Report of the Subcommittee on NAPA Implementation

of the

National Science Foundation's Business and Operations Advisory Committee

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Business and Operations Advisory Committee

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Executive Summary

In early 2015, NSF commissioned the National Academy of Public Administration (NAPA) to evaluate NSF's use of Cooperative Agreements for Large Scale Research Infrastructure, and in December, 2015 NAPA issued its final report. The NAPA report made thirteen recommendations that fall into three general categories: business practices; planning, oversight and accountability; and project management. NSF has completed action in response to four NAPA recommendations, namely those focused on pre-award cost analysis exceptions, retention of contingency funds, cost-estimating guidance, and the staffing and role of NSF's Large Facilities Office. Action on seven other NAPA recommendations are underway at NSF at this time. In responding to two of the NAPA recommendations and to an additional two issues associated with NSF's oversight of large-scale research infrastructure projects, NSF sought additional input and guidance from the NSF Business and Operations and Advisory Committee (BOAC). To that end, the BOAC Subcommittee on NAPA Implementation was convened to provide options for appropriate agency-wide oversight by the NSF Office of the Director on the following four charges:

1. Re-scope of the role, duties, and membership of the Major Research Equipment and Facilities Construction (MREFC) Panel to include status update reviews of projects in the development and construction phases focusing on cost, schedule, and performance. [NAPA Recommendation 6.2].
2. Evaluate the potential value in extending the MREFC Panel's role to operating facilities, including divestment (i.e. full life-cycle).
3. Evaluate the potential value in creating an internal agency "senior official" position in Office of the Director charged with reporting to the Director and Deputy Director/Chief Operating Officer (COO) on large facilities;
4. Evaluate the potential value in creating a new Federal Advisory Committee Act (FACA) committee to provide the NSF Director with a sounding board for objective insight on large research projects. [NAPA Recommendation 6.4]

Findings. The Subcommittee found that NSF has made significant improvements to the oversight of MREFC projects, in large measure due to the leadership of an appropriately empowered Large Facilities Office (LFO). Based on its study of NSF's policies, processes, and their implementation in practice, the Subcommittee makes the following overarching observations:

- Limiting the role of the stage-gate process to one funding type (i.e., the MREFC budget account) does not support a systematic Foundation-wide approach to risk-management.
- NSF's current use of the MREFC Panel confounds approvals (for moving from one stage to the next in a stage-gate review process) and oversight of performance within a stage (conceptual design, preliminary design, construction, operations, etc.).
- Research infrastructure investments in the development stage (pre-conceptual design phase) are opaque to NSF leadership and oversight.
- Director Cordova's interim watch group that meets regularly to monitor progress on all research infrastructure projects and periodically take a deep dive into an individual project is a move in the right direction.

The Subcommittee believes that large-scale research infrastructure investments require routine oversight throughout their full life cycle, and the NSF needs a consistent framework for risk monitoring independent of the budget account funding any given project. Specifically,

- The role of the MREFC Panel is appropriately focused on reviewing and recommending approval for projects moving through the stage-gated life-cycle, but the duties of the MREFC Panel fall

short of covering the full life-cycle by omitting review of project plans in the development, operations and divestment stages.

- The MREFC Panel is appropriately constituted and vested with sufficient authority to review and recommend the *as-needed approval* of advancement through the project life cycle against the ranking and evaluation criteria assigned in its Charter or to it by the Large Facilities Manual (LFM). The more technically-oriented Integrated Project Teams and LFO-managed independent external reviews are the appropriate mechanism for the *on-going oversight* of project performance during the design and construction stages.
- Quarterly updates on status of projects under design or construction are not adequate to provide adequate continuous oversight should problems arise.
- The agency-wide processes defined in the 2015 LFM are clear, largely comprehensive, and more rigorous than in prior editions. However, there is a general lack of clarity as to how these processes operate at the Directorate or Division level. The Subcommittee understands that there are significant technical and cultural reasons for the variation among disciplines. Within many disciplines, there are stable, well understood processes that can be made more explicit and transparent to senior officials, the executive levels of the NSF and NSB, as well as oversight bodies at the onset of facility projects.

The Subcommittee believes that NSF has opportunities to develop and apply a systematic risk management approach to all research infrastructure investements, regardless of the NSF account the project is budgeted in, and that there are opportunities to improve the internal on-going oversight processes.

- The Subcommittee supports NSF exercising its managerial discretion to apply the LFM guidance and process requirements to projects below the legislatively mandated minimums in section 110(g)(2) of the recently enacted American Innovation and Competitiveness Act of 2017.

The Subcommittee believes a senior NSF executive vested with the appropriate authority and responsibility must serve unambiguously as the "owner" of the agency-wide oversight processes for research infrastructure projects underway.

- The issue of a Senior Official and the NAPA Panel's call for a Large Facilities FACA are tightly linked. The Subcommittee sees value in the Office of the Director having a clearly articulated responsibility with respect to facilities and research infrastructure, which may include more than the MREFC budget account.

The Subcommittee believes existing subcommittee mechanisms, such as the Committee of Visitors model, can provide the necessary external assurance that NSF's internal processes as codified in the LFM are operating with rigor.

- The Subcommittee does not believe an additional external review of individual projects by a Large Facilities FACA would improve performance. Independent project management and cost estimating reviews of individual research infrastructure projects must be designed into processes codified in the LFM.
- The Subcommittee notes that the charter of the BOAC is not in compliance with the General Services Administration's Committee Management Secretariat guidance document, *Preparing Federal Advisory Committee Charters*, that states the agency "identify the agency or official (by title or position) to whom the advisory committee provides its advice. Normally, this is the agency head."

Recommendations. As noted above, the Subcommittee believes that NSF has made significant improvements to the MREFC processs to date. In light of that and the fact that the NAPA Panel made a

number of broad recommendations, some of the Subcommittee's recommendations below are offered in the spirit of fine tuning the process improvements already underway rather than suggestion of large-scale redesign.

3.1 Strengthen the role of the MREFC Panel during the project development stage by amending §2.2.1 of the LFM to require approval from the MREFC Panel prior to development activities. The focus of this approval should be on defining the capability gap and preliminary functional requirements needed by the Directorate.

3.2 Strengthen the role of the MREFC Panel during the operations stage by amending §2.4.2 of the LFM to require review and recommendation by the MREFC Panel of each project's Transition to Operations Plan as part of their review of final design and again at the completion of construction.

3.3 The MREFC Panel Charter should be brought into alignment with the LFM by specifically enumerating each of the stage-gates where MREFC Panel review and recommendation is required.

3.4 The Deputy Director/COO should meet at least monthly with the Head of the LFO and the chairs of all active IPTs to review progress, including all earned value management tracking, on projects under design and under construction.

3.5 The LFM can be clearer in assigning responsibility for the composition of and the authorship of external review panel charges to the LFO to ensure that the NSF Director has direct access to independent project and cost estimating expertise during the pre-design and construction phases.

3.6 Directorates and Divisions should define their discipline-specific processes for the development stages of their large research infrastructure projects and for the general performance criteria against which facilities or suites of facilities will be evaluated during their operations phase.

4.1 Although the Subcommittee does not specify any particular threshold for inclusion in the MREFC account, all relevant thresholds should be clearly documented in §1.4 or §2.7 of the LFM. All research infrastructure investments above the MREFC threshold, regardless of the NSF budgetary source, should follow the NSF LFM guidance and process.

4.2 The Large Facilities Office, working on behalf of the Deputy Director/COO, should work with Program Staff and NSF Management to assure that the skill sets included on IPTs are matched to the risk spectrum of the project being reviewed.

4.3 The NSF should develop a set of risk "tracks" that group projects not by size or funding source, but rather based on the Foundation's risk exposure. These tracks should consider the risk and the size of the project, and the risk monitoring and oversight should be suitably tailored. The requirements for these alternative tracks should be added to the LFM and clearly documented.

4.4 NSF should expand its enterprise risk management in research infrastructure investments to include monitoring facility operations and productivity, as well as progress on facility upgrade investments above the recommended threshold level.

