demonstrate at KDP A the alignment between the program mission objectives and the agency's strategic goals and critical needs, as well as the feasibility of proposed mission concepts.

- **Phase A**: Concept and Technology Development (KDP B). In Phase A, the program continues refining its lifecycle cost and schedule range estimates (using parametric estimates based on historical data) and starts developing its preliminary cost and schedule confidence levels. The program's lifecycle cost range estimate should be risk-informed and schedule-adjusted. In addition, the program is required to develop a preliminary *Integrated Master Schedule*, which reflects the total program scope and all program/project tasks and milestones.

[181] NASA website: http://www.nasa.gov/offices/nac/about.html.

Moreover, during this phase, the program manager, with the support from the Office of Procurement, develops an acquisition plan to specify program acquisition strategy and identify major proposed acquisitions.

- **Phase B**: Preliminary Design and Technology Completion (KDP C). A single-project program is required to establish the program baseline—Agency Baseline Commitment (ABC)—at this phase. The ABC consists of program requirements, work breakdown structure, lifecycle cost estimate (including contingency, which NASA refers to as "unallocated future expenses"), schedule estimate, and the Joint Cost and Schedule Confidence Level (JCL) analysis. JCL is a probabilistic analysis tool that combines program cost, schedule, risks, and uncertainties (the JCL process and requirements are discussed in detail in the "Lifecycle Cost and Schedule Estimate" section). At the end of this phase, the lifecycle cost estimate and schedule estimate are risk-informed, and program costs are mapped to the schedule. Cost and schedule estimates are no longer presented as "ranges" but instead as "single numbers." The agency program baseline is assessed in the program life-cycle review process and approved/disapproved at KDP C. The NASA Associate Administrator approves the baselines for all programs.

  A single-project program is assessed for its readiness for implementation at KDP C and required to develop a program commitment agreement in order to progress from the Formulation phase to the implementation phase.

Implementation

The implementation lifecycle phase includes program acquisition, operation and sustainment. The program manager is in charge of executing the program plan and monitoring program performance. As the program evolves, the program manager is responsible for ensuring that the program plan remains aligned with program resource needs and requirements during the Implementation phase; the program's lifecycle cost and schedule estimates are updated as needed. The Implementation phase is further divided into four sub-phases, including:

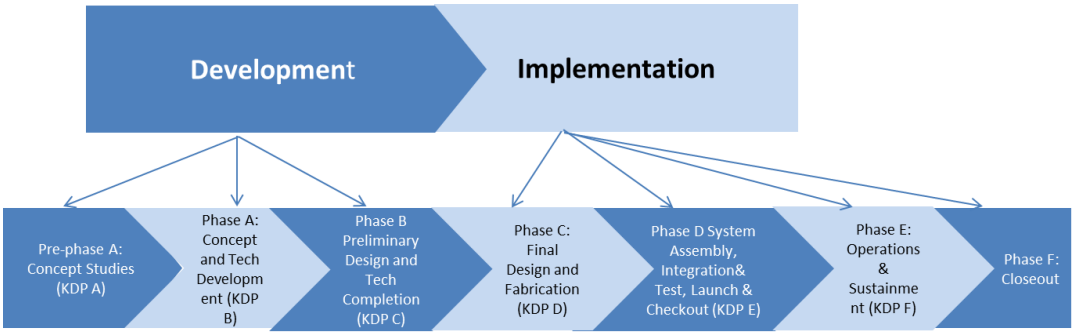
- **Phase C**: Final Design and Fabrication (KDP D). is usually a long phase. At the end of this phase, the program is expected to have a well-developed final design in place and ready for full implementation.
- **Phase D**: System Assembly, Integration and Test, Launch and Checkout (KDP E). During this phase, the program is required to complete various systems reviews, testing, and internal reviews. At KDP E, the program should demonstrate its readiness for launch and early operations.
- **Phase E**: Operations and Sustainment (KDP F). Program activities in this phase are guided by its mission operations plan. The Operations phase ends when the program completes its mission objectives. At KDP F, the program is required to conduct a decommissioning review and a project level disposal readiness review to evaluate its readiness to conduct program

closeout activities. The decision authority has the final authority to approve/disapprove program decommissioning at KDP F.[182]

- **Phase F**: Closeout. After the program decommissioning is approved, the program is required to complete a series of program close-out activities. In addition to technical close-out activities (e.g. the disposal of spacecraft, ground systems, test beds, etc.), the program should archive science and management data, document program results, prepare mission reports, and document lessons learned.

