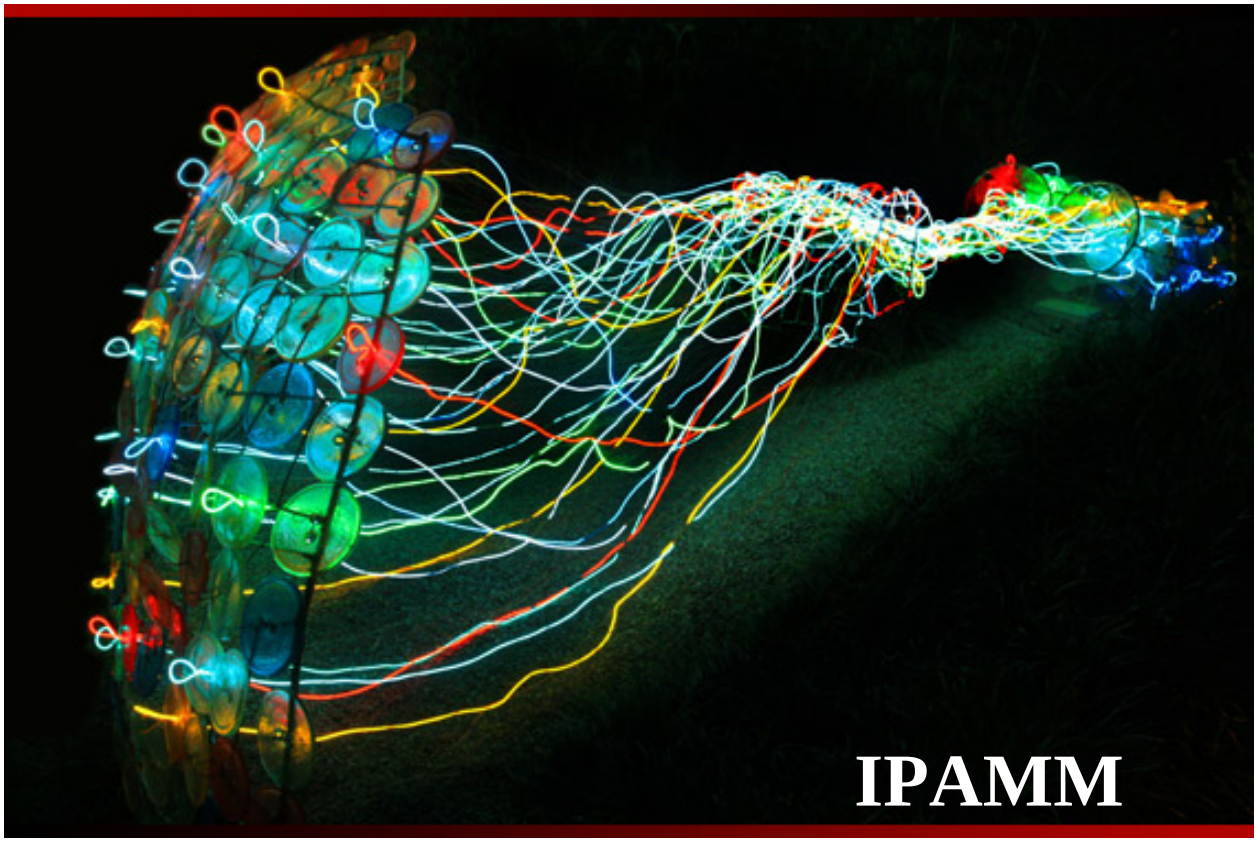


Impact of Proposal and Award Management Mechanisms

Final Report

August 1, 2007

National Science Foundation

Cover photo: ***Sensation: Interior View (2006)*** *is an abstract sculpture by Jersey City artist Nancy Cohen that was inspired by discussions with Princeton University President Shirley Tilghman. Tilghman, a leader in the field of molecular biology, collaborated with Cohen and Princeton University Electrical Engineering Professor James Sturm on the artwork, which is an abstraction about the sense of smell and how odors are recognized and remembered. Multi-colored cast resin discs are affixed to a steel armature forming a wall that connects to bulb-shaped structures by vibrant wires. The different colors of discs represent the sensor neurons in the nose that detect different odorant molecules; the wires represent the axonal connections that pass through the skull to the olfactory bulb in the brain, with the neurons from each type of sensor going to their own specific region in the olfactory bulb.*

Credit: *Edward Greenblat, Photographer, Princeton, NJ; Nancy M Cohen, Sculptor, Jersey City, NJ, and Professors Shirley Tilghman and James Sturm, Princeton University*

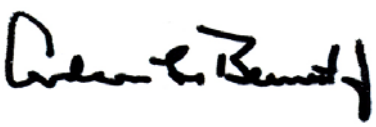
PREFACE

The National Science Foundation (NSF), created over 50 years ago, is the premier Federal agency supporting basic research at the frontiers of discovery across all fields of science and engineering as well as science, technology, engineering, and mathematics education at all levels. As envisioned in our Strategic Plan, NSF strives to sustain excellence in the science and engineering research and education enterprise and to support research with the transformative potential to produce new discoveries, fuel innovation, stimulate the economy, and improve our quality of life. To do this, we must nurture and engage the innovative scientists, engineers and students who are achieving these goals and stimulate broader, continuing participation in this enterprise throughout the nation.

A substantial decline in NSF's proposal funding rate between FY 2000 and FY 2004 raised concerns about the potential impacts on the nation's science and engineering capacity. The potential effects on early career researchers and on the nature of the research that is proposed and funded were of particular concern. To enable the development of evidence-based policy to address these concerns, NSF charged the Impact of Proposal and Award Management Mechanisms (IPAMM) working group to perform a detailed study of the trends, impacts, and causal factors associated with the recent declines in proposal funding rates and the simultaneous growth in proposal submission rates.

The IPAMM results reflect a careful and thoughtful analysis of a wide variety of interrelated issues and concerns. Although the data show that the system is under stress, they also reveal that the NSF program staff and our proposer and reviewer communities are dedicated to maintaining excellence in the nation's scientific and engineering enterprise. Additionally, NSF program officers have demonstrated their commitment to broadening participation, ensuring that beginning investigators, underrepresented groups, and smaller institutions are not disproportionately affected by the reduction of NSF's funding rate.

The data and recommendations contained in this report will be invaluable as the Foundation seeks optimal management mechanisms to maintain the excellence of our merit review process and ensure a vibrant science and engineering enterprise, both now and into the future. NSF will carefully consider these findings and options as we revise existing and develop new funding opportunities.