4.4.1 The Deputy Director/COO should meet at least every six months with the Head of the LFO and the chairs of all IPTs to review performance metrics of operating large-scale research facilities. These metrics, which should be developed in consultation with the relevant research community, must reflect both the scientific productivity of the facility (e.g. number of user proposals, number of users served, publications, high-impact research results) as well its operational efficiency (e.g. beam-up time, number of operating hours vs. scheduled, etc.) for all operating large facilities.

4.4.2 Each Large Facility should report on facility performance annually to NSF. NSF should report large facility performance to the NSB in summary form. Results from facility operational reviews should also be reported in summary form to NSF leadership and the NSB.

4.4.3 The IPT's purview and lifespan should be extended to the operational phase of the project with a mandate to regularly review operational performance of NSF large facilities; and the membership of the IPT should include members who have experience operating large facilities.

4.4.4 At least once every five years after the initial ten years of operations, the annual review should evaluate whether divestment should be considered for the facility. Any resulting plan developed by a Directorate or Division that proposes significantly repurposing and redirecting a facility or its decommissioning, disassembly, and disposal – any of which can involve significant expenditures of resources – to go through the MREFC Panel for review and recommendation to the Director

4.5 NSF should work with the research communities, including consultation with the Directorate advisory committee, to explore and document approaches and best practices for managing facility end of life and divestment from large research facilities. NSF should develop policy and guidance for programs to support divestment consideration and decision making.

5.1 The Subcommittee believes that there should be a clearly-designated senior official in the Office of the Director with direct visibility into and accountability for the Foundation's facilities and research infrastructure – which would encompass significant projects in the directorates as well as in the MREFC account. This official would serve a role analogous to the Acquisition Executive role in DOE and NASA

6.1 Instead of creating a new Large Facilities FACA, NSF should utilize BOAC subcommittees as needed to periodically review the rigor of NSF's large facilities oversight processes in a manner analogous to the role a Committee of Visitors has in providing external expert assessment of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions. BOAC, like other FACA committees, has a mechanism for creating subcommittees as necessary.

6.2 To ensure that the NSF Director has full awareness of all such BOAC subcommittee assessments, NSF should recharter BOAC so that the NSF Director, through the BFA and OIRM Heads, becomes the official to whom the committee reports as recommended by the General Services Administration's Committee Management Secretariat guidance.

In addition to the formal charges addressed above, the Subcommittee makes three additional obervations with respect to MREFC review packages, MREFC ranking criteria, and the chartering of high level FACA committees. The Subcommittee recommends that LFM §2.3.2.6 be revised to make more explicit the responsibility of the Director's Review Board to prepare cover memos for packages advancing to the Director and NSB that focus executive attention on cost, scope and schedule risks, mitigation options analyzed, and remediation actions taken to manage those risks. The Subcommittee recommends that the international leadership question be considered as one criterion for approval to enter the Conceptual Design Phase. And, consistent with recommendation 6.2 that NSF recharter BOAC so that the NSF Director be the official to whom the committee reports in compliance with the General Services Administration's Committee Management Secretariat guidance to address the NAPA Panel's concern that the NSF Director does not have direct access to advice on important issues, the Subcommittee recommends that NSF consider rechartering the advisory committees reporting to the Associate Directors as well as the two joint NSF/DOE FACAs.

I. Introduction

In early 2015, the NSF Director and the National Science Board (NSB) asked the National Academy of Public Administration (NAPA) to review issues raised by the NSF Office of the Inspector General (OIG) about the agency's use of cooperative agreements for funding the construction and operation of large-scale, multi-user research facilities as well as the adequacy of the management, oversight and accountability practices for monitoring those investments. Additional charges for the NAPA study derived from congressional hearings and language in the America COMPETES Act of 2015 (H.R. 1806) and the NSF Major Research Facility Reform Act of 2016 (H.R. 5049) that would have codified a number of the OIG's previous recommendations. As the NAPA Panel notes, "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."[1]

The NAPA report, issued in December 2015, made thirteen recommendations that fall into three general categories: business practices; planning, oversight and accountability; and project management. NSF has completed actions on recommendations related to improving business practices by requiring NSF officials to review and approve any proposed exceptions to the recommendations of pre-award cost analyses (NAPA rec. 3.1), retaining a portion of contingency budgets at NSF (rec. 4.1), and requiring award recipients to follow the guidance in the Government Accountability Office's Cost Estimating & Assessment Guide and Schedule Assessment Guide (rec. 4.2). NSF has hired two additional staff in the Large Facilities Office (LFO), and the Head of that office is now a voting member of the NSF Major Research Equipment and Facilities Construction (MREFC) Panel (rec. 6.5).[2]

Two NAPA report recommendations have been assigned to this Subcommittee for study. They are calls for the Foundation to add more rigor to the process of reviewing major facilities projects at the MREFC Panel level of oversight for readiness and performance (rec. 6.2) and to provide the NSF Director direct access to independent project and cost estimating expertise for reviewing large research projects (rec. 6.4).

Two reforms included in the House-passed bills mentioned above were assigned to this Subcommittee for study. They are evaluating the extension of the scope of the MREFC Panel to include oversight for the full life-cycle of operating facilities, including divestment, and evaluating the need for creating a new internal agency "senior official" specifically responsible for large facilities (both facilities in development and those that are operating) within the Office of the Director.

Action on the remaining seven NAPA recommendations are underway at NSF in parallel with this Subcommittee's study. Since this study began, Congress has taken action, and the American Innovation and Competitiveness Act (AICA, P.L. 114-329) was signed into law on January 6, 2017. The AICA requires full life-cycle oversight for all major multi-user research facilities regardless of whether the facility is funded out of the MREFC account or whether it is funded out of the Research & Related Activities account and it exceeds one of two statutorily-defined thresholds. The AICA also requires appointment of a "senior official" in the Office of the Director to be specifically responsible for large facilities.

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[1] National Academy of Public Administration, *National Science Foundation: Use of Cooperative Agreements to Support Large Scale Investment in Research* (December 2015) p 6.

[2] That status will be correctly reflected in Section 2.1.6.4 of the next release of the NSF Large Facilities Manual.

II. Explanation of Process Used for Subcommittee's Work

The Subcommittee composition and charter were finalized in June 2016, and the group began its work with a kick-off meeting at NSF in August 2016. The morning session focused on NSF's views of the challenges the agency faces with respect to its oversight of research infrastructure,[3] including an overview by Dr. Fae Korsmo, Senior Advisor in the Office of the Director, of the Foundation's interpretation of and actions to date in response to the NAPA report. Matt Hawkins, Head of the Large Facilities Office, provided a detailed briefing about the current NSF business processes for each stage of the research infrastructure life cycle from the support of earliest development and design stages through construction and operations to the ultimate decommissioning of a facility (Figure 1). He noted some of the differences in process between largest projects funded out of the MREFC account and the mid-scale projects funded out of R&RA. That was followed by a frank and detailed discussion with staff from the Office of the Director and the Office of Budget, Finance and Award Management about known challenges the agency has faced in its handling of facilities projects and lessons learned. The morning session concluded with a brief tutorial by Jeff Lupis, Director of the Division of Acquisitions & Cooperative Agreements, on the cooperative agreement mechanism.

The afternoon session was anchored by a panel discussion with the leadership of the NSF directorates responsible for research infrastructure, namely Dr. Fleming Crim, Assistant Director for Mathematics and Physical Sciences; Dr. James Kurose, Assistant Director for Computer & Information Science & Engineering; Dr. James Olds, Assistant Director for Biological Sciences; Dr. Roger Wakimoto, Assistant Director for Geosciences; and Dr. Grace Wang, Deputy Assistant Director for Engineering. Given the increasing internationalization of many of the largest research infrastructure investments within NSF and across the federal portfolio, Dr. Rebecca Keiser, Head of the Office of International Science and Engineering, also participated in the discussion. NSF Chief Operating Officer (COO), Dr. Richard Buckius, joined the discussion as an observer.

