

## **VI. FINDINGS AND RECOMMENDATIONS**

NSF seeks to expand the capacity and capability of the academic research community and its infrastructure. This may involve developing a new research tool, establishing a new research facility, building a major scientific and engineering knowledge base, or developing the next generation of researchers in key scientific and engineering fields. This study was initiated to determine the impact that declining funding rates and increasing proposal submissions is having on NSF's capacity to fulfill its mission, and on the scientific and engineering communities that it serves.

As detailed in the preceding sections, IPAMM found that many factors influence proposal submissions and proposal funding rates. Casual consideration of the trends may give the impression that the funding rate problem is the direct and simple result of budget issues, but a careful analysis of the data failed to identify any single factor as being the primary contributor. Nonetheless, trends and patterns did emerge that helped formulate the following findings.

### **Major Findings**

NSF proposal funding rates declined due to a surge in proposal submissions at the same time NSF was responding to earlier community concerns by making a concerted effort to increase the average award size. Between FY 2000 and FY 2004, NSF's budget increased nearly 44% and the average award size increased by 41%, leaving little room to absorb the nearly 50% increase in proposal submissions.

The increase in proposal submissions can be attributed both to an increased applicant pool and to an increased number of proposals per applicant. There are a number of reasons for the expanded applicant pool, including increased size of the research community, an increase in the proportion of the community dependent on grants for key parts of their income, and increased research activity at more types of institutions. The growth in the intellectual capital of the country is a positive outcome of Federal investments in building the nation's capacity, which will need to be incorporated into planning by all funding agencies, including NSF.

Responses to the 2007 NSF Proposer Survey suggest that there are significant institutional pressures on regular tenure-track faculty members to get grants to achieve promotion and tenure, and to support their students and labs. These pressures, compounded by the declining funding rate, increased NSF use of targeted solicitations in new areas, and decreases in funding levels in other Federal agencies, are likely contributors to the growth in the number of proposals per applicant.

Although IPAMM did not attempt to quantify it in this report, a related and interacting issue is the shift toward interdisciplinary research and the move away from small, single-investigator projects to the dominance of teams in the production of new knowledge. NSF has actively fostered this shift, both through the use of solicitations requiring interdisciplinary teams of researchers and by simplifying the mechanism for submitting collaborative projects to any NSF program through FastLane. This qualitative change in the way research is being conducted has important long-term implications for the merit review system, as the quantity and the nature of proposals change along with the research. NSF recognizes that there are review and funding

challenges inherent within this shift toward more interdisciplinary and team-based research and is giving this topic serious consideration.

The increase in proposal submissions has had an impact on NSF's merit review system; there are several indications that it is overstressed. Reviewers are reviewing more proposals than they were in the past, and responses to the 2007 NSF Proposer Survey suggest that the reviews submitted by overworked reviewers may be diminishing in quality. Although the increased proposal workload has not affected the percentage of proposals that are processed within six months, feedback received through the 2007 NSF Proposer Survey indicates that there is growing dissatisfaction with the time to decision.

The NSF merit review process, seen by many as the gold standard for merit review, is a robust and verifiable system that was designed to distinguish excellent ideas from those that need more refining. It is, however, under considerable stress in the current highly collaborative, interdisciplinary research environment that places excellent science and engineering proposals in competition with different but equally excellent science and engineering proposals, a scenario that is more frequent as funding rates decline. Addressing the structure of the merit review system is beyond the scope of this report, nonetheless IPAMM suggests that NSF, an agency at the forefront of science and engineering research, needs to keep pushing the frontier on how to evaluate that research.

NSF and the community it serves appear to be coping, despite increasing workload and stress. For example:

- The high quality of proposal submissions and awards was maintained.
- No underrepresented group (women, minorities, institution type) was disproportionately disadvantaged.
- Support for new investigators was maintained.
- The percentage of research proposals processed within six months of receipt was maintained.
- Researchers' current overall satisfaction levels with NSF's proposal submission and review processes are comparable to 2003 levels.