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MEMBERSHIP AND ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The competition for National Science Foundation (NSF) funds has always been intense, but it has grown more so in recent years. From Fiscal Year (FY) 2000 to FY 2006, NSF's overall funding rate for research proposals decreased from 30% to 21%. During this period, research proposal actions (awards and declinations) increased by 47%, from 21,442 to 31,518. Members of the research and education community have expressed concern that the funding rate and proposal action trends may be negatively impacting the academic research infrastructure, resulting in increased workload and diminished science and engineering capacity. Responding to these concerns, in March 2006 NSF established the Impact of Proposal and Award Management Mechanisms Working Group (IPAMM) to: *"recommend policies and preferred practices to improve NSF's program announcement and solicitation processes in ways that achieve appropriate balances between proposal funding rates, award sizes and award durations…."*

In conducting its study, IPAMM analyzed quantitative data from internal NSF databases and attitudinal data collected through a survey of all NSF principal investigators (PIs) who submitted research proposals during the last three fiscal years. The survey focused on PI perceptions about the proposal review process, factors that influence decisions to submit proposals, reviewer workload, and funding rates with NSF and other organizations.

IPAMM found that many factors influence proposal submissions and proposal funding rates. Casual consideration of the trend may give the impression that the funding rate problem is the direct and simple result of budget issues, but careful analysis of the data failed to identify any single factor as being the primary contributor. When IPAMM examined all of the data, including results from the survey and case studies, trends and patterns emerged that helped formulate its findings.

Findings:

- NSF proposal funding rates declined due to a surge in proposal submissions at the same time NSF was making a concerted effort to increase the average award size. Increases in the overall NSF budget were absorbed by the growth in the average award size, such that the annual number of awards made stayed relatively constant. As a result, funding rates dropped significantly between FY 2000 and FY 2004, leveling off in FY 2005 and FY 2006.

- The increase in proposal submissions can be attributed both to an increased applicant pool and to an increased number of proposals per applicant. The expansion of the applicant pool is due in part to an increased size and capacity of the research community, loss of funding from other sources, and the increased use by NSF of targeted solicitations in new areas. 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. External institutional pressures, combined with the decreased funding rate, contributed to the growth in the number of proposals submitted per proposer.

- There is evidence that NSF's peer review system is overstressed. Reviewer workloads have increased, and feedback received through the NSF Proposer Survey indicated that the reviews submitted by overworked reviewers may be diminishing in quality.

- The overall decrease in funding rate has affected the entire NSF proposer community, but does not appear to have had a disproportionate effect on women, minorities, beginning PIs, or PIs at particular types of institutions.

- A major impact of the reduced funding rates and increased proposal submission rates has been the increased work for all involved – the PI community, the reviewer community, and the NSF staff. More time is being spent on efforts associated with obtaining funds, which detracts from the nation's scientific and engineering enterprise. Although the increased workload has not yet reduced NSF's timeliness in processing proposals, various units across NSF employed one or more strategies to alleviate the pressure on the PI and reviewer communities, either by limiting proposal submissions or by increasing the available pool of resources for particular competitions.

- NSF and the community it serves appear to be coping, despite the increasing workload. The quality of proposals submitted and awarded has not declined due to increased competition or lowered funding rates, though there is evidence that more high quality proposals are being declined. Although it was not possible to quantify, NSF is taking steps to ensure that decreased funding rates do not discourage PIs from submitting proposals with risky, potentially breakthrough ideas.

Recommendations:
The results of this study do not support a single best or preferred approach to managing proposal submissions and funding rates, or in establishing an appropriate balance between funding rate and award size. Rather, there are a variety of options, all of which balance trade-offs between keeping the proposal workload to a manageable and productive level (for both NSF and the community) and encouraging the free flow of ideas to NSF. 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 excellent research with the minimum amount of time spent in the propose-review-decline-resubmit cycle.

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. 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. NSF should require that each of the directorates and research offices develop an overarching framework 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 collaborative interdisciplinary research activities.

2. Research investments 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. 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.

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.

4. Careful consideration should be given to the short-term use of various management practices to increase the number of awards (including changing the balance of standard and continuing awards, or using funding from multiple years) to ensure 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.

5. NSF management should inform the appropriate internal and external communities when implementing new proposal management practices and should monitor their concerns during implementation. Changes to these practices should incorporate annual evaluations of proposal data and feedback from the research community.

6. To ensure that the community has access to specific and accurate statistical data on funding rates, NSF should evaluate the Budget Internet Information System (BIIS, NSF's public portal to award information) to determine if it is readily available to the community and responsive to their needs, and make appropriate changes if necessary to accomplish those goals.

7. The changing nature of the science and engineering enterprise and the increasing burden on the review system warrant continued attention. It is recommended that the trends analyses reported here be updated annually for internal NSF review, and included in the 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.

REPORT OF THE IMPACT OF PROPOSAL AND AWARD MANAGEMENT MECHANISMS WORKING GROUP (IPAMM)

I. INTRODUCTION

Background

As the nation's foremost agency responsible for funding academic institutions to conduct basic science and engineering research, for advancing science and engineering education, and for ensuring the health of the academic research community and its infrastructure, the National Science Foundation (NSF) currently supports over 50% of the Federal non-medical fundamental research at U.S. colleges and universities. NSF's stewardship is vital for maintaining the nation's competitive edge in a world where the solutions to many of the challenges facing society have their roots in our scientific understanding, where technology increasingly drives the global economic engine, and where many other nations are gaining rapidly in scientific and engineering capabilities.

The competition for NSF funds has always been intense, but it has grown more so in recent years. Beginning in FY 2000, the overall average proposal funding rate[1] for NSF research proposals decreased from 30% to 21% in FY 2006, although the NSF budget grew nearly 44% during the same period of time. Many researchers are dismayed that it has become more difficult to get funded by NSF. Members of the science and engineering (S&E) community, including those on NSF Advisory Committees, Committees of Visitors (COVs), proposal review Advisory Panels, and the National Science Board (NSB), have expressed concern that this trend may be negatively impacting the academic research community, resulting in increased workload and diminished S&E capacity. In response, a number of NSF program areas have attempted to manage workload (for both NSF and the community of proposers) and community expectations through a variety of approaches, such as restricting the number of program solicitations and solicitation target dates, and limiting the number of proposal submissions.