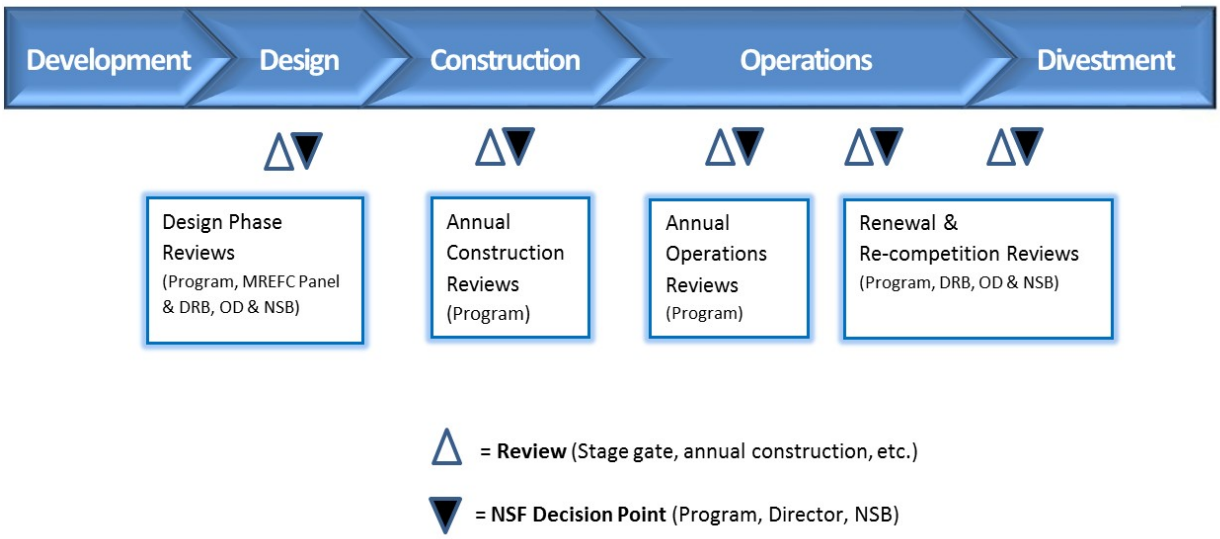

Figure 1. Life Cycle for Research Infrastructure Development

[3] In carrying out this study, the Subcommittee encountered the terms "large facility," "large research project," "major research facility," and "MREFC project" used almost interchangeably. To avoid confusion, the Subcommittee will use the term "**research infrastructure**" to refer to multi-user research facilities. Our usage of the term is not tied to a specific NSF budget account, since funding for major multi-user research facilities (MMURF) is supported by both the Research & Related Activities (R&RA) account and the MREFC account. "**Large-scale infrastructure**" will be used to differentiate projects eligible for MREFC funding from "mid-scale infrastructure," which fall below the $70 million MREFC threshold and above the $4 million limit of the Major Research Instrumentation (MRI) program. Thresholds for mid-scale infrastructure, which is funded out of the R&RA account, are defined by each of the Directorates.

Michael Sieverts, Division Director, NSF Budget Division, and Julia Jester, Office of Legislative & Public Affairs, briefed the Subcommittee about the viewpoints of external organizations with oversight responsibility, namely the Office of Management & Budget, the Office of Science & Technology Policy, and the Congressional authorization committees. The day concluded with a discussion with Allison Lerner, NSF Inspector General, and her staff.

The Subcommittee continued its work gathering insight into the Foundation's oversight of research infrastructure with several follow-on calls. In one call, NSF Director Dr. France Cordova briefed the Subcommittee on her experience with the National Ecological Observatory Network (NEON) project beginning as a NSB member, on her experience with other NSF facilities, and on the interim actions she had taken to date to reform NSF's processes for the approval and oversight of research infrastructure. Her remarks focused on the visibility that the executive and leadership levels have into the facilities portfolio, the Foundation's approach to risk management, and the NSF staffing culture.

The Subcommittee had a subsequent call with NSB Executive Officer Dr. Michael Van Woert, Dr. Elise Lipkowitz, and Dr. John Veysey to better understand the roles and responsibilities of the NSB in the approval and oversight of research infrastructure. The Subcommittee also spoke with Lt. Gen. James A. Abrahamson, USAF (Ret.), whom Director Cordova brought in as a Senior Advisor to undertake a root-cause analysis of NEON. The conversation focused on his observations about NSF's approach for assessing and responding to risk factors in major projects.

On the basis of these briefings and other materials NSF provided, the Subcommittee makes the following observations:

- Limiting the role of the stage-gate process to one funding type (i.e., the MREFC budget account) does not support a systematic Foundation-wide approach to risk-management.
- NSF's current use of the MREFC Panel confounds approvals (for moving from one stage to the next in a stage-gate review process) and oversight of performance within a stage (conceptual design, preliminary design, construction, operations, etc.).
- Research infrastructure investments in the development stage (pre-conceptual design phase) are opaque to NSF leadership and oversight.
- Director Cordova's interim watch group that meets regularly to monitor progress on all research infrastructure projects and periodically take a deep dive into an individual project is a move in the right direction.

III. Scope of the MREFC Panel

Background. In its analysis of NSF's internal governing structures, the NAPA Panel notes that, "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."[4] The Subcommittee certainly concurs with the NAPA Panel's view that "the role of the MREFC Panel is particularly important as it is, in effect, the gatekeeper for advancing projects during the design stages."[5] The charge for this Subcommittee was to assess whether the role, duties, and membership of the MREFC Panel are appropriate and whether the Panel's scope should be expanded to include status update reviews of projects in the development and construction phases focusing on cost, schedule, and performance.

The 2015 NSF Large Facilities Manual (NSF 15-089) currently in force assigns the MREFC Panel the appropriate role of making recommendations to the Director for advancement of projects into successive

[4] NAPA Report, p 72.

[5] NAPA Report, p 73.

stages of development (§2.1.6.4). Convening periodically on an as-needed basis, the MREFC Panel reviews specific on-going and candidate research infrastructure projects above the $70 million threshold as presented by the originating organization and makes recommendations to the NSF Director on readiness for advancement to subsequent project stages or design phases.

This duty includes recommending approval of the formal start of the design stage (§2.2.2); advancing the project into the conceptual design phase and through the preliminary design phase and inclusion of the project in the NSF Facilities Plan (§2.3.1.4); concurring with the sponsoring Directorate that the Preliminary Design is reasonable and poses an acceptable level of risk, and ensuring that anticipated costs for construction and operation are sufficiently well known to support a future MREFC budget request (§2.3.2.5). As part of this gate for advancement to the final design phase, the MREFC Panel forwards a prioritized list of projects to the Director, who makes the decision on whether to forward to the NSB for approval. A positive MREFC Panel recommendation is also required for the successful conclusion of the final design phase and any revisions required to make a project's construction plans consistent with the Administration's pending budget request (§2.3.2.5). After Congressional appropriations are received and NSF makes the Construction Stage award, the MREFC Panel must review and recommend any increases in total project costs exceeding 20 percent of the NSB-approved baseline cost or $10 million (§2.4.1).