This finding demonstrates the great resilience of NSF's proposal evaluation and processing system and its research community. Nonetheless, there are signs that the system is overstressed. The combination of increasing average award size during a period of increasing proposal submissions resulted in making approximately the same annual number of awards at somewhat higher budget levels, while processing many more proposal actions. Overall the major impact has been more work for all involved – the PI community, the reviewer community, and the NSF staff. If this trend is not reversed, it is likely to have a negative long-term impact on science and engineering, reducing both the quantity and quality of research and infrastructure.

An important consequence of the reduced funding rate is that highly fundable proposals that are declined tend to be resubmitted, sometimes multiple times. Although it was difficult to document this definitively, the effect of this is that there is a continual pile of proposals being considered repeatedly, with new ones being added to the mix, introducing a 'churn' effect that increases the

number of proposals to be considered, but not the number of awards. This could be a major problem if it were allowed to evolve to a queue effect, in which one could not expect to receive support for any idea until one had revised and resubmitted the same proposed project several times. Further, NSF policy indicates that proposals that have not been substantially revised after having been previously reviewed and declined may be returned without review. However, revising and re-reviewing proposals that are already fundable is a non-productive use of both PI and reviewer time.

The approaches NSF has taken to manage proposal load and funding rates are not uniform throughout the organization, but rather vary remarkably among different directorates and divisions. A decade ago, NSF programs relied much more on mail reviews and much less on panels for proposal evaluation; this trend has reversed over the past several years, partly as a consequence of the significant increase in proposal load. Of the various practices NSF employed to manage proposal submissions, NSF-imposed limitations on proposal submissions is probably the most controversial. Recently, Congress has expressed interest in NSF policies related to this practice—H. R. 1867 (The National Science Foundation Authorization Act of 2007) contains language instructing the NSB to “determine whether current policies are well justified and appropriate for the types of programs that limit the number of proposal submissions.”<sup>43</sup> Results from the 2007 NSF Proposer Survey indicate that, while acknowledging that NSF-imposed limitations tend to have a positive impact on the quality of the proposals that are submitted to NSF, the respondents tended to feel that NSF-imposed limitations on proposal submissions from their institutions have a negative impact on their motivation to seek future NSF funding and on the fair representation of their fields of research. As expected, PIs from RI institutions expressed this view more frequently.

Because of important contextual factors, the decision to use any particular proposal management practice should be made, as they have been, on a case-by-case basis among the program, division, and/or directorate leadership. The Federal research and development (R&D) enterprise is a complex and integrated system, of which NSF is only one element. As several of our case studies illustrate, simple interventions may have limited impact and/or unintended consequences.

### **Recommendations**

NSF is concerned about the effects of decreased funding rate on the research community, particular on the possibility that PIs will feel discouraged about submitting proposals with risky potentially transformative scientific ideas. The challenge facing NSF and the community is to find the right level of competition, i.e., one that hones the quality of the proposals, and results in funding quality research with the minimum amount of time spent in the propose-review-decline-resubmit cycle.

The results of this study do not support a single best or preferred approach to managing proposal submissions and funding rates. Nor do they identify what the appropriate balance between funding rate and award size should be at an agency level. Rather, there are a variety of options, all of which balance trade-offs between keeping the proposal workload to a manageable and

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<sup>43</sup> H.R. 1867 (The National Science Foundation Authorization Act of 2007), Sec. 3(f)2.

productive level (for both NSF and the community) and encouraging the free flow of ideas to NSF.

IPAMM believes that this can best be accomplished by giving the directorates and research offices the responsibility and flexibility to meet this challenge, and by focusing on maintaining both enabling award sizes and funding rates that respond to the priorities and needs of the different communities that each unit serves. Further, NSF management should view the proposal and award management process as a total system. Manipulating any one component of this system is very likely to affect other parts of the system in ways that may not be obvious, thus care should be taken to consider possible unintended consequences when making changes to the system. Because of the complex nature of the interactions between internal and external factors, the following recommendations focus on the development of strategies that are appropriate within the context of the directorate/office, and that balance long-term planning with the ability to respond to changing needs.