All programs and projects develop a decision memorandum to ensure all major program/project decisions and their bases are well documented. More specifically, the decision memorandum documents: major program decisions, programmatic and technical requirements, cost and schedule estimates, key assumptions, and actions. The management agreement, which is essentially a "contract" between the agency and the program or project manager, is documented in the decision memorandum at every KDP. The management agreement defines key program parameters (e.g., cost and schedule estimates, unallocated future expenses, etc.) and program/project management authorities. In addition, the agency baseline commitment is documented in the decision memorandum at KDP C for single-project programs. NASA has a standard template to guide the development of the decision memorandum. A decision memorandum is developed and approved at every KDP and is in effect for the lifecycle phase that follows the KDP.[183] Decision memorandums are managed by the agency's Office of the Chief Financial Officer. At every KDP, the decision memorandum is signed by the decision authority (NASA Associate Administrator) as well as concurring members, including the mission directorate associate administrator, the chief engineer, the Office of Safety and Mission Assurance chief, the chief health and medical officer, the director of the Office of Evaluation, the chief financial officer, the host center director, the principal investigator (if applicable), the program manager, and the project manager.

Figure E.2 NASA Single Project Programs Lifecycle Phases



[182] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook*, NASA/SP-2014-3705 (September 2014), p. 95.
[183] National Aeronautics and Space Administration, "PM and SRB Handbooks: A Hitchhiker's Guide to the Universe of NPR 7120.5E, VPM Challenge" (January 28, 2014), p. 7.

Project Management Skillsets and Training

NASA has established a program/project manager certification process. Program/project managers who manage major acquisitions with lifecycle costs greater than $250 million are required to be certified. Managers who are not certified need to earn the certification within a year after they assume the role.[184] Prospective program/project managers are required to develop a personal development portfolio, which includes a current resume, a NASA program/project manager competency assessment, and supervisory endorsement. Managers who do not meet the project management competency requirements are required to complete a set of development activities within an established timeframe and resubmit their portfolios for review. Certified program and project managers are required to earn 80 "continuous learning points" (through formal education, rotating assignments, mentoring or coaching) every two years to maintain their certifications.

Each NASA center establishes a center review panel to validate and document the capabilities of existing and future program/project managers managing major acquisitions in accordance with the agency's certification requirements. The NASA Office of Chief Engineer ultimately approves employee certifications based on centers' validations and recommendations. The NASA Academy of Program/Project and Engineering Leadership, operated by the NASA Office of Chief Engineer, provides support to NASA centers by offering various program/project management learning opportunities at the individual, team, and organizational level (e.g., on-the-job experiences, training courses, hands-on development programs, and knowledge sharing activities). The NASA Acquisition Career Manager, who is appointed by the NASA Chief Acquisition Officer, manages the development of agency acquisition workforce[185] and oversees the agency's program/project manager certification process.

Oversight and Accountability Processes

NASA has developed and implemented a range of policies, processes, and procedures to strengthen program oversight and ensure accountability.

Reviews

To ensure programs meet the requirements of relevant laws and regulations and follow agency best practices, NASA requires programs to conduct a series of reviews throughout the program lifecycle.

[184] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 373.
[185] U.S. Government Accountability Office, *Chief Acquisition Officers: Appointments Generally Conform to Legislative Requirements, but Agencies Need to Clearly Define Roles and Responsibilities*, GAO-12-792. Washington: D.C.: July 2012, p. 18.

Internal Technical Reviews

In each lifecycle phase for single project programs, several types of internal technical reviews take place. Major systems reviews are conducted by the program, with support from an independent review sponsored by the center, to assess the technical progress of a program and serve as major program technical milestones. Engineering peer reviews are in-depth reviews of a program's entire system or subsystem performed by a review panel consisting of technical experts with relevant practical experiences. Internal reviews and tabletop reviews are conducted by program team members and serve as one of the important internal technical program control elements for a program.