Analysis. The MREFC Panel is involved in entrance, transit through, and exit from the design stage of the project life cycle and has only one engagement point (re-baselining recommendation) during the construction stage. There are three stages where the MREFC Panel is not explicitly involved: the development, operations and divestment stages. By comparison, both the Department of Energy's and NASA's policy manuals governing facility approvals require approval at the executive level for the development and operations phases.[6] In DOE's case, sign-off by the Acquisition Executive is required for stage gates at the commencement of the development phase – Critical Decision (CD)-0, Approval of Mission Need – and at the commencement of the operations phase – CD-4, Approval of the Start of Operations or Project Completion. For CD-0, the program is required to identify a credible performance gap expressed as a set of functional requirements between its current capabilities and those required to achieve the goals articulated in its strategic plan. The mission need is to be independent of a particular solution, and is not defined by equipment, facility, technological solution, or physical end-item. For DOE's CD-4, the program must demonstrate that the project is ready for turnover or transition to operations. This includes a Project Transition to Operations Plan that clearly defines the basis for attaining initial and full operating capability. In NASA's case, Pre–Phase A activities begin to define preliminary program requirements, constraints, ground rules and assumptions on the project and stakeholder expectations, including preliminary mission objectives/goals and mission success criteria (NASA/SP -2014-3705, §4.3.1.3). This is the stage where initial cost estimate ranges are developed. The transition to operations requires a Program Implementation Review by the project's Standing Review Board. For both agencies, approvals at these stages provide early visibility for the leadership into program elements that will have the potential for significant impacts on strategic directions, agency reputation, future risks and budgetary liabilities. In the NSF context, the MREFC Panel is asked to evaluate whether a project fits within the strategic plans of the NSF and that of the sponsoring Directorate or Division at the exit from development and entry into the design stage (§2.2.2) rather than at the onset of development. No MREFC Panel review is required under current policy upon entry to operations.

> *Finding: The role of the MREFC Panel is appropriately focused on reviewing and recommending approval for projects moving through the stage-gated life-cycle, but the duties of the MREFC Panel fall short of covering the full life-cycle by omitting review of project plans in the development, operations and divestment stages.*

[6] DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Asset and NASA Space Flight Program and Project Management Handbook (NASA/SP -2014-3705).

Recommendation 3.1: Strengthen the role of the MREFC Panel during the project development stage by amending §2.2.1 of the LFM to require approval from the MREFC Panel prior to development activities. The focus of this approval should be on defining the capability gap and preliminary functional requirements needed by the Directorate.

Recommendation 3.2: Strengthen the role of the MREFC Panel during the operations stage by amending §2.4.2 of the LFM to require review and recommendation by the MREFC Panel of each project's Transition to Operations Plan as part of their review of final design and again at the completion of construction.

Recommendation 3.3: The MREFC Panel Charter should be brought into alignment with the LFM by specifically enumerating each of the stage-gates where MREFC Panel review and recommendation is required.

The June 2016 Charter for the MREFC Panel establishes the membership as comprising the NSF Chief Operating Officer or Deputy Director (Chair), the Assistant Directors (ADs), Program Office Heads, the Chief Financial Officer, the Head of the Large Facilities Office and representatives from the Budget Division and the Offices of Legislative & Public Affairs, General Counsel and Integrative Activities.

The MREFC Panel evaluates projects according to criteria that fall in three broad categories: [1] the scientific and technical criteria assessed by researchers in a field or interdisciplinary area (generally at the NSF division level); [2] agency-specific criteria assessed across related fields (NSF directorate level); and [3] national criteria assessed across all fields (overall NSF Level).[7]

Of the fifteen specific questions the MREFC Panel is expected to examine when evaluating a project against the LFM's ranking criteria, most are science policy, portfolio management, and community prioritization related. Only two – Which projects are the most technologically ready? and Are the project-management capabilities of the proposal team of the highest quality? – explicitly require evaluation of the technical readiness of a project's cost, scope and schedule or whether its technical risks have been adequately bought down or managed. For a senior level panel that meets as-needed, these are the appropriate level questions. For the oversight of performance of large-scale infrastructure projects, on-going engagement with greater technical expertise, including experience with facility contruction and facility operations, is required. Here, the LFM has appropriately vested oversight responsibility in the Integrated Project Teams (IPT, §2.1.6.3) by streamlining and strengthening the routine oversight of project performance in the stages between approvals of transit through the project life cycle.

Section 4.5.3 of the November 2016 draft LFM requires periodic external reviews that provide advice on the status and anticipated future performance of the facility activities. The Manual directs NSF to develop a review charge that elicits advice matched to the specific needs and challenges of the facility at the time. In much the same fashion that DOE's 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), the Subcommittee believes it is important that LFO be intimately involved through the IPTs in selecting the requisite expertise for any project's external review committee. The LFM can be clearer in assigning this responsibility for the composition of and the authorship of external review panel charges to the LFO during the design and construction phases so that the NSF Director has direct access to project and cost estimating expertise during these critically important phases when cost increases are most likely. This independent perspective can help inform oversight actions as NAPA called for, while ensuring that expertise is available in an on-going manner

[7] NSF Large Facilities Manual: NSF 15-089 (June 2015), Appendix A. 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.

during construction and tailored to technical challenges of the project at hand in a way that a FACA committee meeting only occasionally would not provide. The Subcommittee further notes the importance of continuity in external review panel membership throughout critical phases of a project's life-cycle, such as construction, when detailed knowledge technical performance is essential.

> *Finding: The MREFC Panel is appropriately constituted and vested with sufficient authority to review and recommend the as-needed approval of advancement through the project life cycle against the ranking and evaluation criteria assigned in its Charter or to it by the LFM. The more technically-oriented IPTs and LFO-managed independent external reviews are the appropriate mechanism for the on-going, detailed oversight of project performance during the design and construction phases.*

> *Finding: Quarterly updates on status of projects under design or construction are not adequate to provide adequate continuous oversight should problems arise.*

Recommendation 3.4: The Deputy Director/COO should meet at least monthly with the Head of the LFO and the chairs of all active IPTs to review progress, including all earned value management tracking, on projects under design and under construction.

Recommendation 3.5: The LFM can be clearer in assigning responsibility for the composition of and the authorship of external review panel charges to the LFO to ensure that the NSF Director has direct access to independent project management and cost estimating expertise during the design and construction phases.

During the Subcommittee's examination of NSF's processes and in our discussions with the Associate Directors during our kick-off meeting, the Subcommittee was struck by the lack of specific procedures describing how individual Directorates or Divisions advance nascent facilities project concepts. This echoes the lack of visibility expressed to the Subcommittee by other senior and executive level officials. As a follow-up request, the Subcommittee asked to see any written policies the Directorates have setting forth the requirements a project must meet or the processes to be followed during the development stage, before emerging into conceptual design. There were none.

NSF is expected to be a fully engaged partner with the research communities with a strong sense of ownership of the research policy, program plans, and budgetary resources invested in large facilities. There are significant differences between the various disciplines in their community prioritization traditions and in the technical details of how use of the multi-user facilities is allocated, although these prioritization traditions and user time allocation methods can be quite stable over time within a discipline. These disciplinary differences manifest themselves most strongly as variations within the LFM process at the early stages of project development and community prioritization and in the development of facility resource allocation and performance expectations during the operations phases. Making those processes explicit improves transparency and helps ground expectations.

> *Finding: The agency-wide processes defined in the 2015 LFM are clear, largely comprehensive, and more rigorous than in prior editions. However, there is a general lack of clarity as to how these processes operate at the Directorate or Division level. The Subcommittee understands that there are significant technical and cultural reasons for the variation among disciplines. Within many disciplines, there are stable, well understood processes that can be made more explicit and transparent to senior officials, the executive levels of the NSF and NSB, as well as oversight bodies at the onset of facility projects.*

Recommendation 3.6: Directorates and Divisions should define their discipline-specific processes for initiation of a potential large research infrastructure project and for the general performance

criteria against which those facilities or suites of facilities, once built, will be evaluated during their operations phase.

IV. Full Life-cycle Oversight Role and Risk-Based Management

Background. Large facilities are one subset of research infrastructure; however, large research facilities merit special attention as the development and construction of world leading facilities involves the design and development of a state-of-the-art, frequently one-of-a-kind capability which entails significant technical and financial risks. Importantly, while the cost of construction of large-scale infrastructure can range from tens of millions to hundreds of millions of dollars—or more for other agencies—operations costs are typically on the order of ten or more per cent of construction. Full life cycle costs (including operations and maintenance costs as well as the costs associated with facility upgrades) can be several times the cost of the construction of the facility. NSF's annual outlays for research infrastructure operations and maintenance is many times the annual outlays for concept development and construction (see Figure 2). Importantly, the construction of state-of-the-art facilities is a very complex undertaking, and failure to properly manage risks throughout design, construction, and commissioning phases can negatively impact facility performance (operational efficiency, productivity or both) during operations, thereby reducing the scientific return on the nation's investment. Full life-cycle management of large research infrastructure investments, from cradle to grave, is vital to optimize the return on investment.