Charge to IPAMM

Responding to these concerns (and opportunities for improvement), the Impact of Proposal and Award Management Mechanisms Working Group (henceforth, IPAMM) was established in March 2006.[2] It was charged to: "*recommend policies and preferred practices to improve NSF's program announcement and solicitation processes in ways that achieve appropriate balances between proposal funding rates, award sizes and award duration in the various types of awards that comprise the total NSF portfolio, with the emphasis on individual, investigator-initiated grants.*" [3]

[1] Sometimes referred to as "success rate", the proposal funding rate for a given period is calculated by dividing the number of awards by the number of proposal submissions.
[2] See the full IPAMM membership and acknowledgement of those who assisted IPAMM on page ii.
[3] See the full charge to IPAMM in Appendix A.

As set forth in its charge, the key issues for IPAMM are:

- What are the reasons for the recent declines in proposal funding rates and increases in proposal submissions?[4]
- How have these trends impacted the ability of NSF to fulfill its mission?
- What has been the impact and effectiveness of NSF efforts to manage proposals and funding rates?
- How can NSF data regarding funding rates, award amounts, and award duration be disseminated more effectively?

Scope and Definitions

The scope of the charge focuses on enabling NSF's goal of supporting as many high quality proposals as possible, while minimizing the workload on the principal investigator (PI) and community, which goes beyond simply reducing proposal submissions. In order to address the issues outlined in the charge, IPAMM used both quantitative and qualitative research methods and analyzed data from several sources.[5] In general, IPAMM focused its overall data analyses at the NSF level, and used case studies to explore differences among directorates.

The primary source of attitudinal data was a survey of all NSF PIs who submitted research proposals during FYs 2004, 2005 and 2006, conducted by Booz Allen Hamilton. In January 2007, these PIs (numbering 43,412) received an invitation to complete the online survey. A total of 24,378 PIs responded to the survey for a response rate of 56%.[6] The survey focuses on PI perceptions about the proposal submission process, factors that influence decisions to submit proposals, reviewer workload, and funding rates within NSF and other organizations. A copy of the survey instrument and the survey results are available at: http://www.nsf.gov/od/ipamm/ipamm_2007nsfproposersurvey.pdf.

The findings from the survey are presented and discussed wherever they are relevant throughout this report. In addition to the survey, IPAMM received feedback from the external S&E community through focus groups with new NSF rotators[7], discussions with Directorate-level Advisory Committees, analysis of COV reports, and discussions with the NSB.

Unless noted otherwise, the analysis contained in this report is based on award and decline decisions across the last five to ten years for the *research grant subset*[8] of NSF proposals.

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[4] The 47% increase in proposal submissions began in FY 2000, peaked in FY 2004, and leveled off in FY 2005 and FY 2006.

[5] In collecting data to analyze these issues, a wide variety of data sources were tapped, including the Enterprise Information System (EIS) database, and existing reports (e.g., Science Indicators, business analysis, merit review, etc.). The overall framework for analysis was to identify and analyze the major discontinuities in trends (i.e., funding rates and proposal submissions), and then formulate and test hypotheses with trends analysis of internal and external data, case studies of various practices, and a survey of NSF proposers.

[6] A non-response analysis of the survey data indicated that the respondent population was representative of the overall population.

[7] Rotators are experts from the S&E community who assume temporary professional positions at NSF, usually for one to two years.

[8] The research grant subset of NSF proposals was developed to identify proposals that represent a typical research grant (as opposed to educational or development grants), particularly with respect to the size of the grant. Large awards (such as centers and facilities operations) and equipment and instrumentation grants are excluded, as are small items such as conferences and symposia. Also excluded are Small Business Grants and Small Grants for

Proposals are grouped by Fiscal Year (FY) by the date of the decision, unless otherwise noted. The proposal funding rate for a given period is calculated by dividing the number of awards by the number of proposal submissions.[9] Unless otherwise noted, the term *proposal submissions* represents the number of proposals processed (i.e. awarded and declined) by NSF within a given time period, and does not include withdrawals, proposals returned without review, supplement requests, and other similar actions.

Unless otherwise noted, proposal and PI data include the lead PI only. In this report, the term PI refers to individuals that are identified as principal investigators on all proposals, regardless of whether or not the proposal was ultimately funded.

Organization of Report

This report is organized as follows:

- Section II, *The Issues in Context,* discusses major issues and data trends of concern to NSF and IPAMM.
- Section III, *Impacts on NSF and the Community*, examines how NSF's ability to fulfill its missions of supporting research at the frontier and investing in the development of all segments of the scientific and engineering workforce has been impacted by declining funding rates and increasing proposal submissions.
- Section IV, *Causal Factors,* analyzes the key factors contributing to declining funding rates and increasing proposal submissions.
- Section V, *NSF Efforts to Manage Proposal Submissions and Funding Rates*, assesses NSF practices that have been developed to manage proposal submission and funding rates.
- Section VI, *Findings and Recommendations,* discusses the principal findings of this study and offers some options and potentially promising practices for managing NSF's proposal and award processes.

Exploratory Research (because the award size for both is established at a particular level by policy) and most EHR grants unless they are specifically related to education research.

[9] Among the proposals received by NSF are those from single institutions and those in which investigators from two or more organizations collaborate on a unified research project. In some cases, the collaborating institutions submit a single proposal, in which a single award is being requested (with subawards for the partner organization(s) that are administered by the lead organization). In other cases, the collaborating institutions may simultaneously submit separate, collaborative, proposals (which are joined together in FastLane), in which each organization requests a separate award. For the purpose of calculating funding rates, each of the collaborative proposals and awards are counted individually. For the purpose of calculating average award sizes, the awards for a collaborative project are grouped together as a single unit.