Lifecycle Reviews

The internal/technical reviews are followed by lifecycle reviews, a critical component of the NASA's checks and balance system. One or more reviews are conducted in each program lifecycle phase to assess program technical and programmatic performance against a set of criteria. The criteria include alignment of the program design with agency's strategic goals; adequacy of the program's management and technical approach, the integrated cost and schedule estimate, and risk management approach; and resource availability.[186]

Key lifecycle reviews include: mission concept review; mission definition review; system definition review; preliminary design review; critical design review; production readiness review; system integration review; operational readiness review; and program implementation review. The program manager, the standing review board chair, and the center director jointly assess a program's readiness for the lifecycle review 30-90 days in advance of the planned date of the review. If the program is ready for review, the program manager and the Standing Review Board Chair work together to set the review agenda. The Standing Review Board conducts the lifecycle reviews and presents the final findings and recommendations, together with the program or project responses, to the program's governing management council to support the KDP decision.

Management Council Reviews

Three sequential management council reviews are performed in each program lifecycle phase after lifecycle reviews. First, the Center Project Management Council conducts program performance, technical, and management reviews to ensure the center's best practices and requirements are followed properly and submits the assessment findings to the Mission Directorate Program Management Council and the Agency Program Management Council. The Mission Directorate Program Management Council conducts its own evaluation of all programs within the directorate and determines whether the programs are ready for the Agency Project

[186] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 24.

Management Council review. Based on the assessment results from the Center Project Management Council and the Mission Directorate Program Management Council**,** and the lifecycle review findings from the Standing Review Board, the Agency Project Management Council assesses the program's readiness to advance to the next phase and make recommendations to the decision authority (the NASA Associate Administrator).

In addition to the regular reviews required for each lifecycle phase, other types of reviews are conducted to ensure program performance and accountability. For example, NASA baseline performance reviews (BPR) are held monthly to review program and project performance in each mission directorate. The BPR is chaired by the NASA Associate Administrator and Associate Deputy Administrator, and involves agency senior management leaders and center directors. They use a color-coded dashboard approach (red/yellow/green) to indicate program/project health. The BPRs mainly focus on the "reds"—those projects in danger of exceeding costs and/or experiencing schedule slippage and scope changes.

Another example is program termination reviews**.** The termination review is conducted under certain circumstances, such as the inability of a program to meet the objectives defined in the program plan or unanticipated changes in agency strategic planning or budget.[187] If the decision authority, the mission directorate associate administrator, or program executive believes that the agency should stop funding a program, he/she can make a recommendation to the governing Program Management Council. An internal termination review is convened by the decision authority and conducted by the Standing Review Board or an independent team specifically formed for the task. In some cases, an external organization is engaged to perform an independent review, as the decision authority deems necessary. A termination decision should be fully documented and reviewed with the NASA Administrator before the final resolution. Lessons learned are documented in the agency's systems (i.e., the on-line Lessons Learned Information System).

NASA has established a formal dissenting opinion process for resolving disagreements during reviews to support program/project decision makers.

Reporting

Programs are required to report regularly to the center on program/project risks, status, and progress. Additionally, NASA's Office of the Chief Financial Officer (OCFO) issues a quarterly data call to all mission directorates to collect core project data, including the current project life-cycle cost estimate, development costs, schedule (key milestones), etc.

Like other executive branch agencies, NASA is required to report on its program/project performance to OMB and Congress in various ways (e.g., congressional hearing, budget, annual

[187] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 340.

performance report, etc.). In addition, NASA prepares a major program annual report on projects with an estimated life-cycle cost over than $250 million.

Work Breakdown Structure (WBS)

A program WBS serves as an important project management and internal control tool and identifies the program/project scope, deliverables, resources, and important program/project management activities (e.g., plans, procedures, standards, processes, etc.). The program usually starts developing its WBS in Phase A as part of the Formulation activities. The WBS is included in the agency baseline commitment presented to the decision authority for approval at KDP C.

Given the variance in the structures of mission directorates, NASA does not have a standard WBS template for programs. The single-project program generally follows the WBS template for space flight projects. The standard project WBS has eleven key elements, including project management, system engineering, safety and mission assurance, science and technology, payloads, spacecraft, mission operations, launch vehicle/services, ground system, system integration and testing, and education and public outreach.[188] All programs are required to develop a WBS with a dictionary down to the project level.

Earned Value Management (EVM)

EVM is required for all single-project programs and projects valued at or greater than $20 million regardless of the system acquisition phase. Single-project programs follow the same EVM process as projects.