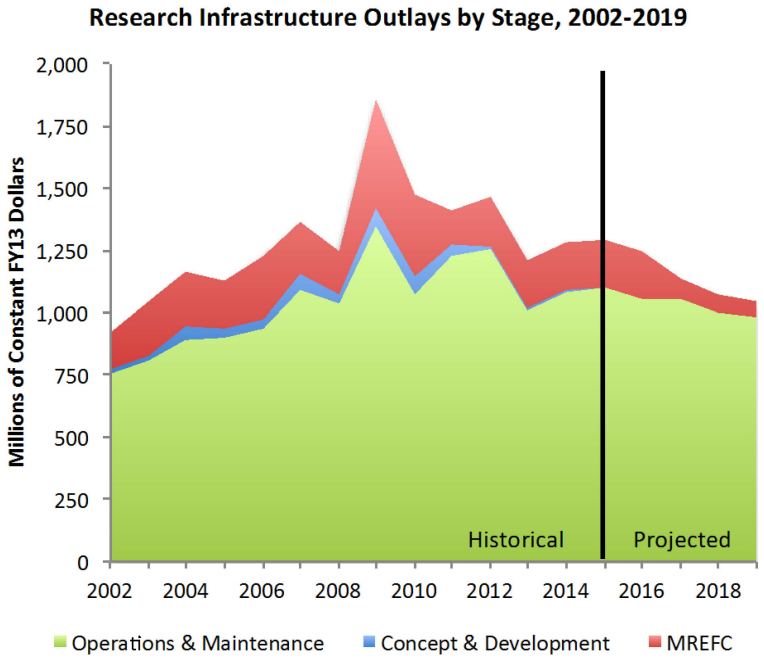

Figure 2. Outlays for Research Infrastructure for Facilities Concept Development, Construction (MREFC), and Operations & Maintenance (National Science Board 2014).

Analysis. NSF has adjusted the Total Project Cost (TPC) eligibility threshold for potential inclusion in the Major Research Equipment and Facilities Construction (MREFC) account to $70 million, partially addressing a funding gap that had existed between large facilities and major research instrumentation investments (MRI).[8] At the same time, a recently enacted bill, the American Innovation and Competitiveness Act (AICA) of 2017, has provided a different threshold:

[8] NSF Director Memo NSB-2016-46, dated October 20, 2016.

Sec. 110(g)(2). MAJOR MULTI-USER RESEARCH FACILITY PROJECT. —The term ''major multi-user research facility project'' means a science and engineering facility project that—

(A) exceeds the lesser of—

(*i*) 10 percent of a Directorate's annual budget;

or

(*ii*) $100,000,000 in total project costs; or

(B) is funded by the major research equipment and facilities construction account, or any successor account.

Additional thresholds defining midscale research infrastructure that fall above the threshold for MRI but below the threshold for MREFC are defined at the program level and legitimately vary from one field to the next.

Finding: The Subcommittee supports NSF exercising its managerial discretion to apply the LFM guidance and process requirements to projects below the legislatively mandated thresholds in section 110(g)(2) of the recently enacted AICA.

Recommendation 4.1: Although the Subcommittee does not specify any particular threshold for inclusion in the MREFC account, all relevant thresholds should be clearly documented in §1.4 or §2.7 of the LFM. All research infrastructure investments above the MREFC threshold, regardless of the NSF budgetary source, should follow the NSF LFM guidance and process.

Early in the conceptual design phase of a potential research infrastructure investment, NSF program staff should work with the LFO to perform an initial risk analysis of a potential project. The development of such a preliminary risk profile would help guide the procurement process, and the oversight process should be tailored to the risk profile. For instance, purchases of commercial off-the-shelf (COTS) equipment might be "large" in the sense of high cost, but represent a relatively moderate risk, while other projects that require the custom development of a unique piece of equipment might be higher risk. Other projects may contain collections of relatively small, low-risk awards that do not require much, if any, oversight. For monitoring purposes, the NSF should develop a set of risk "tracks" that group projects not just by size or funding source, but rather based on enterprise risk. These tracks should consider the risk and the size of the project, and the risk monitoring and oversight should be continuous and tailored as the project moves through the successive stages of project execution as the risk "spectrum" will evolve continuously through the stages of development. In early phases of a facility development, there may be relatively high-risk R&D investments needed to develop new capabilities that are on the critical path for realizing the facility's design performance. Once the R&D is successfully completed and capabilities have been developed, this risk is retired and other risks may arise (for example, manufacturing of key components). Thus, the necessary skill sets of the IPT should be reviewed at each stage and adjusted to be sure the status of important risks is appropriately assessed.

Recommendation 4.2: The Large Facilities Office, working on behalf of the Deputy Director/COO, should work with Program Staff and NSF Management to assure that the skill sets included on IPTs are matched to the risk spectrum of the project being reviewed.

At the same time, it is vital to find the right balance between the need for appropriate risk management and excessive oversight, which itself can increase cost. A critical aspect of the track system is that each track should have clear, well-defined, and documented processes for review, reporting, and decisions, and which aspects of the LFM do and do not apply should be clear and unambiguous. A critical success factor is for the LFM to be clear about requirements for preliminary risk assessment and associate processes, and the LFO and NSF staff to work together to develop credible risk assessments and appropriately tailor oversight.

Recommendation 4.3: The NSF should develop a set of risk "tracks" that group projects not by size or funding source, but rather based on the Foundation's risk exposure. These tracks should consider the risk and the size of the project, and the risk monitoring and oversight should be suitably tailored. The requirements for these alternative tracks should be added to the LFM and clearly documented.

Once in operation, however, facility performance does not appear to be continuously monitored at the agency level. Given the on-going outlays for facilities operation, it is important for NSF to understand the return on investment associated with operating facilities. Therefore, NSF should expand its enterprise risk management framework to include facilities operations. The NAPA report suggests that the MREFC Panel should extend into its oversight into the operational phase. Consistent with recommendation 3.2 that the MREFC Panel review and recommend each project's Transition to Operations Plan as part of their review of Final Design and again at the completion of construction, the IPT is better suited to provide on-going operational oversight.

Recommendation 4.4: NSF should expand its enterprise risk management in research infrastructure investments to include monitoring facility operations and productivity, as well as progress on facility upgrade investments above the recommended threshold level.

- **4.4.1: The Deputy Director/COO should meet at least every six months with the Head of the LFO and the chairs of all IPTs to review performance metrics of operating large-scale research facilities. These metrics, which should be developed in consultation with the relevant research community, must reflect both the scientific productivity of the facility (e.g. number of user proposals, number of users served, publications, high-impact research results) as well its operational efficiency (e.g. beam-up time, number of operating hours vs. scheduled, etc.) for all operating large facilities.[9]**
- **4.4.2: Each Large Facility should report on facility performance annually to NSF. NSF should report large facility performance to the NSB in summary form. Results from facility operational reviews should also be reported in summary form to NSF leadership and the NSB.**
- **4.4.3: The IPT's purview and lifespan should be extended to the operational phase of the project with a mandate to regularly review operational performance of NSF large facilities; and the membership of the IPT should include members who have experience operating large facilities.**
- **4.4.4: At least once every five years after the initial ten years of operations, the annual review should evaluate whether divestment should be considered for the facility. Any resulting plan developed by a Directorate or Division that proposes significantly repurposing and redirecting a facility or its decommissioning, disassembly, and disposal – any of which can involve significant expenditures of resources – to go through the MREFC Panel for review and recommendation to the Director.**

The development of large facilities is motivated by the desire to extend a research community's scientific reach and the promise of discovery this brings. Given the large capital investment in developing new research facilities, most undergo one or more upgrades to keep capabilities current with emerging

[9] One concrete example of a best practice for scientifically-driven performance metrics for a multi-user research facility is the suite of DOE x-ray synchrotron light sources. See Birgeneau, R. J., & Shen, Z. X. (1997), "Report of the BESAC Panel on Synchrotron Radiation Sources and Science," U.S. Department of Energy for scientific productivity metrics and Lüdeke, A., Bieler, M., Farias, R. H. A., Krecic, S., Müller, R., Pont, M., & Takao, M. (2016), "Common operation metrics for storage ring light sources," *Physical Review Accelerators and Beams*, *19*(8), 082802 for operational efficiency metrics for the core technical component of the light source.

research challenges or morph to address new research opportunities, thereby extending their lifetime and increasing the return on investment. In this way, large facilities can have useful lifetimes of the order of decades. Nonetheless, facilities have a finite lifetime. At some point, the scientific impact of a facility will become diminished and the carrying costs may no longer be justified in comparison to other competing priorities for program investments. The termination of a large facility can have serious impacts on the associated research community, and abrupt divestment of any facility would impact hundreds to thousands of scientists, engineers, and highly experienced staff. Therefore, careful transition planning for facility divestment is critically important. NSF will need to develop guidance for programs considering facility divestment. Engagement and communication with the affected research community and key stakeholders is a vital element.