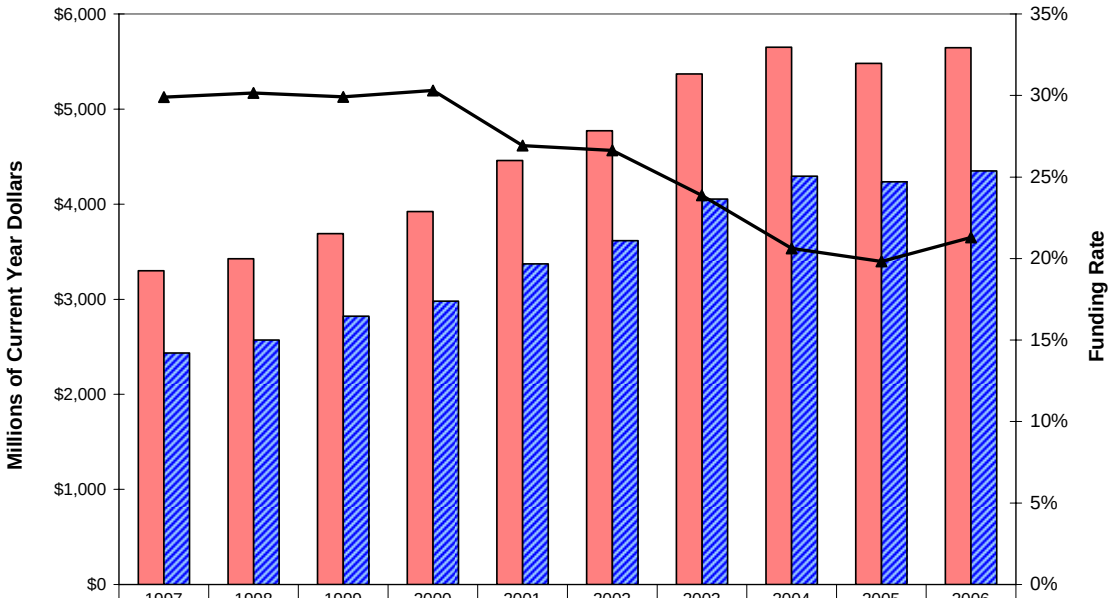
II. THE ISSUES IN CONTEXT

To understand the context of the issues, trends for the following indicators were analyzed: the NSF's overall and research budget, award size and duration, proposal submission rates, funding rates for proposals, and funding rates for PIs.

The NSF Budget

As noted in the introduction, the competition for NSF funding has grown more intense in recent years as the funding rate for research proposals has decreased from 30% in FY 2000 to 21% in FY 2006. This decrease occurred even though the NSF budget increased annually through FY 2004 (Figure 1). The NSF budget was cut in FY 2005, but was then increased in FY 2006. Although the overall FY 2006 budget was still below the FY 2004 level, the level of the Research and Related Activities (R&RA) account within the overall FY 2006 budget was slightly higher than the FY 2004 amount. Clearly, the proposal funding rate is being influenced by other factors beyond the size of the NSF budget.

Figure 1
Comparison of Trends in Research Proposal Funding Rates and Growth of the NSF Research Budget



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
NSF Budget	3,298.8	3,425.7	3,690.3	3,923.4	4,459.9	4,774.1	5,369.3	5,652.0	5,480.8	5,645.8
R&RA Budget	2,433.9	2,572.6	2,821.6	2,979.9	3,372.3	3,616.0	4,054.4	4,293.3	4,234.8	4,351.0
Funding Rate	30%	30%	30%	30%	27%	27%	24%	21%	20%	21%

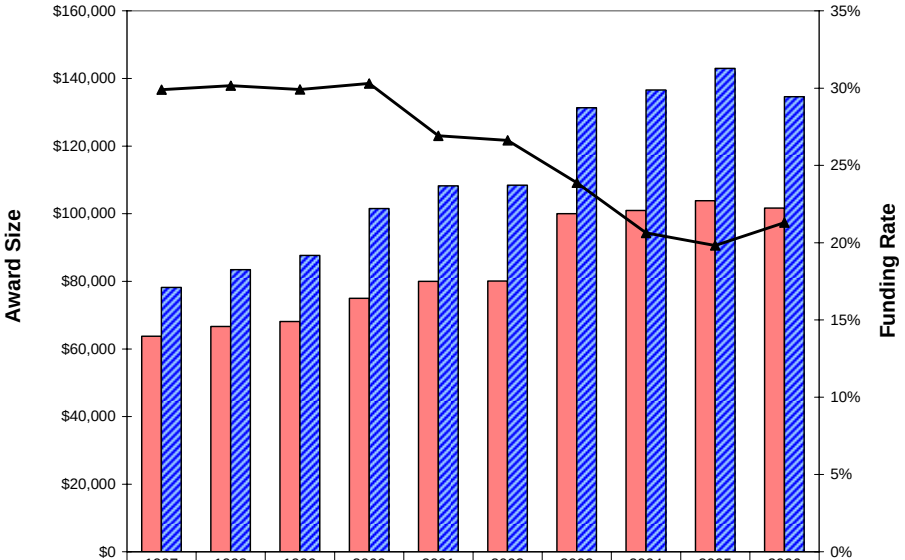
Figure legend: A comparison of trends in the growth of the total NSF budget and the Research and Related Activities (R&RA) portion of the NSF budget with changes in the research proposal funding rate shows that the decline in funding rate occurred at the same time that both the R&RA account and the NSF budget as a whole were increasing (the research portion of NSF's budget is approximately 75% of the total budget). Budget numbers are shown as current dollars, i.e., not adjusted for inflation. Source: NSF Budget Division

Award Size and Duration

In the FY 2001-2006 NSF Government Performance and Results Act (GPRA) Strategic Plan, NSF discussed the need to increase the average award size and award duration.[10] It had become increasingly apparent that individual NSF research awards were not large enough to enable a PI's research efforts.[11] It was thought that longer, larger grants would increase productivity by minimizing the time PIs would spend writing multiple proposals and managing administrative tasks, providing increased stability for supporting graduate students, and facilitating collaborations to address particularly complex issues. In its December 2003 report to Congress, the NSB said that "increasing the average NSF research award size and duration" was one of its highest priorities for increased NSF investment.[12]

In response to these policy statements, NSF made a concerted effort to increase award size and duration. Between FY 2000 and FY 2005, the mean annual award size of research awards increased 41% (from approximately $101,200 per year to approximately $142,600 per year), decreasing somewhat in FY 2006 (to approximately $134,500 per year). During this same period of time, the average award duration stayed fairly stable at close to three years. Figure 2 shows that as the award size (mean and median) increased, the overall research proposal funding rate decreased.

Figure 2
Comparison of Trends in Changes in Award Size and Research Proposal Funding Rates



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Annual Median Award Size	$63,775	$66,666	$68,090	$74,991	$80,000	$80,099	$100,000	$101,000	$103,800	$101,698
Annual Mean Award Size	$78,223	$83,473	$87,668	$101,525	$108,224	$108,451	$131,336	$136,586	$142,980	$134,595
Funding Rate	30%	30%	30%	30%	27%	27%	24%	21%	20%	21%

