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SETTING PRIORITIES FOR LARGE RESEARCH FACILITY PROJECTS SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION



Introduction

The National Academies Report regarding NSF's process for identifying, approving, constructing, and managing large-research-facility projects states:

"A number of concerns have been expressed by policy-makers and researchers about the process used to rank large-research-facility projects for funding. First, the ability of new projects to be considered for approval at the National Science Board (NSB) level has stalled in the face of a backlog of approved but unfunded projects. Second, the rationale and criteria used to select projects and set priorities among projects for MREFC funding have not been clearly and publicly articulated. Third, there is a lack of funding for disciplines to conduct idea-generating and project-ranking activities and, once ideas have some level of approval, a lack of funding for conceptual development, planning, engineering, and design—information needed when judging whether a project is ready for funding in light of its ranking and for preparing a project for funding if it is selected. Those concerns have eroded confidence among policy-makers and the research community that large-research-facility projects are being ranked on the basis of their potential returns to science, technology, and society."

The Report includes a number of recommendations by the Study Committee for actions by NSF to address these concerns. NSF embraces the spirit of the Report's recommendations. In this response we address the principles of the primary recommendations, leaving the detailed mechanisms to be addressed in consultation with our communities, OMB and Congress.

Transparency or Clarity of the MREFC Process

The National Academies' Report calls for an open process with well-defined criteria and with a maximum of community input. The Report also recommends that the results of the final prioritization be "discussed, explained and documented." NSF concurs with these recommendations and is making the necessary changes to its processes to ensure that decisions are clearly documented and explained, and selection criteria clearly articulated. There is in fact substantial overlap between the "Criteria for Developing Large-Facilities Roadmaps and Budgets" in the National Academies Report and those already in use by NSF¹. NSF has begun

¹ The documents referenced here and elsewhere include the Facilities Management and Oversight Guide (NSF-03049) (<http://www.nsf.gov/pubs/2003/nsf03049/nsf03049.pdf>), and the Guidelines for Planning and Managing the

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the process of evaluating and adapting the National Academies' criteria for application in making decisions about and setting priorities among large facility projects. The revised NSF criteria and the details of the revised MREFC process will be made public. The *Guidelines for Planning and Managing the Major Research Equipment and Facilities Construction Account*, which is available on the NSF Website, will be modified to include the revised selection criteria and process. The rationale for and results of the final prioritization of projects will be discussed, explained, documented and made public as well. Periodic updates of the NSF *Facility Plan* (discussed below) by the NSF Director will also contribute to transparency.

Community Involvement

NSF will continue to encourage and invite the involvement of research communities to provide scientific input for the planning, development, and implementation of the Large Facility Projects it funds. Presently NSF utilizes Academies studies, community workshop reports and professional society activities, and many other methods to ensure community input. NSF will also continue to use Directorate advisory committees for input to the process, and will continue to involve members of the community in the merit review of MREFC projects. The goal is to make sure that the voices of the communities are solicited and clearly heard, in a manner that is systematic and fair.

NSF will encourage disciplinary and interdisciplinary science planning by all of the research communities that NSF supports. In particular, NSF will encourage formal planning in fields in which scientists and engineers have traditionally not been organized to identify MREFC projects needed for breakthrough advances.

Roadmap: NSF Facility Plan

In response to the recommendation that there be a Major Research Equipment and Facilities (MREFC) "Roadmap", NSF will develop an NSF *Facility Plan*, including the process for selection of MREFC projects. The *Facility Plan*, illustrated graphically in Appendix 1, will combine in one document a report on major facilities under construction and in various stages of development, together with an extensive discussion of the science objectives and opportunities at the frontiers of science and engineering that provide the context and compelling need for major facilities. The Objectives and Opportunities section of the document will provide an overarching, cross-discipline context for assessing the value of a proposed facility in comparison to other investments.

On at least an annual basis, the Director will provide an update of the Facility Plan. The NSB will have an opportunity at that time to review the MREFC process and provide guidance to the Director if necessary. NSF believes that the Facility Plan, updated regularly and made public, will be a valuable planning tool within NSF and the Executive Branch, providing a comprehensive exposition of needs and plans to inform decisions in Congress, and serving as an important vehicle for communicating with our research communities.

Major Research Equipment and Facilities Construction Account (<http://www.nsf.gov/home/about/mre01.html>). Both of these documents will be revised as the MREFC process is refined.