In 2005-2006 the Division of Astronomical Sciences undertook a "Senior Review" of its portfolio of facilities.[10] This review, a recommendation of the NRC/NAS Astronomical Decadal Survey, was motivated by the budget outlook, as well as the ambitions of the astronomical community as reflected in the Decadal Survey, and other reports such as "Connecting Quarks with the Cosmos."[11]

This review examined the balance of NSF investments in the various facilities supported by AST, and sought to re-balance the NSF portfolio to support and grow a strong portfolio of investments in astronomical and astrophysical sciences, and to seed the next generation of facilities. This included the need to divest and/or re-direct the mission of some facilities. This process is an excellent example of programmatic planning through research community/stakeholder involvement, which explicitly included divestment options.

Recommendation 4.5: NSF should work with the research communities, including consultation with the Directorate advisory committee, to explore and document approaches and best practices for managing facility end of life and divestment from large research facilities. NSF should develop policy and guidance for programs to support divestment consideration and decision making.

V. A Senior Official for Large Facilities in the Office of the Director

Background. The Large Facilities Office was created in 2003 to improve oversight of research infrastructure projects. Since its inception, LFO has authored the LFM (formerly the Facilities and Management Oversight Guide), which documents NSF policies and procedures for effective project planning, management, assistance, assurance, and oversight of large facilities. While it is a component of the Office of Budget, Finance and Award Management, LFO has historically served as an NSF-wide resource on project management and large facilities assistance and oversight particularly during the design and construction stages.

One of LFO's most important roles is as a member of the MREFC Panel. This panel is chaired by the NSF Deputy Director, and is charged with reviewing research infrastructure projects during design and making recommendations as to their readiness to proceed. Formerly a non-voting member, the LFO head was recently elevated to serve as a voting member. This notable change places the LFO head on par with senior leadership in the directorates when it comes to large facilities management and oversight. It also solidifies a direct connection between LFO and the Deputy Director on project management and large facilities issues.

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[10] "From The Ground Up: Balancing The NSF Astronomy Program," Report of the National Science Foundation Division of Astronomical Sciences Senior Review Committee, October, 22 2006.

[11] McKee, Christopher F., and J. H. Taylor, "Astronomy and Astrophysics in the New Millennium," Report of the Astronomy and Astrophysics Survey Committee, National Academies of Science (2001) and National Research Council. "Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century," National Academies Press, 2003.

The NAPA report notes that a 2012 internal study commissioned by the NSF Director recommended the designation of a senior official for large facilities in the Office of the Director to coordinate facilities planning and oversee development of the then Project Assessment Office (now LFO). The House-passed version of the America COMPETES Act of 2015 would have required the NSF Director to appoint a senior official within the Office of the Director responsible for oversight of major multi-user research facilities. Despite that, the NAPA Panel did not recommend the designation of a senior official in the Office of the Director, noting that where the LFO organizationally resides is not as important as clear project management roles, responsibilities, and authorities—together with leadership support.

Since the Subcommittee began its work, Congress has taken legislative action. Paragraph 110(a)(2)(H) of the American Innovation and Competitiveness Act of 2017 requires NSF to "appoint a senior agency official whose responsibility is oversight of the development, construction, and operations of major multi-user research facilities across the Foundation." NSF's interpretation is that this statute is not prescriptive with respect to line reporting or positioning within NSF, so the Subcommittee's initial charge remains relevant.[12]

Analysis. The charge for this Subcommittee is to evaluate the potential value in creating an internal agency "senior official" position in the Office of the Director charged with reporting to the Director and Deputy Director/COO on large facilities.

As described elsewhere in this report, the Subcommittee believes the current NSF process for stage gate approvals confounds these approvals (i.e., readiness to proceed to the next stage) with oversight of performance within a stage (i.e., cost and schedule performance during preliminary design). Exacerbating this issue is a lack of clarity regarding who holds the final approval authority for such decisions. Together, these issues create a level of opacity that hinders management and oversight at the executive level.

The Subcommittee believes that there should be a senior NSF executive who serves as the final gatekeeper on approvals prior to presentation to the National Science Board and as the "owner" of the agency-wide oversight processes for projects underway. The Subcommittee sees this as the proper role of the Senior Official posed in this charge question. The role is analogous to the Acquisition Executive function at the Department of Energy and at the National Aeronautics and Space Administration. It is the Acquisition Executive that considers project performance, recommendations from various review committees, and feedback from stakeholders, and then ultimately decides whether to proceed or not. Locating the large facilities senior official in the Director's office would solidify that position's role in establishing cross-agency standards and policies as relate to large facilities and other major research infrastructure. It would also provide for improved consistency regarding technical and administrative review and approval processes.

> *Finding*: *The issue of a Senior Official and the NAPA Panel's call for a Large Facilities FACA are tightly linked. The Subcommittee sees value in the Office of the Director having a clearly articulated responsibility with respect to facilities and research infrastructure, which may include more than the MREFC budget account.*

Recommendation 5.1: The Subcommittee believes that there should be a clearly-designated senior official in the Office of the Director with direct visibility into and accountability for the Foundation's facilities and research infrastructure – which would encompass significant projects in the directorates as well as in the MREFC account. This official would serve a role analogous to the Acquisition Executive role in DOE and NASA.

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[12] The Subcommittee notes the passage of P.L. 116-264, the Program Management Improvement Accountability Act, which calls on each agency to designate a senior executive of the agency as the Program Management Improvement Officer, whose role is to support continuous improvement in program and project management.

The Subcommittee also believes that it is important to avoid the creation of a separate position to serve in this role, as the Subcommittee believes that would dilute the authority and accountability of the Director and Deputy Director, as well as create ambiguity between the senior official role and the LFO head. The Subcommittee therefore recommends that the Deputy Director/COO serve as this senior accountable official. The Deputy Director/COO would then have discretion to staff the role as needed – whether that be placing direct staff in the OD or leveraging the LFO head to serve that function.

VI. A New Large Facilities FACA

Background. The NAPA Panel states that a FACA committee for large research projects 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. The NAPA Panel notes that the BOAC advises BFA and OIRM on issues related to oversight, integrity, and enhancement of NSF's business operations with the goal of improving agency performance. But because BOAC is chartered jointly to the Heads of BFA and OIRM, NAPA believes the committee is not able to fulfil the envisioned role of providing the Director direct access to independent project and cost estimating expertise for reviewing research infrastructure projects.

BOAC has a history of establishing facilities-focused subcommittees. In addition to the current subcommittee, the 2011 *ad hoc* Subcommittee on Funding and Governance of Future Major Multi-user Facilities and the 2012 Subcommittee on Recompetition of Major Research Facilities carried out studies that have informed oversight actions.[13]

The 2015 NSB Policy Statement on Recompetition of Major Facilities[14] acknowledges that the Board was strongly influenced by the January 2012 BOAC Subcommittee on Recompetition of Major Research Facilities. In that policy statement, the Board "affirms that merit-reviewed competition must remain the foundation for the NSF's grant/award making process, but is concerned that imposing a recompetition for the management of a major facility at every renewal, typically at five-year intervals, could be damaging to the best interests of U.S. science and technology." The Recompetition Subcommittee's recommendations that NSF adopt a statement of goals and principles guiding the recompetition of major research facilities and that the NSF adopt uniform definitions for the terms "recompetition" and "renewal" across NSF programs are reflected in §2.5.2 and §3.5.2 of the 2015 LFM.