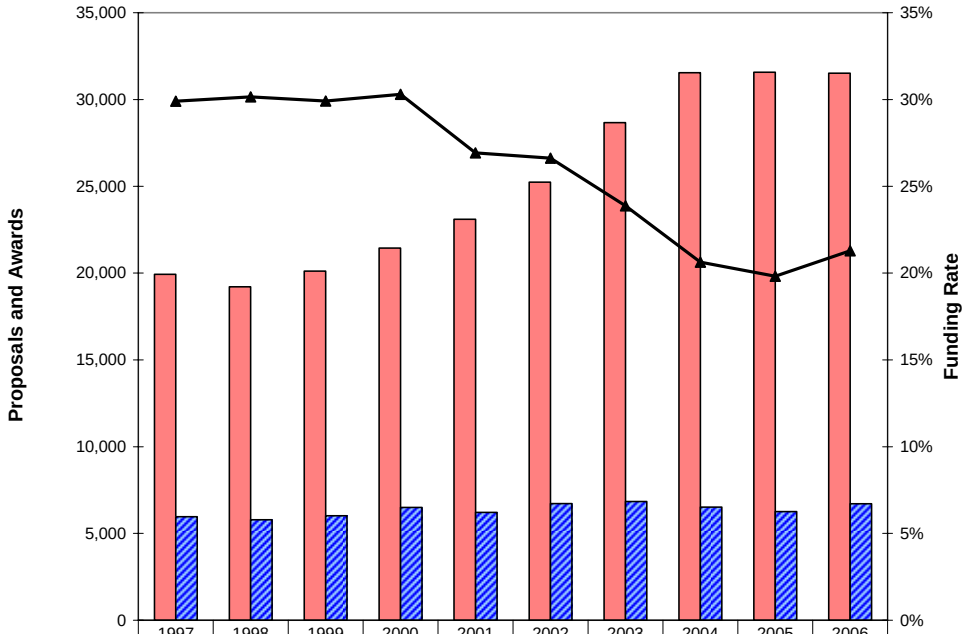
Figure legend: Trends in the median and mean annual award size in current dollars (i.e. not adjusted for inflation) are contrasted with the change in research proposal funding rate. The data show that funding rates decreased at the same time that award sizes increased. Source: NSF Budget Division

[10] NSF GPRA Strategic Plan, FY 2001-2006 (NSF 01-04, http://www.nsf.gov/pubs/2001/nsf0104/nsf0104.pdf).
[11] NSF Report on Efficiency of Grant Size and Duration (NSF 04-205, prepared by Mathematica Policy Research, Inc., http://www.nsf.gov/pubs/2004/nsf04205/)
[12] "Fulfilling the Promise: A Report to Congress on the Budgetary and Programmatic Expansion of the National Science Foundation" (NSB 03-151).

Research Proposal Submission Rates

Figure 3 shows that from FY 1997 through FY 1999 NSF received and acted upon a fairly constant number of research proposals annually (approximately 20,000), and made a fairly constant number of awards, sustaining a funding rate of approximately 30%. Beginning in FY 2000, there was a steady increase in the number of research proposals submitted each year. By FY 2004, proposal submissions had climbed to over 31,000 per year, an increase of nearly 50%. As the number of research proposals rose, the funding rate began to decline.

Figure 3
Comparison of Trends in Changes in Research Proposal Numbers and Funding Rates



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Competitive Proposal Actions	19,935	19,218	20,118	21,442	23,096	25,241	28,676	31,553	31,574	31,514
Competitive Awards	5,961	5,796	6,019	6,498	6,218	6,722	6,846	6,509	6,258	6,708
Funding Rate	30%	30%	30%	30%	27%	27%	24%	21%	20%	21%

Figure legend: Relationship between the number of proposals processed each year, the number of awards made each year and the proposal funding rate. As the number of proposals processed each year grew significantly, the proposal funding rate dropped. Source: NSF Budget Division

PI Submission Rates

As seen in Figure 4, one reason proposal submissions increased was that the average number of proposals submitted by successful PIs before receiving an award increased from 1.7 in the three-year period between FY 1997-1999, to 2.2 in the three-year period between FY 2004-2006. This represents a 30% increase in the number of proposals an individual submitted, on average, before receiving an award. An analysis of the distribution of proposal submissions per PI for all PIs, whether or not they received an award (shown in Figure 5), indicates that fewer PIs submitted only one proposal and more submitted four or more proposals between FY 2004-2006 than between FY 1997-1999.

Figure 4
Average Number of Research Proposals Submitted Per PI before Receiving One Award

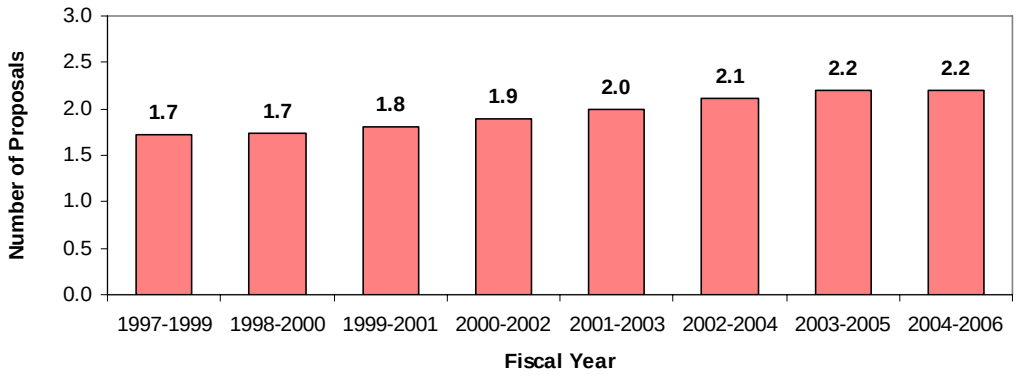


Figure legend: The average number of research proposals submitted in a three-year period before one award was received was calculated for all successful PIs. Source: NSF Budget Division