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Considerations in the Development and Revisions of the Facility Plan

As recognized in the National Academies' Report's discussion of the "Roadmap," in order to develop and maintain its *Facility Plan*, NSF will need to establish a process that respects NSF's distinctive culture and mission. NSF supports research and education in nearly every field of science and engineering. Over decadal time spans, the enormously diverse NSF research community is very likely to reconsider its views regarding what science is most important and also its facility requirements and prioritizations. NSF therefore appreciates the Report's recognition that NSF needs to be able to reconsider facilities at every stage in their development. Preserving NSF's flexibility to re-consider the Facilities Plan, and even the MREFC decisional processes is essential for many reasons:

- Technology needed for an instrument or facility may be uncertain, unproven or need to mature. To manage risk and ensure key technology readiness will often require substantial research and development over many years.
- Community judgments about what are the most important projects to build "next" may well change over decadal timescales. New technology and capability emerge and make possible facilities that might not have been considered earlier. New discoveries change the view of the community about what research questions should be answered most urgently, and therefore what facilities are needed.
- NSF facilities often involve industrial and interagency participation, as well as international consortia, agreements, and even co-funding. Such cooperation cannot be planned a decade in advance, and then shelved until funds are available. The Foundation needs to be appropriately responsive. NSF has been particularly effective at such collaborations.
- NSF does not have a single core mission but funds fundamental research in all nearly all science and engineering disciplines. There is often little relationship between facilities needed by one discipline and those needed by another. The balance and timing of investments in different areas need to be taken into account.

Process of Large Facility Project Development

The process of nurturing and maturation of a concept for a facility can take many years to fully develop, or it can come together as a detailed proposal more quickly. This depends largely on the nature of the opportunity, the immediacy of scientific need, and the potential payoffs scientifically and for society in general. Typically, potential projects first come to light at the "Horizon Stage" that includes ideas and opportunities identified by the research communities with perhaps a 10 to 20 year forward look. NSF program officers, divisional and directorate staff are always alert for such breakthrough concepts and actively encourage continued thinking and planning. The availability of such funding and guidance for requesting funds will be included in the MREFC Guidelines posted on the NSF Website.

The Concept Stage, which follows the Horizon Stage, is defined as starting when a candidate facility project is proposed for support of development. The MREFC Panel is fully apprized of the evolution of projects from Horizon to Concept stage.

On the basis of merit-reviewed proposals, NSF will fund these planning and project development efforts. These will include ad hoc workshop groups in one or more disciplines, National Academies' studies, and research projects related to the development of new

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technologies. In many research disciplines, appropriate community evaluation groups exist that will critique and evaluate each project along the way. For several communities, such planning bodies have as a routine part of their deliberations discussions of facility needs, and even priority setting among possible facilities. Examples of such planning groups are the High Energy Physics Advisory Panel (HEPAP) and the Astronomy and Astrophysics Survey Committee of the National Academies Board on Physics and Astronomy.

Development Stage: Formation of Development Plans

Concept Projects mature into more formal Development Projects on varying timescales and with varying requirements for NSF support. This support is provided from accounts other than the MREFC account, on the basis of merit-reviewed proposals. Decisions at this stage are made at the appropriate level of NSF, according to well-established delegations of authority and corresponding processes. As this evolution occurs, the MREFC panel is informed on a regular basis of the status of the project. The *Facility Plan* will serve to provide periodic updates on the progress of each project to the Board.

At an appropriate time in the development, which may differ for each case, project and NSF program staff will define the project's Development Plan. The Development Plan, updated regularly, will lay out the necessary technical, logistical, and financial trajectory of the project, including decision points, needed to ready the project for construction consideration. The Development Plan will also identify long-lead items at the appropriate stage and should set out strategies to minimize possible gaps in support as planning matures. These Development Plans are presented within the *Facilities Plan*. Through regular briefings of the MREFC panel and, at appropriate intervals, the NSB, all stakeholders remain aware of the progress and the projected resources necessary to continue development. These projections will be taken into account in the development of the NSF budget, as well as planning for future MREFC investment.

It is important to note that some projects may arise from internal exigencies, such as the upgrade of the Polar Support Aircraft, or from studies conducted by external groups, such as the Academic Research Fleet Renewal Plan. These projects will often come to NSF very well developed, having required very little in the way of concept stage support. Such projects are subjected to rigorous scrutiny as they are developed by the responsible NSF Directorates.