Analysis. For individual large-scale infrastructure projects, an appropriately empowered LFO will provide as called for in recommendation 3.5 the Director with direct access to independent project and cost estimating expertise. Section 5.4 of the November 2016 draft LFM, which states that guidelines for planning and executing external reviews of NSF's large facilities are under development, signals that NSF is moving in this direction. Language was added indicating that [1] the reports and recommendations from external reviews are made directly to NSF and [2] NSF evaluates the review panel input, determines the appropriate response, and issues written guidance to award recipients for any subsequent response and action.

The Subcommittee does concur with the NAPA Panel's view that the NSF Director requires an independent perspective as to whether the LFO and program officers are identifying and tasking the required independent project and cost estimating expertise with sufficient rigor. Here, NSF's Committee of Visitors process is an appropriate existing model. NSF uses Committees of Visitors to periodically assess the quality of its program management activities related to the reviewing and awarding of research- or education-related grants, cooperative agreements, and contracts. A primary focus of the COVs it to examine the quality and integrity of matters pertaining to proposal decisions. In a similar fashion, BOAC

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[13] Available at https://www.nsf.gov/oirm/bocomm/meetings/may_2011/Report_of_the_FGFMMF_Subcommittee_Mar_17_2011.pdf and https://www.nsf.gov/oirm/bocomm/meetings/spring_2012/Recompetition_report.pdf

[14] The National Science Board approved NSB Statement NSB-2015-45 on November 19, 2015.

subcommittees can be periodically charged to assess the quality and integrity of the LFO and Directorates risk assessment, program management and cost estimating activities as related to research infrastructure investments.

> *Finding: The Subcommittee does not believe an additional external review of individual projects by a Large Facilities FACA would improve performance. Independent project management and cost estimating reviews of individual research infrastructure projects must be designed into processes codified in the LFM.*
>
> *Finding: The Subcommittee notes that the charter of the BOAC is not in compliance with the General Services Administration's Committee Management Secretariat guidance document, Preparing Federal Advisory Committee Charters, that states the agency "identify the agency or official (by title or position) to whom the advisory committee provides its advice. Normally, this is the agency head."*[15]

Recommendation 6.1: Instead of creating a new Large Facilities FACA, NSF should utilize BOAC subcommittees as needed to periodically review the rigor of NSF's large facilities oversight processes in a manner analogous to the role a Committee of Visitors has in providing external expert assessment of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions. BOAC, like other FACA committees, has a mechanism for creating subcommittees as necessary.

Recommendation 6.2: To ensure that the NSF Director has full awareness of all such BOAC subcommittee assessments, NSF should recharter BOAC so that the NSF Director, through the BFA and OIRM Heads, becomes the official to whom the committee reports as recommended by the General Services Administration's Committee Management Secretariat guidance.

VII. Additional Considerations/Observations

In the course of its work, three issues arose where the Subcommittee identified additional opportunities for NSF to improve its internal processes for reviewing, approving and overseeing its research infrastructure investments.

MREFC Review Packages. In the Subcommittee's conversations with NSF and NSB executives and staff, the issue was raised about the staffing culture at NSF. When documentation is required for agency-wide reviews by the MREFC Panel, the NSF Director, or the NSB, the default posture is conveyance of complete documentation packages. While these levels of disclosure of detail is laudable, executives and oversight staff do not have the intimate familiarity with projects nor their documentation to catch every relevant detail. ***The Subcommittee recommends that LFM §2.3.2.6 be revised to make more explicit the responsibility of the Director's Review Board to prepare cover memos for packages advancing to the Director and NSB that focus executive attention on cost, scope and schedule risks, mitigation options analyzed, and remediation actions taken to manage those risks.***

MREFC Ranking Criteria. The United States remains atop the list of the world's R&D-performing nations, but our share of total global R&D has declined from 42% to 33% over the 1996-2013 period as research capacity has grown globally.[16] With the arrival of an era where the U.S. finds itself approaching parity with other nations in many fields of research, NSF needs to be strategic about identifying research areas where US leadership is essential, and the facilities which help to ensure that leadership. To that end, the ranking criteria included in Appendix A of the LFM correctly include the requirement for the MREFC Panel to review projects for their potential for maintaining US leadership in key science and engineering

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[15] GSA Committee Management Secretariat, "Preparing Federal Advisory Committee Charters," at http://www.gsa.gov/portal/mediaId/165487/fileName/Preparing_FAC_Charters_%28F%29-110211.action.

[16] Science and Engineering Indicators 2016 (NSB-2016-1), Figure 4-8: Gross domestic expenditures on R&D, by the United States, the EU, and selected other countries: 1981–2013.

fields. However, the Subcommittee believes that NSF should be more explicit in the assessment of that particular criteria earlier in the MREFC process than it is currently. The international leadership question is a component of the LFM's Third Ranking Criteria, which does not formally enter the analysis until the NSF Director's Recommendation for Advancement to Final Design (§2.3.2.5, footnote 1, p. 2.3.2.5-1). ***The Subcommittee recommends that the international leadership question be considered as one criterion for approval to enter the Conceptual Design Phase***. Some research communities (e.g. Astronomy, High Energy Physics) conduct rigorous community-based planning efforts (e.g. the Decadal Survey for Astronomy and Astrophysics) and this could be one source for this analysis/assurance.

FACA Committees. The revised LFM requires that the originating directorate obtain an endorsement from the appropriate advisory committee prior to requesting NSB approval for inclusion of the project in a future NSF budget request to Congress.[17] Many of these high level advisory committees with a role in prioritizing discipline-wide investments and in the oversight of the performance of large facilities are not chartered comparably to those of the other agencies that build and operate large scientific facilities. According to the GSA Committee Management Secretariat, the NSF has 50 registered FACA committees.[18] Excluding the 34 grant review panels, the nine FACA committees that advise the Directorates (BIO, CISE[19], EHR, ENG, GEO, MPS and SBE) or the Office of International Science & Engineering are chartered at the Associate Director or Office Head level. Comparable FACA committees in DOE's Office of Science or at NASA are chartered to an official appointed by the President needing Senate confirmation (PAS).[20]

There are three additional advisory committees that are jointly chartered by NSF, DOE and NASA or by NSF and DOE. The Astronomy and Astrophysics Advisory Committee is chartered to the NSF Director, the NASA Administrator, and the Secretary of Energy. Two additional FACA committees that have significant roles in the prioritization of large scientific facility investments, the High Energy Physics Advisory Panel and Nuclear Sciences Advisory Committee, are jointly chartered to the Director of DOE's Office of Science and the AD for MPS. The Director of Office of Science, however, is a PAS appointment, so the chartering officials are not of a comparable level of authority and accountability in the two agencies.

Consistent with recommendation 6.2 that NSF recharter BOAC so that the NSF Director be the official to whom the committee reports in compliance with the General Services Administration's Committee Management Secretariat guidance, the Subcommittee recommends that NSF consider rechartering the advisory committees reporting to the Associate Directors as well as the two joint NSF/DOE FACAs. This will help ensure greater visibility of the NSF Director and Deputy Director, the agency's two PAS officials, into the operations of these FACA committees that are assigned critical roles in the evaluation and endorsement of research infrastructure projects by the LFM.

VIII. Conclusion

In response the NAPA report, NSF has focused much of its attention on improving business practices and oversight for research infrastructure investments in the design and construction stages. Given the large financial investment in the construction of facilities and the associated risks, as well as the high visibility of research infrastructure projects in the scientific community, the Executive Branch, and Congress, improving risk management for research infrastructure investments in these stages of the facility life cycle

[17] LFM, §2.1.6.2, duties assigned to the AD (or Office Head) of the Originating Organization.

