

MPSAC Subcommittee on MPS Facilities & Major Research Infrastructure Version 2021.05.25

Background

The Mathematical and Physical Sciences Directorate (MPS) has responsibility for the funding and oversight of development, design, construction, and operations and maintenance (O&M) of a set of large and mid-scale facilities. These components of research infrastructure represent strategic investments that enable transformational science. Such activities, whether at the Major Facility or Mid-scale level, accounted for more than \$363 million out of the total budget of \$1,491 million in FY 2019 MPS Research and Related Accounts (R&RA), plus an additional \$73 million of facilities construction in Major Research Equipment and Facilities Construction (MREFC) spending for FY 2019. MPS funding for facilities O&M accounted for over 35% of NSF's total O&M budget for major multi-user research facilities in FY 2019, the largest of any Directorate in NSF.

In 2004, in response to a request from Congress, the National Academy of Sciences issued a report¹ regarding NSF's process for identifying, approving, constructing, and managing large-research-facility projects. The report includes a number of recommendations for actions by NSF and recommends that NSF implement a set of well-defined criteria for the selection of large projects for construction. The National Science Foundation (NSF) and the National Science Board (NSB), in a joint report², responded by embracing the spirit of the Report's recommendations and addressed the principles of the primary recommendations, leaving the detailed mechanisms to be addressed in consultation with its communities, the Office of Management and Budget (OMB), and Congress. In particular, the NSB/NSF response states "NSF will also continue to use NSF directorate advisory committees for input to the process, and will continue to involve members of the community in the merit review of MREFC projects." More recently, the NSB issued a study on the costs of operations and maintenance of NSF facilities³ and a report on the importance of Mid-scale Research Infrastructure⁴, which further illuminate the complex and important challenges that MPS faces in its development and operations of the research infrastructure upon which much of its science relies.

NSF directorate advisory committees have specific responsibilities with respect to facilities under consideration for future construction. NSF policy requires that when a

¹ *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*, The National Academies Press, 2004 (<https://www.nap.edu/catalog/10895/setting-priorities-for-large-research-facility-projects-supported-by-the-national-science-foundation>).

² *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation* (NSB-05-77), <http://www.nsf.gov/pubs/2005/nsb0577/index.jsp>.

³ *Study of Operations and Maintenance Costs for NSF Facilities* (NSB-2018-17), <https://www.nsf.gov/pubs/2018/nsb201817/nsb201817.pdf>.

⁴ *Bridging the Gap: Building a Sustained Approach to Mid-scale Research Infrastructure and Cyberinfrastructure at NSF* (NSB-2018-40), <https://www.nsf.gov/nsb/publications/2018/NSB-2018-40-Midscale-Research-Infrastructure-Report-to-Congress-Oct2018.pdf>.

Directorate intends to request NSB action to authorize the inclusion of a new large facility project in a future NSF MREFC budget request to Congress⁵, the Directorate's advisory committee should first examine and provide their endorsement of the proposed facility. This examination can be conducted in the context of the ranking criteria found in the Academy's report (Appendix I) and/or other criteria, as appropriate. With the recognition of the strategic importance of Mid-scale investments, including the new, agency-wide programs in Mid-scale Research Infrastructure that were developed in response to the NSB report⁴ on the importance of mid-scale strategic investments, the subcommittee will also be asked to examine the MPS portfolio of investments through the mid-scale initiatives (at both Division and agency-wide levels) and assess their strategic value to fostering the science supported by the Directorate. This applies especially to mid-scale investments at the larger scale (greater than \$20M) that are funded via the MREFC account. Consideration of the role of current and potential future cyberinfrastructure facilities and/or institutes both as stand-alone entities and as integral components of large facilities is also a critical element of the research infrastructure that must be considered.

The primary purposes of the MPSAC Subcommittee on Facilities & Major Research Infrastructure are to support the MPSAC responsibilities with respect to potential new facilities and provide strategic advice on issues, opportunities, and challenges posed by the MPS large and mid-scale research infrastructure portfolio. In order for the subcommittee to accomplish these tasks, it will need to acquire an understanding of the existing MPS research infrastructure portfolio and the impacts on the divisions and on MPS concerning resources needed to carry out proposed projects and ongoing operations. Because the Subcommittee members will be knowledgeable of the MPS portfolio and associated challenges, the Assistant Director may also periodically request the Subcommittee provide advice on other elements of facilities planning and implementation.