A project should start its EVM planning early in the Formulation (Phase A: concept and technology development and Phase B: preliminary design and technology) and start employing EVM in the Implementation phase (Phase C: final design and fabrication and Phase D: system assembly, integration and test, launch and checkout).

The Office of Chief Engineer has the ultimate responsibility for developing the agency's EVM policies and requirements and providing EVM oversight. A mission directorate or program office develops an EVM surveillance plan, collects EVM data and performance metrics, and monitors project EVM activities. The project establishes the performance measurement baseline (a time-phased cost plan for accomplishing a program[189]), which is assessed in an integrated baseline review (IBR) prior to KDP C. The purpose of the initial IBR is to assess the feasibility of the preliminary performance measurement baseline, and as the project evolves, IBRs are also required when there are significant changes to the Performance Measurement Baseline. The project uses EVM to measure its performance against the performance measurement baseline.

[188] National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014).
[189] ibid. p. 368.

For a new project, a surveillance review is performed by the Integrated Surveillance Team[190] during the Formulation phase (prior to KDP C) to ensure proper EVM processes and procedures are in place. After the project enters the Implementation phase, the Integrated Surveillance Team conducts annual reviews to monitor a project's EVM process and compliance. The Integrated Surveillance Team reports review results to the project manager and program manager and issues concern area reports to document non-compliance issues, which are reported to the Office of Chief Engineer on a monthly basis. Projects start their EVM monthly reporting within 60 days after the approval of KDP C. EVM data are included in all management reviews and lifecycle reviews of a project.

EVM is required for contracts valued at more than $20 million.[191] For contracts with total costs greater than $20 million but less than $50 million, EVM must comply with federal guidelines and standards (agency validation, however, is not required). For projects/contracts over $50 million, EVM must be in compliance with federal standards and validated by the agency. NASA (the project manager and contract officer) delegates the authority to the Defense Contract Management Agency to validate a contractor's EVM system and monitor the EVM implementation and compliance. Contract EVM monthly reporting starts no later than 90 days after the contract is awarded. At a minimum, a contractor needs to submit a contract performance report and project integrated master schedule to the agency every month.

Management Plans

Program Plan/Project Plan

For single-project programs, a preliminary program plan, together with the program commitment agreement, is due at KDP B and finalized at KDP C. Included in the program plan are a set of programmatic and technical leading indicators (e.g., technical performance measures, cost trends, schedule trends, staffing trends, etc.). The program plan is reviewed and updated as needed for any changes in the program requirements, cost, and budget. For single-project programs, program and project plans may be combined as approved by the mission directorate associate administrator.

Technical, Schedule, and Cost Control Plan

A technical schedule, and cost control plan describing how the program plans to control programmatic requirements, technical design, schedule, and costs, is developed during the early Formulation phase and finalized at the end of Phase A. More specifically, the plan describes how the program monitors its management agreement and program baseline, the re-

[190] The Integrated Surveillance Team is a multidisciplinary team and independent from projects being reviewed; the team lead is appointed by the Office of Chief Engineer.
[191] For contracts less than $20 million, EVM may be applied as a risk-based decision of the project manager.

baseline review process, the use of EVM, and additional tools to implement effective program control processes.

Risk Management Plan

For single-project programs, a risk management plan should be developed before the system requirements review (the first lifecycle review in Phase A) and reviewed/updated periodically to ensure its currency. The risk management plan summarizes the program's approach to implementing the agency's risk management processes and requirements (i.e., risk-informed decision making and continuous risk management) and typically includes a risk list, mitigation actions for each risk, and the resources needed for managing and mitigating the risks.

Knowledge Management Plan

The single project program develops a knowledge management plan to document the program's strategies and processes for capturing and transferring knowledge. The plan includes steps to examine the agency's existing lessons learned database for practices and lessons that can be applied to the current project and delineates approaches for documenting lessons learned throughout the program's lifecycle. A draft version of the knowledge management plan is required before the system requirements review (the first lifecycle review in Phase A), and the final version is due at the system definition review (the second lifecycle review in Phase A).

In addition to the plans discussed above, programs are required to develop other types of plans, such as a product data and life-cycle management plan, an education plan, a communications plan, and a decommissioning plan.