Figure 5
Distribution of Single vs. Multiple Submissions per PI

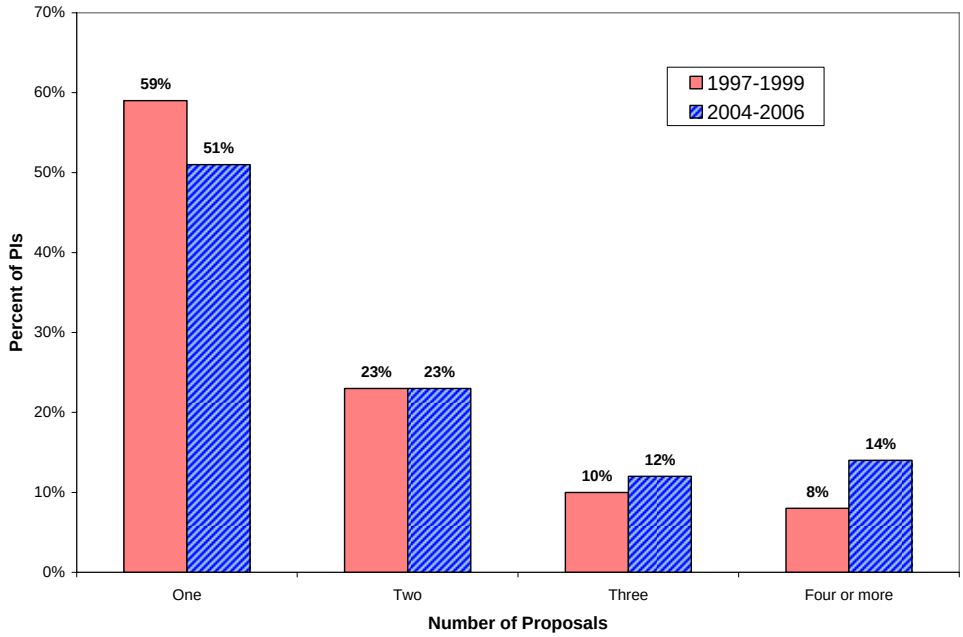


Figure legend: Comparison of the number of research proposals submitted by each PI during the three year period from FY 1997 to 1999, and the three year period from FY 2004 to 2006. The proportion of PIs submitting only one proposal declined by eight percentage points, while the proportion submitting four or more proposals nearly doubled when comparing these two periods. Source: NSF Budget Division

One factor associated with the increase in the number of proposal submissions per PI per award is that, because of decreased funding rates, more declined proposals are being revised and resubmitted. Whereas some degree of revision and resubmission is expected and is, in fact, a positive aspect of the merit review system, when funding rates drop, many highly rated proposals

enter this recycling, or "churning", of declined proposals. 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 proposals that are already fundable is a non-productive use of both PI and reviewer time. Because NSF treats all proposals as independent submissions, it is not possible to determine from NSF data how many proposals are being revised and resubmitted. As a proxy, IPAMM determined the degree to which PIs submitted proposals to the same or multiple programs before receiving an award.

Multiple Proposal Submissions

As shown in Figure 6, for those PIs who submitted multiple research proposals before receiving an award, there has been an increasing tendency to submit to more than one program. Since nearly 95% of the PIs responding to the 2007 NSF Proposer Survey indicated that they either never (65.7%) or seldom (28.7%) submitted a revised version of a declined proposal to a different unit within NSF, it does not seem likely that PIs are merely moving proposals from one program to another. Instead, it appears that PIs are diversifying their efforts, submitting a larger number of different research ideas to a variety of programs, possibly in response to new types of funding opportunities. These are further discussed in Section IV, *Causal Factors*.

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Figure 6
Distribution of Proposal Submissions by PIs Submitting Two or More Research Proposals Before Receiving an Award

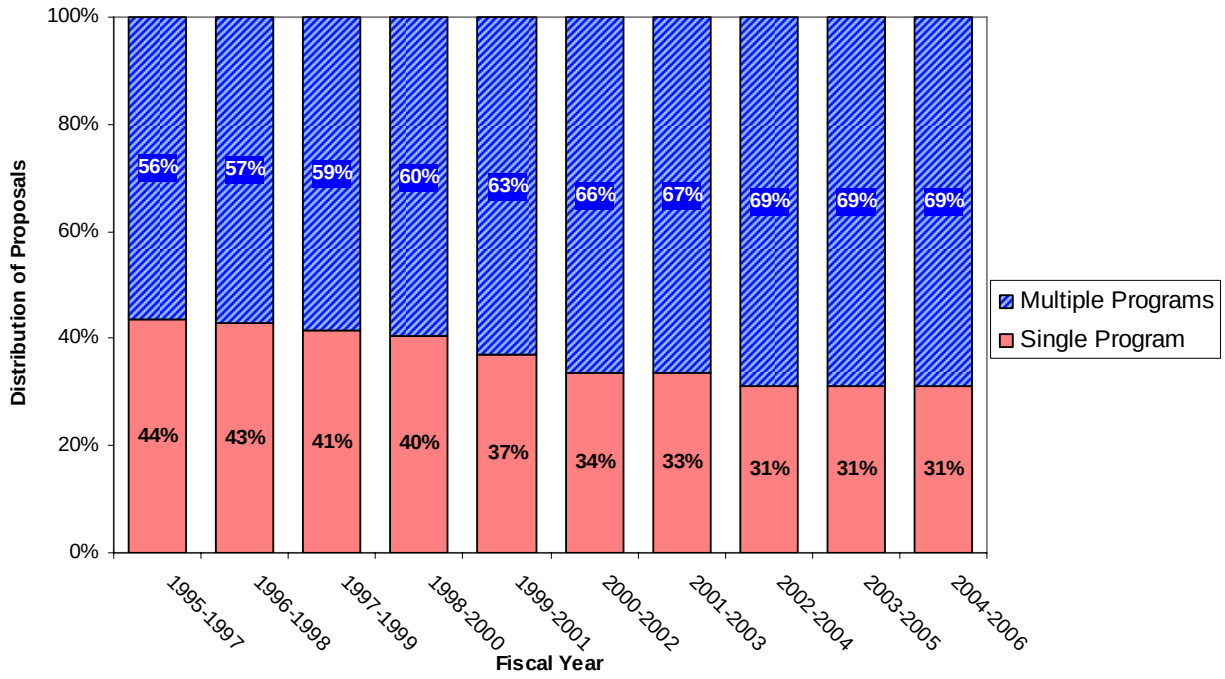


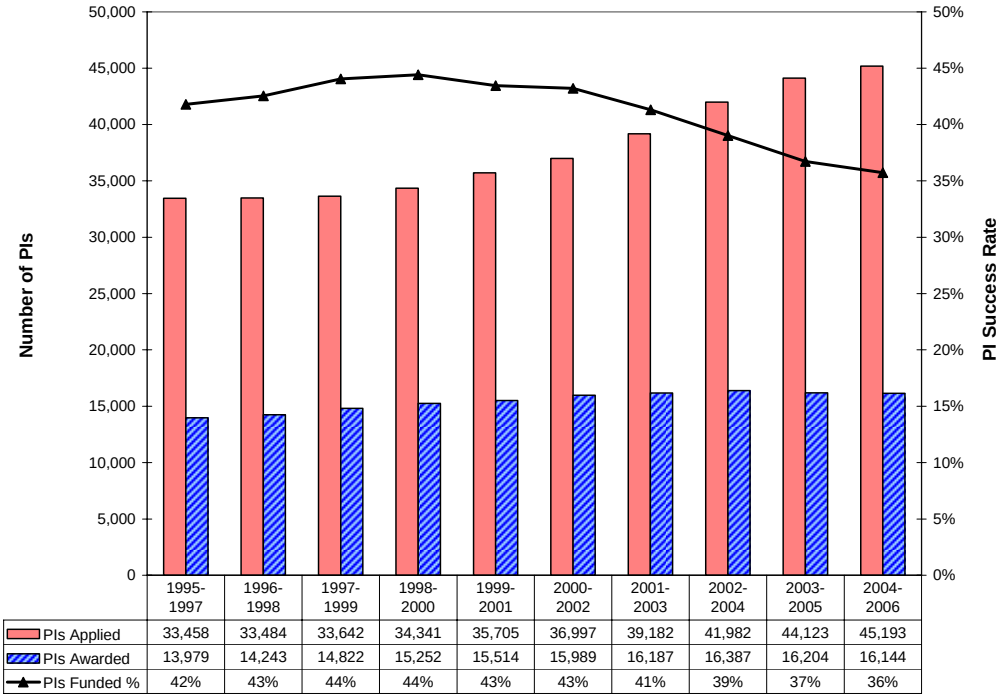
Figure legend: For those PIs who submitted two or more research proposals within a three-year period before receiving an award, the proportion that submitted those proposals to a single program decreased over time, as the proportion submitting multiple proposals to different programs increased. Source: NSF Budget Division