It is in the Concept and Development Stages that the appropriate first and second rank evaluations suggested by the Report are performed². First level evaluation of the proposed project includes assessment by appropriate expert peers of the scientific and technical criteria for a project, and the second level evaluation extends to include assessment from the view of related fields. NSF will seek input from its directorate advisory committees in the performance of the second level assessment, and will include committee members in review panels. However, these committees are not constituted appropriately to conduct thorough evaluations of facilities or to compare the merits of facilities in different disciplines.

As already noted, NSF will evaluate and adapt a set of first and second ranking criteria and publish the resulting criteria on the NSF Website in revised versions of the *Facilities Management and Oversight Guide* and of the *Guidelines for Planning and Managing the Major*

² Appendix 2 identifies all three levels of criteria suggested by the National Academies.

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Research Equipment and Facilities Construction Account. The rationale for application of the criteria to specific projects will be included as part of the Facility Plan. NSF will revisit these criteria periodically to determine whether changes are needed.

Funding for Pre-approval Planning and Development

The National Academies' Report properly calls attention to the necessity for considerable pre-approval funding for planning and development when it questions whether there is sufficient NSF support for this "bottom up" process. NSF endorses the Report's recommendations to provide researchers access to funding sufficient to develop compelling research agendas, to refine and prioritize their facility requirements, and to complete research and development on facility designs and needed technologies. The level and form of funding for planning and development will be reviewed, and an evaluation will be made of how project funds are best invested to attain robust plans and schedules with better cost projections, so that only well-defined and thoroughly-costed projects are brought forward for consideration by the Board. The availability of such funding and guidance for requesting such will be included in the MREFC Guidelines posted on the NSF Website.

Readiness Stage

On at least an annual basis, the Facility Plan will identify a small group of projects in the advanced stages of development (Readiness) that the MREFC panel has agreed will be ready to go the Board for approval within approximately the next year as Candidates for New Start. The rationale for these decisions will be clearly articulated in the Facility Plan. Readiness is defined in terms of a clearly defined science program, sufficiently mature engineering design and construction plans, plans for operation subsequent to construction, budget projections, and late stage evaluation of the proposed project both by the research community and within the NSF. In accepting the Facility Plan the NSB will concur that each of the Readiness List projects has attained that status by an appropriate process.

Individual Large Facility Projects may be removed fall from the Readiness List due to insufficient priority over the long-term, failure of the plans to reach construction readiness, eclipse by other projects, collapse of major international agreements, or any other reason that the Director deems appropriate. Specific decision criteria for removing Large Facility Projects from the Readiness List will be developed by NSF and, following Board approval, made available to the public.

Candidates for New Start

The MREFC panel and the Director will prioritize the Readiness List projects using an appropriately modified set of "third ranking" (National) criteria. When deemed appropriate the highest priority projects will go to the NSB for approval and inclusion in the "Candidate for New Start" pool of NSB approved projects. Any project that is recommended to the Board for approval will be expected to have achieved its specific goals, as laid out in its development plan. An additional important aspect of planning for future facilities is consideration of the costs of operation and maintenance, since these costs are not borne by the MREFC Account; NSF must be able to operate and maintain the facilities it constructs. The rationale for the

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prioritization of projects will be clearly articulated in the Facility Plan. The Director and the Board will communicate the rationale for decisions to the community.

The Board may prefer to consider several projects at a time and may ask the Director to defer proposal of individual projects until additional projects are ready for consideration. The Board will reconsider its current guidelines for project approval in order to refine and adapt them using the third ranking (National) criteria proposed in the National Academies' Report, and then re-publish them as the necessary criteria for a project to move into the "Candidate for New Start" pool of Board approved projects. (Appendix 3 includes a draft of these criteria.)

The Director will prepare annually, as part of the Facility Plan, an analysis of projects included in the "New Start Pool" and propose a recommended prioritization among those projects, including the new additions. Priority among projects may be changed at that time, utilizing the third ranking (National) criteria. If a project's plans are no longer deemed to be clearly and fully construction ready, the Director may recommend that the project be remanded back to Readiness Stage for further consideration and development. The Director will present these recommended actions to the Board for approval. The Director and the Board will make public the rationale for the prioritization of projects.

Budgetary Approach

Large Facility projects that are under construction have the very highest priority and all have the same priority. Every effort will be made to move them all forward at a rate consistent with sound management and well-conceived engineering and construction plans, in accordance with the longstanding policy of the Administration, Congress, the Board, and the Foundation.