[18] GSA Committee Management Secretariat, FACA Database Downloadable Datasets, "FACA Data collected and verified for FYs 1997-2015," at http://www.facadatabase.gov/datasets/.

[19] Both the Advisory Committee for Computer and Information Science and Engineering and the Advisory Committee for Cyberinfrastructure report to the AD for CISE.

[20] In DOE's Office of Science, these are the Advanced Scientific Computing, Basic Energy Sciences, Biological & Environmental Research, and Fusion Energy Science Advisory Committees. At NASA, this is the NASA Advisory Council.

has been the first-priority. NSF has strengthened its methodology for contingency estimating and analysis, as well as the management of project contingency funds. Further, the NSF has been actively clarifying the roles and responsibilities of NSF staff and offices, as well as the NSB, to improve management oversight. The recently updated LFM reflects this maturation and is a significant step forward, providing a strong policy and framework for the management and oversight of large research infrastructure construction projects, and if followed carefully and fully implemented, will significantly reduce NSF exposure to risks associated with these investments. The NSF efforts in strengthening oversight of large-scale infrastructure construction projects are laudatory.

The recommendations of this Subcommittee are motivated by an understanding that large-scale research infrastructure projects require routine oversight throughout their full life cycle, and that a stable, transparently applied, enterprise-wide framework for risk monitoring, independent of the budget account funding any given project, is necessary from conception to de-commissioning and divestment. The Subcommittee believes that a key component of this enterprise risk management involves not only monitoring facilities in construction, but also monitoring the health of operating facilities, as well as carefully analyzing the risks inherent in new, one of a kind research facilities *at the earliest stages of conception*.

Appendix A

Charge from the Business and Operations Advisory Committee to the Subcommittee on NAPA Implementation

Dated August 3, 2016

The National Science Foundation (NSF) hereby initiates the formation and operation of an ad hoc Subcommittee of the NSF Business and Operations and Advisory Committee (the Committee) on NAPA Implementation (the Subcommittee). The purpose of the Subcommittee is to issue a report to the Committee with recommended ideas for NSF for implementing a subset of National Academy of Public Administration (the Academy) recommendations related to NSF-wide oversight of large-scale research facilities in the report *National Science Foundation: Use of Cooperative Agreements to Support Large Scale Investment in Research.*

Context

The NSF Director and the National Science Board (NSB) requested that the National Academy of Public Administration 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. Specifically, the Academy was asked to:

- Address how CAs are currently used at NSF, examining the effectiveness of NSF's current CA policy;
- Compare the CA mechanism with other federal funding mechanisms;
- Ascertain how comparator scientific agencies manage similarly large, complex research facilities projects; and
- Identify potential improvements to the NSF's processes that support large-scale research facilities.

NSF seeks to ensure effective implementation of a subset of the NAPA recommendations in a manner that provides the greatest benefit to the scientific community served by the NSF while ensuring exemplary stewardship of taxpayer resources. In order to ensure this effective implementation, NSF must be fully informed of the best oversight practices of other agencies and organizations that sponsor, oversee, or manage large-scale research facilities.

Charge to the Subcommittee

Because of the topical nature of the subject matter of the advice requested, the Committee hereby charges the Subcommittee to prepare a report for the Committee to advise NSF on the following areas, and to identify and advise the Committee, and ultimately NSF, on other important topics that the Subcommittee deems relevant. The Committee will then be prepared to provide advice to NSF to support the Foundation's goal to be comprehensively informed and equipped to implement the NAPA recommendations in an expert fashion. **Specifically, the Subcommittee should provide options for appropriate agency-wide oversight** for the NSF Office of the Director (OD). In developing options, the Subcommittee should consider the following:

- Re-scope of the role, duties, and membership of the Major Research Equipment and Facilities Construction (MREFC) Panel to include status update reviews of projects in the development and construction phases focusing on cost, schedule, and performance. [Recommendation 6.2].
- Evaluate the potential value in extending the MREFC Panel's role to operating facilities, including divestment (i.e. full life-cycle).
- Evaluate the potential value in creating an internal agency "senior official" position in OD charged with reporting to the Director and Deputy Director/Chief Operating Officer (COO) on large facilities;

- Evaluate the potential value in creating a new Federal Advisory Committee Act (FACA) committee to provide the NSF Director with a sounding board for objective insight on large research projects. [Recommendation 6.4]

To carry out this charge, the Committee requests the Subcommittee meet with:

- NSF OD, Directorate, and Office leadership and staff;
- NSB Members, Office leadership and staff;
- NSF's Inspector General
- Representatives from other agencies with analogous facilities, to benefit from experience at those agencies.

The Subcommittee may collaborate with the Committee if the Subcommittee deems it necessary to do so.

Subcommittee Membership: The Committee's Designated Federal Officials (the Heads of the NSF Office of Information and Resource Management and Budget, Finance and Award Management) shall initiate a list of approximately 8 individuals for Subcommittee membership, including at least one Committee member who shall serve as the liaison to the Committee. Final membership shall be approved by NSF with collaboration and advice from the Committee.

Additional Background: *Attach material such as the NAPA implementation chart, any draft guidance, proposed options, detailed questions to the Subcommittee, etc*.

Activities of the Subcommittee: The Subcommittee is requested to provide a written report to the Committee recommending NSF actions on a priority basis established by NSF so that implementation can take place incrementally, if possible. The Committee requests an update on Subcommittee activities at 3 month intervals and a final report by April 1, 2017.

NSF will organize and convene at least one in-person meeting at NSF, comprised of the Subcommittee, NSF staff cognizant of the projects and issues concerning the Subcommittee, and with the individuals mentioned above necessary to carry out this charge. Additional in-person meetings will be considered depending on need and budgetary resources.

NSF will provide logistical and travel support for invited non-local participants. Participants will be invited to submit written materials to the Subcommittee for reference in their report preparation.

The Subcommittee may organize additional meetings by conference call or other virtual technology as it deems necessary to do so.

The Subcommittee chair will submit its written report to the Committee and provide a verbal presentation at a duly organized Committee meeting subsequent to submittal to NSF. The Subcommittee liaison to the Committee will facilitate this presentation, and will ensure that the report is discussed and deliberated at the meeting. The Committee will accept the report and make it publicly available. The Committee may also provide feedback to NSF and any additional comments it has to offer on the report by way of a cover letter to NSF.

On or before the meeting where the Subcommittee's written report is discussed, the Committee's Designated Federal Officials may extend the Subcommittee's charge and activities as deemed necessary by NSF; otherwise, the Subcommittee will terminate upon completion of the activities set forth in the charge.

Appendix B
Membership of the Subcommittee on NAPA Implementation

Dr. Michael J. Holland (Subcommittee Chair, BOAC member) – Executive Director, Center for Urban Science & Progress, New York University, Brooklyn NY.

Dr. J. Patrick Looney – Chair, Sustainable Energy Technologies Department, Brookhaven National Laboratory, Upton NY.

Dr. Kevin B. Marvel – Executive Officer, American Astronomical Society, Washington DC.

Ms. Kathryn S. Schmoll (former BOAC member) – Independent Consultant

Dr. Richard P. Seligman (former BOAC Co-Chair) – Associate Vice President for Research Administration, California Institute of Technology, Pasadena CA.

Ms. Stephanie A. Short (BOAC member) – Associate Deputy Director for Field Operations, Office of Science, U.S. Department of Energy, Washington DC.

Dr. Dan C. Stanzione, Jr. – Executive Director, Texas Advanced Computing Center, The University of Texas at Austin, Austin TX.

Dr. John C. Tao (BOAC member) – President, O-Innovation Advisors LLC, Allentown PA.

Dr. David Trinkle (former BOAC member) – Director, Berkeley Research Development Office, University of California, Berkeley CA.

Dr. Joseph A. Whittaker – Dean, School of Computer, Mathematical & Natural Sciences, Morgan State University, Baltimore MD.