PI Success Rates

As previously mentioned, the proposal funding rate is defined as awards divided by proposal submissions (i.e., awards plus declinations), and is often cited as a measure of how successful the scientific community is in obtaining support for their research. However, success can be measured in a variety of other ways. For example, success can be measured as dollars awarded over dollars requested, or as a factor of the effort (i.e., how long and/or how many proposals) it takes for an individual PI or a particular idea to get funded. Success can also be defined more broadly from a community perspective, as a measure of the percentage of the PIs within a particular community that are funded. This type of measure can be useful when considering a particular scientific and engineering community (ecosystem scientists, electrical engineers, etc.), a demographic community (women, minority investigators, new PIs, etc.), or even an institutional community (all of the faculty members in a certain university system, for example).

This latter measure is a more direct way to assess NSF's effectiveness in supporting the scientific community than using the proposal funding rate. IPAMM thus investigated PI success rates, i.e., the number of PIs receiving NSF research awards divided by the number of PIs that apply for research awards over a given period of time. As Figure 7 shows, 44% of PIs who submitted one or more research proposals during the three-year period from FY 1997-1999 received at least one research award; in FY 2004-2006, this number had dropped to 36%. This decline is due at least in part to a 35% increase in the number of PIs submitting proposals to NSF.

Figure 7
NSF PI Success Rates



	1995-1997	1996-1998	1997-1999	1998-2000	1999-2001	2000-2002	2001-2003	2002-2004	2003-2005	2004-2006
PIs Applied	33,458	33,484	33,642	34,341	35,705	36,997	39,182	41,982	44,123	45,193
PIs Awarded	13,979	14,243	14,822	15,252	15,514	15,989	16,187	16,387	16,204	16,144
PIs Funded %	42%	43%	44%	44%	43%	43%	41%	39%	37%	36%

Figure legend: Percentage of PIs that received at least one research award within a period of time spanning three fiscal years. The percentage is derived by dividing the number of PIs that received an award by the number of PIs that submitted at least one proposal during each three-year period of time. Within any given three year period, each PI is only counted once, regardless of the number of proposals submitted or awards received. Source: NSF Enterprise Information System

Growth in Interdisciplinary Research

A related issue that interacts with the major trends in proposal submissions and funding rates 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. One measure of this shift is the increased prevalence of multi-investigator projects within the NSF award portfolio (including single awards with multiple co-PIs and collaborative projects with multiple awards), which has grown from 26% of all NSF awards in FY 1997 to 44% in FY 2006. 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. The use of solicitations and the effect of FastLane will be discussed further in Section IV, *Causal Factors*.

Directorate-level Trends

At the NSF level, the overall research proposal submission rate and funding rate appear to be flattening in FY 2005-2006. However, a somewhat different picture emerges when looking at the data for particular Directorates and Offices. The steady rise in proposal submissions and decline in funding rate at the NSF level, as well as the recent flattening of both, gives way to higher variability at the Directorate/Office level. Although all of the units within NSF experienced increased proposal submissions and decreased funding rates, there was significant variability in the rate of change, the degree of change, and the starting and ending points for the different units.

Figure 8 shows that research proposal funding rate trends are down for all directorates, but that the local environment varied. The lowest points for CISE and SBE occurred in FY 2004, while the lowest point for GEO, ENG, and MPS was in FY 2005. The funding rates in these directorates are now trending upward. In contrast, the funding rate in BIO continues to trend downward, and may not yet have hit its lowest point.

Figure 9 shows the rates at which research proposal submissions increased in the R&RA directorates. All of these directorates experienced increases in proposal submissions, but the rate of increase varied substantially from one directorate to another. CISE experienced the greatest growth—in FY 1997, this directorate had the fewest proposals of the set shown, but by FY 2004 was surpassed only by ENG. By FY 2006, proposal submissions to CISE had dropped again, but overall CISE's FY 2006 proposal load was nearly triple that of FY 1997. In the meantime, proposals loads nearly doubled in SBE and ENG by FY 2006, those in MPS and BIO grew by 40% and 50%, respectively, while the proposal load in GEO grew by 15%. Overall, proposal submission rates continue to trend upward for all of the directorates except CISE.

Figure 8
Trends in Research Proposal Funding Rates for Selected NSF Directorates

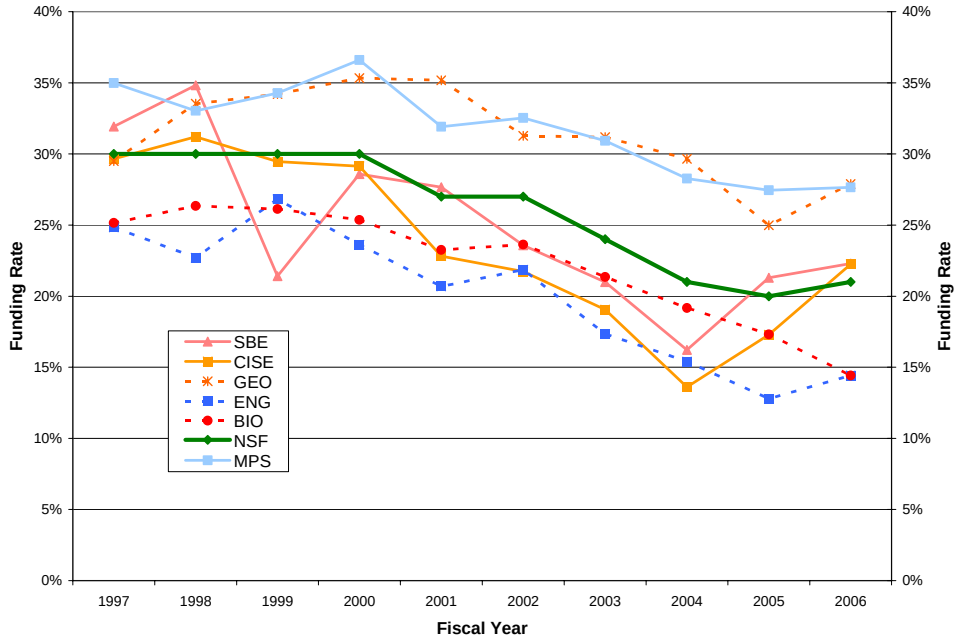


Figure legend: Funding rates for research proposals submitted to the six R&RA Directorates are shown, compared to the overall funding rate for all research proposals submitted to NSF. Funding rates also decreased over time for the research proposals submitted to EHR, OPP and O/D offices (not shown). Source: NSF Budget Division.