As part of the annual budget preparation, the Director will propose funding for some subset of the Board-approved New Start pool of projects in their priority order, as budget constraints permit, and then negotiate with the Office of Management and Budget (OMB) on budget inclusion. This approach is apparent in the NSF FY 2005 Request to Congress, which includes funding for three projects currently under construction and five projected new starts with budget estimates detailed through FY 2009. In the future, the observations and considerations used by the Director and the Board to rank one large-facility-project idea over another for inclusion in NSF's annual budget requests will be clearly and publicly described so that policy-makers and researchers understand the rationale for the decisions. Whenever possible and appropriate, OSTP and the Congress will be informed concerning the process and decisions about prioritization. NSF will seek OSTP assistance in the development of interagency collaborations.

Oversight of and Flexibility in Implementation of Large-Facility Projects

The Director and the Board recognize the need to strengthen oversight of the implementation of large facility projects, which will require increased investments of NSF staff time and travel funds. The Report emphasizes the importance of initial planning and definition of technical scope, budget, and schedule, followed by periodic post-award status reviews held on-site by external experts, with implementation of a transparent process for management of changes to a project's implementation plan. These principles are well appreciated, but they have not been uniformly applied at NSF. Furthermore, they constitute a new rigor of oversight for some

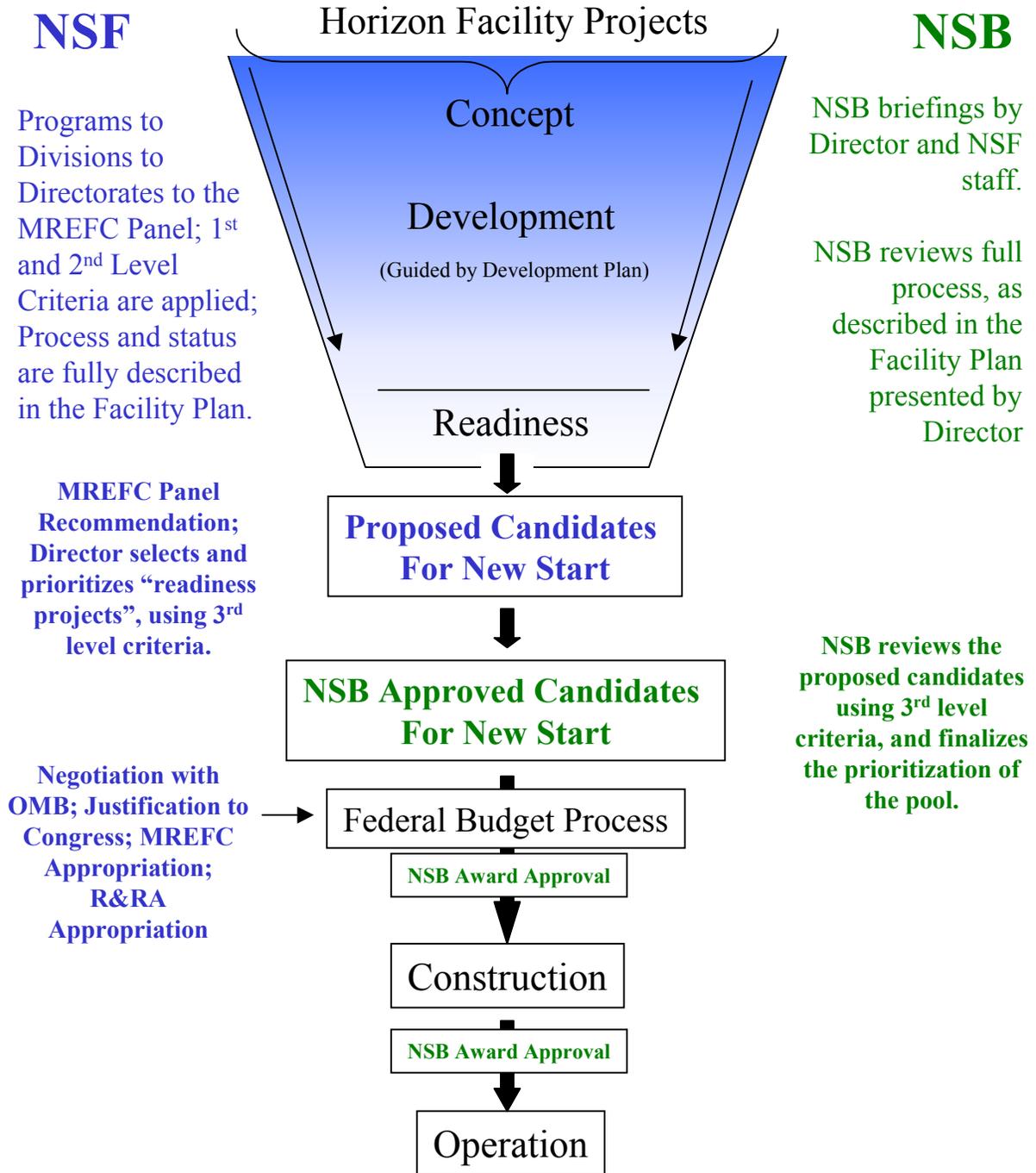
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disciplines supported by the Foundation. While NSF construction projects are typically well-managed and there is a good record on meeting cost, schedule, and especially facility performance goals, we recognize the need to apply standards uniformly, in accordance with the recently developed Facilities Management and Oversight Guide.