Lifecycle Cost and Schedule Estimates

A key element of NASA program/project management is the development of cost and schedule estimates. The cost and schedule estimating process in terms of timeframes and approval processes was described earlier in the lifecycle management section. This section focuses on the agency's cost estimating approach and requirements.

To enhance program/project management, NASA has implemented a probabilistic cost and schedule analysis tool called the Joint Cost and Schedule Confidence Level (JCL), which assigns a confidence level to the likelihood of a project meeting its cost and schedule targets. The JCL is a quantitative framework that integrates a program/project's cost estimate, schedule estimate, and risk factors. A JCL is required for all single-project programs regardless of costs. NASA's baseline JCL policy is to budget projects at the 70th percentile and fund to at least the 50th percentile, but allow for deviation of single project programs due to risk and lack of a portfolio. The program/project managers are required to participate in the JCL process.

Programs' cost and schedule estimates should be well documented. As discussed in the "Lifecycle Management" section, a program's cost and schedule estimates are defined in the

program's management agreement, which is documented in the decision memorandum. A preliminary basis of estimate, a document describing the ground rules and assumptions used in program cost and schedule estimates, is developed prior to KDP A (Pre-Phase A) and updated throughout the project. In addition, the cost analysis data requirement (CADR) is a formal project document that captures key project cost and schedule information and tracks all major project changes in a standard format. This document is developed by the agency's Cost Analysis Division. The first CADR is prepared after the KDP B and updated at key project milestones.

Baseline Change Control Process

Re-baselining is required if the development cost[192] exceeds the budgeted development cost in the original program baseline by more than 30 percent. Changes to the program baseline are managed and controlled through a formal approval process. A re-baseline review is initiated by the decision authority (NASA Associate Administrator) and conducted by the Standing Review Board to assess whether the program should continue. An independent cost and schedule assessment is conducted as a part of the review, and the JCL is recalculated and approved when changes are made to program baseline. The decision authority approves/disapproves the re-baseline request based on the results of the re-baseline review. For single-project programs, congressional reauthorization is required to allow the program to proceed to a new baseline.

Contingency

NASA does not use the term, "contingency," in determining risks and calculating cost estimates. In its place, NASA uses the phrase "unallocated future expenses" or "UFE." UFE was established to make it clear that (based on experience) these funds will be required to complete the project but cannot yet be allocated to a specific work breakdown structure activity. All UFEs are included in the agency commitment baseline and the project's budget. Unallocated future expense estimates are developed following probabilistic methodologies as defined in the JCL process.

At NASA, all UFE funds are held by government employees. During the Formulation phase, UFEs are managed at the project level; while in the Implementation phase, UFEs are managed by the project, program, and mission directorate and documented in the project's management agreement, the program's management agreement, and the decision memorandum respectively. The percentages of UFE funds held at each level are determined based on the JCL analysis. A major portion of UFE funds are managed by directorates at headquarters, while program and project funds are managed in the field. The program or project manager is allowed to access the unallocated future expenses funds under his/her control without others' approval. For projects, unallocated future expenses held at the program or mission directorate

[192] Development cost is the total cost from KDP C through the end of phase D (KDP E). National Aeronautics and Space Administration, *NASA Space Flight Program and Project Management Handbook,* NASA/SP-2014-3705 (September 2014), p. 280.

level are released through a change to the project's management agreement, which requires the program's/directorate's approval. Similarly, a program director needs to seek mission directorate's approval and amend the program management agreement/decision memorandum to access the funds held by the directorate.

Management Fee

NASA does not provide management fee under federal financial assistance awards (i.e., grants and cooperative agreements) to non-profit organizations. NASA did in the past, but largely based on concerns raised by the NASA Inspector General, the agency decided to move away from funding management fee.[193] The change in NASA regulations became effective in November 2014.

[193] Interview Notes.