1. Each of the directorates and research offices should be required to develop an overarching framework, reported in annual planning documents, that accounts for and balances all of their research-related activities, to help guide strategic planning when determining the appropriate balance between funding rates and award size for particular solicitations or more broadly across the unit. The framework should incorporate flexible management approaches that enable the directorates/offices to track and respond to developments that are most relevant to their communities, including the growth of interdisciplinary research activities. NSF should also encourage the directorates and offices to continue their efforts to communicate with the communities they serve, to obtain feedback from them, and to monitor carefully the impacts of their policies and practices.
2. An important consideration that should be included in strategic planning at both the NSF level and the directorate/office level is that solicitations build communities and infrastructure (including both physical infrastructure and human resources) that have real needs that persist after the funding opportunity ends. Long-term planning for accommodating this growth must go beyond expecting the newly developed community to be absorbed later by the core programs. New research solicitations should be developed within a larger context, so that infrastructure built through one effort can be leveraged by other future efforts. Program solicitations that are intended to develop targeted research areas should be focused as much as possible to help the community develop relevant proposals and avoid the unproductive preparation of proposals that have a low likelihood of funding because of limited resources. Management plans should clearly describe how the new funding opportunity fits within the overarching strategic plan of the NSF, directorate and/or office, and how the balance between award size and funding rate for that solicitation was determined.
3. The practice of limiting the number of proposals that a PI or institution can submit is appropriate in some situations. Because this practice is perceived to have negative impacts on the community, its use should be carefully considered in the context of the trade-offs, impacts, and any special circumstances. For limits on institutions, the level at which limits are enacted (i.e. department, school, university) should be considered. Proposal submission limitations should be fully explained and justified in the solicitation management plan.

4. While some degree of revision and resubmission is an expected and valuable aspect of the merit review process, it is important that the decline in funding rates does not trap PIs and reviewers in an unproductive spiral of revising, resubmitting, and re-reviewing proposals that were highly rated but could not be funded due to limited resources. For example, flexible use of the mix of standard and continuing grants, temporarily increasing the outyear mortgage (without exceeding 60%, as per NSF policy), may provide a short-term solution. At the program officer's discretion, and in consultation with their Division Director, a limited number of proposals might be designated for funding as soon as funds become available in the next fiscal year, without requiring additional review. Other practices, such as using funding from multiple years for some competitions, might also be used where appropriate. NSF's goal of reaching a funding recommendation within six months should be balanced against the potential benefit of breaking the decline-revise-resubmit cycle.
5. Because changes to NSF practices and policies can have far-reaching effects within the scientific and engineering communities served, NSF management should inform the appropriate internal and external communities when implementing new proposal management practices, and should monitor their concerns during the implementation phase. Changes to these practices should incorporate annual evaluations of proposal data and feedback from the research community.
6. Many proposers to NSF say they take funding data into account when deciding whether or not to apply to NSF for research support. This information is usually obtained from NSF staff members, NSF publications, and NSF external databases, such as the BIIS. In the absence of reliable data, proposers often base their decisions on anecdotal information, which may or may not be accurate. Feedback from NSF proposers through the 2007 NSF Proposer Survey indicates that most believe that funding rates are lower than they actually are, which may be influencing how they are interacting with NSF and other funding agencies. It is recommended that NSF evaluate the BIIS to determine if it is readily available to the community and responsive to their needs, and to make appropriate changes if necessary to accomplish those goals. For example, a link providing direct access to division level funding data could be added to the NSF home page, additional links connecting proposers to the BIIS could be added to various pages within the NSF web site, and links to other resources such as this report and NSF's annual Merit Review Reports could be added to the BIIS web site.
7. The changing nature of the science and engineering enterprise and the increasing burden on the review system warrant continued attention. The trends analyses reported here can help NSF monitor the level of stress on the overall system. It is recommended that these analyses be updated annually for internal NSF use and be included in NSF's annual Report on the NSF Merit Review Process to the National Science Board. It is further recommended that NSF senior management periodically reassess the impact of the practices and policies employed by the directorates and research offices, to ensure that NSF maintains its capacity to fulfill its vision of sustaining excellence in the science and engineering research enterprise.