NSF has established the Deputy for Large Facility Projects (DLFP) position to have broad administrative, coordinating and accountability roles that span the Foundation, with goals of: defining uniform and well-established processes for reviewing projects; analyzing and monitoring costs; and meeting scientific and technical goals. The DLFP monitors the business operations and project management aspects of large facility project design, construction/acquisition, and operation. In this capacity, the DLFP supports and assists NSF program staff while maintaining NSF divisional and program officer authority to directly oversee large facility projects.

However, enhanced uniformity of process and improved initial planning of facilities must also preserve the flexibility of NSF to pursue opportunities that arise during implementation. For example, while future operations and maintenance budgets must be defined as part of the overall planning for construction and utilization of each new large facility, it is crucial to recognize that the operations phase is the research component of any project and is consequently less predictable. For example, the advent of grid computing has presented new opportunities and new challenges to operating budgets for many NSF facilities. Flexibility must exist to support evolving needs for the most successful projects and to support new developments and opportunities that inevitably arise from research activities. It is important also that NSF sustain a system of checks and balances within its organizational framework. Such a system is integral to ensuring more effective communication, greater transparency, and the ability to elevate concerns to the attention of NSF Senior Management and the National Science Board.

NSF Facility Plan and Process for Selection of MREFC Projects



Criteria for Developing Large-Facilities Roadmaps and Budgets

Excerpted from the National Academies' Report: Setting Priorities for Large Facility Projects Supported by the National Science Foundation.

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 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?

**DRAFT NATIONAL SCIENCE BOARD CRITERIA FOR APPROVING AND PRIORITIZING
LARGE FACILITY PROJECTS (LFPs)³**

In presenting a Large Facility Project to the Board for final Board approval, NSF must document the following properties for that project:

- project plans are judged to be construction ready by the NSF BFA Deputy Director for Large Facility Projects,
- the budget for construction and for operations costs has been justified to the satisfaction of the Chief Financial Officer,
- the project has been evaluated by the community and the NSF MREFC Panel asserts that it is of high priority to meet specifically identified *NSF Science Objectives*,
- the science program to be supported by the facility is adequately planned, and
- the NSF Director proposes the project to move into the *Board approved* stage.

For the Board to approve a project to enter the BOARD APPROVED stage, the Board considers the following:

- research enabled by the proposed facility,
- construction plans together with their risk and readiness,
- budget justification for construction and operation of the facility,
- imminent funding⁴ is likely to be available in the next two or so years, and
- priority of the project for achieving one or several of the *NSF Science Objectives* is validated by the community and the relevant Directorate Advisory Committees.

The Board will utilize the following criteria as part of its consideration to provide BOARD APPROVAL to each LFP:

- Scientific & Technical Assessment w/in Field or Interdisciplinary Area
- Community & Advisory Committee Support; Address Reviews
- Potential to be Transformative
- Essential for US Leadership in S&E
- Greatest Leverage of Researchers, Educators & Students Enabled
- Time Sensitive Window of Opportunity and Commitments
- Impact National Priorities & Needs (include social)
- Impact Across Fields & NSF; Balanced Portfolio

³ These are draft criteria. Not all will be appropriate for every project under consideration, and additional criteria may be appropriate for some projects.

⁴ The certification of "imminent funding" is a clear statement from NSF of intent to include project funds as part of the next or following fiscal year budget request, along with some indication through informal discussions with OMB and the Hill that overall NSF next year funding levels will allow for new project funding requests to be made.