APPENDIX F: FEDERAL ACQUISITION CERTIFICATION FOR PROGRAM AND PROJECT MANAGERS (FAC-P/PM) – REQUIRED KNOWLEDGE, SKILLS, AND EXPERIENCE

Entry Level

Knowledge and Skills	Experience
The knowledge, comprehension and foundational application of general project management tenets, including: • knowledge and skills to contribute as an integrated project team (IPT) member; • ability to manage cost, schedule and performance attributes of low risk and relatively simple projects or manage more complex projects under the supervision of a more experienced project or program manager; • general understanding of project management practices, including risk management, budgeting, scheduling, technology management, performance-based business practices, cost management, stakeholder relations, program control and governance; • comprehension of an agency's requirements development and lifecycle management processes; and • ability to define and construct various project documents with appropriate mentoring and supervision.	At least one year of project management experience within the last five years including: • being a contributing member of an acquisition IPT; • constructing a work breakdown structure; • preparing project analysis documents to ensure that quality, effective, efficient systems or products are delivered; • analyzing and/or developing requirements • monitoring performance and assisting with quality assurance; and • analyzing and/or developing budgets.

Mid-Level

Knowledge and Skills	Experience
The demonstrated application and fundamental analysis skills and abilities in the general program management tenets, including: • knowledge and skills to manage projects or program segments of low to moderate risks with little or no supervision; • ability to apply management processes, including requirements development processes and performance-based acquisition principles supporting the development of program baselines; • ability to plan and manage technology integration, and apply agency policy on interoperability and product support; • ability to identify and track actions to initiate an acquisition program or project using cost/benefit analysis and business case development; • ability to understand and apply the process to prepare information for a baseline or milestone review, and assist in development of ownership cost estimates and applications; and • ability to integrate and manage program cost, schedule and performance through application of comprehensive risk management planning, accounting for the scale of complexity between program and project level acquisitions.	At least two years of program or project management experience within the last five years, including: • leading IPTs; • performing market research and analysis; • developing documents for risk and opportunity management; • developing and applying technical processes and technical management processes; • performing or participating in source selection; • planning and preparing acquisition strategies; • applying performance-based business processes; • developing and managing a project budget; • preparing and presenting a business case; and • contributing to program strategic planning.

Senior Level	
Knowledge and Skills	**Experience**
The knowledge and skills to manage and evaluate moderate to high-risk programs or projects that require significant acquisition investment and agency collaboration, including: • ability to manage and evaluate a program and create an environment for program success; • ability to manage and evaluate the integration of the requirements development, and budgeting and governance processes, and apply comprehensive risk management planning, accounting for the scale of complexity between projects and programs; • ability to communicate and defend the acquisition approach before decision makers and stakeholders; • accomplished leadership and mentoring skills to influence subordinate-level team members in managing the functional domains of program management; and • expert ability to use, manage, and evaluate management processes, including performance-based management techniques and earned value management as it relates to acquisition investments.	At least four years of program or project management experience, which shall include a minimum of one year of experience on Federal programs and projects, within the last ten years, including: • synthesizing and evaluating the efforts and products of functional working groups and IPTs; • managing and evaluating acquisition investment performance; • developing and managing a program budget; • building and presenting a successful business case; and • reporting program results, strategic planning, and high-level communication with internal and external stakeholders.

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APPENDIX H: EXAMPLES OF BFA STANDARD OPERATING GUIDANCE (SOG)

Subject	Issuing Divisions	Applicable Units	Award Types	Purpose
BFA 2015-2 DACS CSB Standardized Cost Analysis Guidance (effective September 15, 2015)	Division Of Acquisition and Cooperative Support (DACS)	DACS-Cooperative Support Branch (CSB)	Large facilities construction and operations cooperative agreements (CA) and cooperative support agreements (CSA).	This SOG identifies standard cost analysis techniques and their application in CSB's review of award recipients' cost books and total project cost estimates developed during the conceptual, preliminary, and final design phases. The SOG is also used to re-evaluate and re-establish project cost estimates during the construction and operations stages. The SOG requires the grants and agreements officer to develop the cost proposal review document (CPRD) for all large facility projects over $100 million to fully document evolving cost estimates and the agency's cost reviews/analyses. The SOG also further specifies the agency's requirements for project cost estimates (e.g., traceability of cost estimates, direct labor costs, indirect costs, contingency, management fee, accounting practice, accounting and other administrative systems, financial capacity, etc.). Additionally, the SOG contains a requirement that large facility project cost estimates are subject to an independent cost assessment, which would be conducted by external contractors. The SOG requires pre-award audits of awardees' accounting systems/practices for large facility projects over $100 million (if such audits have not been conducted within the past two years).