Charge to the MPSAC Subcommittee on Facilities & Major Research Infrastructure

The MPSAC Subcommittee on Facilities & Major Research Infrastructure is charged with the preparation of a strategic report to the MPSAC that:

- Assesses the potential contribution of new proposed major and mid-scale infrastructure projects to the scientific communities of MPS, as well as to those communities outside MPS if applicable; the role of such projects within the existing MPS research infrastructure portfolio; the impact of this infrastructure on future plans and resources of MPS and its divisions; and the role of the resulting investment in the international context. This assessment should take into account

⁵ The MREFC process is described in NSF's *Major Facilities Guide (NSF 19-068)*, <https://www.nsf.gov/pubs/2019/nsf19068/nsf19068.pdf>

as many of the community planning efforts as possible in the time available so as to provide a broadly informed, truly strategic report.

- Provides recommendations to the MPSAC for statements to the MPS Assistant Director concerning requests for inclusion of MPS major facility projects in NSF budget requests to Congress.
- Provides strategic advice on elements of the evolving MPS research infrastructure portfolio at the request of the MPS Assistant Director.
- Provides guidance and decision rules that will lead to a robust 10-year program of strategic investment in the development, construction, and operation of large and mid-scale infrastructure for the physical sciences.

Given the extensive nature of the advice sought and the timescales of the various community studies, both underway and planned, a number of interim reports will be required as the subcommittee prepares its full recommendations.

Membership

Membership of the subcommittee will consist of selected current MPSAC members representing all five MPS divisions plus up to seven additional external members as deemed appropriate by the MPS Assistant Director and the MPSAC Chair.

Members of the subcommittee will be appointed for two-year terms. The MPSAC and MPS Assistant Director may invite members to serve additional terms in order to provide the best advice to pursue opportunities and confront challenges on the horizon for MPS and its facilities portfolio.

Duration

The subcommittee will terminate once it has submitted its final report to the MPSAC Advisory Committee, no later than January 1, 2026. The subcommittee charge will be reviewed and revised as needed by the MPSAC and MPS Assistant Director until the termination date. The MPSAC and MPS Assistant Director may include addenda to the charge clarifying the duties of the subcommittee as it conducts its work.

Schedule of Reports

The subcommittee is asked to submit its final report by January 1, 2026.

The first interim report (Addendum 1) would be most useful on the timescale of September 2021, in order to provide the foundation for further discussions, both with the MPSAC as well as within the NSF, regarding upcoming investment opportunities.

The schedule and subjects of subsequent interim reports will be as mutually determined by the AD/MPS and the MPSAC Chair and will become further Addenda to this charge.

Support

The MPS Directorate will provide appropriate support and documentation to the MPS Facilities Subcommittee in order to enable the subcommittee to develop its recommendations.

Designated Federal Official

The MPS Senior Advisor for Facilities or other MPS Senior Advisor will be the Designated Federal Official for the subcommittee, at the discretion of the MPS AD.

APPENDIX I

The following criteria have been excerpted from the National Academies' 2004 report, *Setting Priorities for Large Facility Projects supported by the National Science Foundation*. These criteria may serve as a guideline for the work of this Subcommittee.

Criteria for Developing Large Facilities Roadmaps and Budgets

Overlapping categories of criteria should guide the preparation of the large facilities roadmap and NSF's annual budget submissions. Scientific and technical quality must be at the core of these criteria. Because these are large facility projects, they must have the potential to have a major impact on the science involved; otherwise, they should not reach the next step.

The rankings show what we would expect to happen first within a field, then within a directorate of NSF, and then across NSF. The criteria from earlier stages must continue to be used as the ranking proceeds from one stage to the next.