Subject	Issuing Divisions	Applicable Units	Award Types	Purpose
DACS CSB SOG 2014-1: Guidance on Pre- and Post-Award Cost Monitoring Procedures for Large Facility Construction and Operations Awards Administered by CSB (updated September 15, 2015).	DACS-CSB	DACS-CSB	All large facility construction and operations agreements administered by CSB.	This SOG provides guidance on pre- and post-award cost monitoring processes for managing costs on all large facility construction and operations agreements administered by CSB. Key requirements on post-award cost monitoring activities set forth in the SOG include: • Post-award cost monitoring activities (the needs for incurred cost audits vs. other cost monitoring methods) are addressed in CRPD and the internal management plan. • A final incurred cost audit is required for large facility projects over $100 million In addition, the SOG identifies seven factors to consider in choosing post-award cost monitoring activities.
DACS CSB SOG 2015-1: Guidance on Negotiation, Award and Payment of Management Fee (effective August 31, 2015)	DACS-CSB	DACS-CSB	CAs for the large facility project design, construction, and operation.	This SOG provides guidance on the implementation of NSF's revised policy on management fee. The SOG provides further clarifications on and additional examples of the "appropriate uses" and "prohibited uses" of management fee. The SOG requires recipients to submit management fee proposals at least 60 days in advance of the initiation of work; the requests for management fee are approved by the DACS Division Director.

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DACS CSB SOG 2014-3: Guidance on DACS/CSB Review and Approval Matrix (updated effective July 27, 2015).	DACS CSB	DACS CSB	CAs and CSAs processed by DACS CSB.	This SOG provides a matrix that sets forth review and approval requirements for key actions and documents processed within DACS/CSB.
BFA SOG 2015-5: Guidance on Annual Planning Process for Business Systems Reviews (BSRs) (effective September 10, 2015)	Large Facilities Office (LFO)	DACS; Division of Financial Management (DFM)/Cash Management Branch; Division of Institution and Award Support (DIAS)/ Cost Analysis and Audit Resolution CAAR Branch; LFO	Large facility construction and operations CAs and CSAs	The SOG provides a revised guidance on the annual planning process for BSRs. The SOG requires that LFO conduct an annual NSF large facility portfolio survey to identify potential risk areas and determine the BSR schedule. New MREFC projects are usually included in the schedule as a priority.
DIAS SOG 2015-1: Pre-Award Review Standing Operating Guidance (FL-99 $10 million CAAR Pre-Award Budget Review) (Effective January 29, 2015)	DIAS	DIAS, Division of Grants and Agreements (DGA), DACS/CSB	CAs	This SOG provides an overview of the pre-award review process for assistance awards over $10 million, with a focus on the roles and responsibilities of CAAR. The primary purpose of CAAR pre-award reviews (one or more reviews) is to evaluate a potential recipient's accounting system, financial capability, proposed budget, indirect cost rate, etc. For new recipients, CAAR conducts pre-award reviews to evaluate their accounting systems, project cost ledger or report, financial viability, indirect cost rate, policies and procedures, and other areas (if needed).

Subject	Issuing Divisions	Applicable Units	Award Types	Purpose
BFA SOG 2015-1: BFA Post-Award Monitoring Guidance (effective January 14, 2015)	DIAS	All BFA Divisions and LFO	CAs Grants	The SOG provides an overview of BFA's three types of post award monitoring activities, including annual risk assessment, baseline monitoring, and advanced monitoring (e.g., BSRs). BFA's post-award monitoring responsibility is shared among DACS, DIAS, DGA, DFM, and LFO. The coordination among each division/office within BFA is critical. This SOG serves as a consolidated reference of existing documents for the financial and administrative procedures and activities for BFA post-award monitoring.
DIAS SOG 2013-3 Guidance on Indirect Cost Rate Proposal Review (effective May 13, 2013)	DIAS	DIAS, DGA, DACS-CSB	Grants and CAs	This SOG describes NSF's awardee portfolio management approach to conducting indirect cost rate proposal reviews; the roles and responsibilities of CAAR staff; and guidance on the indirect cost rate proposal review process.
SOG 2012-1 Policies and Procedures for Audit Report Issuance and Resolution of Findings Contained in Audits of NSF Awardees	DIAS DGA DACS	DIAS DGA DACS	Grants and CAs	This SOG describes NSF's approach to resolving audit findings and questioned costs and the roles and responsibilities of the audit resolution staff of the CAAR throughout the resolution process.

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