- **First Ranking: Scientific and Technical Criteria Assessed by Researchers in a Field or Interdisciplinary Area**
 - Which projects have the most scientific merit, potential, and opportunities within a field or interdisciplinary area?
 - Which projects are the most technologically ready?
 - Are the scientific credentials of the proposers of the highest rank?
 - Are the project-management capabilities of the proposal team of the highest quality?
- **Second Ranking: Agency Strategic Criteria Assessed Across Related Fields by Using the Advice of Directorate Advisory Committees**
 - Which projects will have the greatest impact on scientific advances in this set of related fields taking into account the importance of balance among fields for NSF's portfolio management in the nation's interest?
 - Which projects include opportunities to serve the needs of researchers from multiple disciplines or the ability to facilitate interdisciplinary research?
 - Which projects have major commitments from other agencies or countries that should be considered?
 - Which projects have the greatest potential for education and workforce development?
 - Which projects have the most readiness for further development and construction?
- **Third Ranking: National Criteria Assessed Across All Fields by the National Science Board**
 - Which projects are in new and emerging fields that have the most potential to be transformative? Which projects have the most potential to change how research is conducted or to expand fundamental science and engineering frontiers?
 - Which projects have the greatest potential for maintaining US leadership in key science and engineering fields?
 - Which projects produce the greatest benefits in numbers of researchers, educators, and students enabled?

- Which projects most need to be undertaken in the near term? Which ones have the most current windows of opportunity, pressing needs, and international or interagency commitments that must be met?
- Which projects will have the greatest impact on current national priorities and needs?
- Which projects have the greatest degree of community support?
- Which projects will have the greatest impact on scientific advances across fields taking into account the importance of balance among fields for NSF's portfolio management in the nation's interest?

Ranking projects across disciplines is inherently not an exact science; nevertheless, these criteria, as illustrated by the questions, provide a framework for a discussion of why one project is accorded a higher priority than another and a mechanism for the discussion to be as objective as possible in ranking projects across fields.

Within the ranking categories, the questions might change as governmentwide initiatives and unexpected occurrences shift priorities. Similarly, at times, some questions might have greater weight than others in the judgment of the NSB. The key element is for the questions and weighting to be identified before the ranking process begins and for a clear rationalization to be provided when proposed large research facility projects are ranked.

Background

In preparation for this and all future requests for input, the MPSAC, through its Subcommittee on MPS Facilities, should establish a general understanding of the opportunity space for investment in next-generation facilities. To this end, the Subcommittee may wish to familiarize themselves with a number of past and future community prioritization efforts that have specific relevance to future mid-scale and large facilities. These include, but are not limited to, the 2020 Astronomy and Astrophysics Decadal Survey, the high energy physics community's next Snowmass/P5 strategic plan, and an upcoming National Academies study on the long-term directions for high magnetic field science and technology development. Other communities in astronomy, physics, materials research, chemistry, and the mathematical sciences will present additional reports in the coming years that address midscale facility opportunities as well as the wealth of data that come from facilities at all scales. Taken as a whole, these studies will set forth a list of scientifically important projects and activities, including potential new world-leading facilities.

These next-generation facilities will be both exciting in their promise and challenging in their realization. The Subcommittee should therefore also aim to develop a high-level understanding of the salient challenges on the horizon, most notably with respect to the impacts of resource limitation across the full facility life cycle of current and future facilities. Topics of interest may include barriers to maintaining a robust development pipeline for new facilities, limitations on support available through the Major Research Equipment and Facilities Construction account, escalating operations and maintenance costs, and the relative costs and savings associated with facility divestment.

Interim Report Request

The request of the MPSAC for this interim Subcommittee report is twofold:

1. After its Subcommittee's due consideration of the motivations and impacts of facility investments, **provide a summary for MPSAC consideration articulating the importance of major and mid-scale facilities to NSF's scientific leadership and MPS's role in ensuring that its scientific research infrastructure enables the current and future cutting-edge science of the Directorate.**
2. Pursuing these investments will require the support and buy-in of a diverse set of stakeholders, including NSF senior leadership beyond MPS, Congress, and the Administration. Therefore, the report should **provide advice on how to best "make the case" for this next generation of MPS's Major Facilities and**

related investments as a critical part of the support MPS provides for the scientific disciplines in its broad portfolio.

The brief report to the MPSAC, including the summary as well as the Subcommittee's advice and feedback, would be most useful on the timescale of Q3 of CY2021, in order to provide the foundation for further discussions, both with the MPSAC as well as within the NSF, regarding upcoming investment opportunities.