Figure 9
Trends in Proposal Submission Rates for Selected NSF Directorates

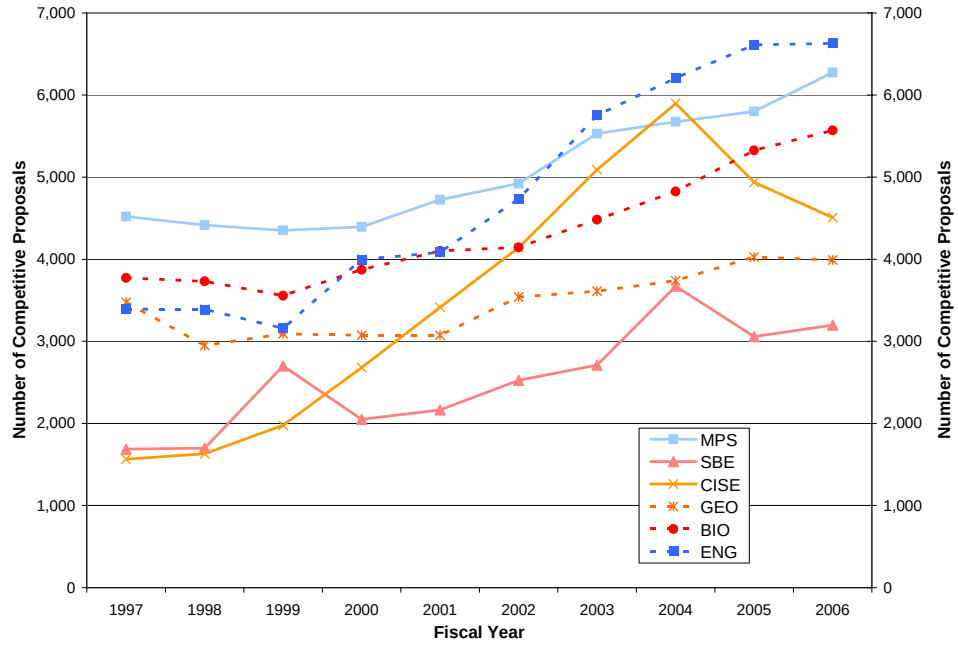


Figure legend: The number of research proposals submitted is shown for the six R&RA Directorates. EHR, OPP and O/D offices also experienced increases in the number of the research proposals submitted (not shown). Source: NSF Budget Division.

Summary

As shown in the trends analyses above, research proposal funding rates decreased significantly across NSF beginning in FY 2000; at the NSF level the decline in funding rates appeared to flatten in FY 2005-2006, although this is not the case at the directorate level. During the same time frame, proposal submissions and the overall size of the NSF budget increased significantly between FY 2000 and 2004. Meanwhile, average award sizes increased between FY 2000 and FY 2005, decreasing somewhat in FY 2006. Thus, there were a number of different variables in play at the same time, any or all of which could have contributed to the decline in the funding rate (award durations did not change much during this time frame, and so were not considered to be a significant variable). These data are summarized in Table 1.

Table 1
Summary of Funding Rate and Award Size Trends

Fiscal Year	Mean Award Size (thousands)	Number of Awards	Number of Research Proposals	NSF Budget (millions)	R&RA Budget (millions)	Funding Rate
2000	$101.2	6,498	21,442	3,923.4	2,979.9	30%
2001	$108.1	6,218	23,096	4,459.9	3,372.3	27%
2002	$108.3	6,721	25,240	4,774.1	3,616.0	27%
2003	$130.9	6,848	28,678	5,369.3	4,054.4	24%
2004	$136.4	6,508	31,553	5,652.0	4,293.3	21%
2005	$142.7	6,258	31,574	5,480.8	4,234.8	20%
2006	$134.5	6,712	31,518	5,645.8	4,351.0	21%

The relationship among the important variables is expressed in the equation:

$$\$ \text{ for New Awards} = (\text{Average award size } \$) \times (\text{funding rate}) \times (\#\ \text{of proposals})$$

Section IV of this report, *Causal Factors,* will explore the relationships among these variables in depth, including regression analysis of variables and the analysis of different hypothetical funding rate scenarios.

III. IMPACTS ON NSF AND THE COMMUNITY

This section seeks to identify where and by how much NSF's ability to fulfill its mission has been impacted by declining funding rates and increasing proposal submissions. In particular, this section examines impacts on:

- NSF's capacity to fund high quality and transformative research
- NSF's review process (reviewer and NSF workload, quality of reviews, etc.)
- Enabling the careers of beginning and new investigators
- Broadening participation of underrepresented groups and institutions
- Different S&E communities

Impact on High Quality and Transformative Research

As NSF's proposal submission rate has increased, the average quality of proposals has not declined. Indeed, the total number of high quality proposal submissions has substantially increased. Each year NSF declines a large number of potentially fundable proposals. However, in recent years the proportion of high quality proposals that are being declined has increased. NSF does not assign numerical scores to its proposals, and does not rank them by percentiles, because the individual review ratings associated with each proposal are not the only measure of the quality of a proposal and do not include the results of the panel evaluation or the assessment of the NSF program director. However, there is a reasonably good correlation between high review ratings and awards.[13] Thus, one way to measure the impact on high quality proposals is to look at the rate at which highly-rated proposals are being funded.

In this analysis, highly-rated proposals were defined as those whose average ratings are equal to or higher than the average rating of the awards in that fiscal year.[14] In FY 1997, 76% of highly-rated proposals were funded; in FY 2006, the funding rate of highly-rated proposals had dropped to 62%. The average rating for awards in FY 1997 and FY 2006 was virtually unchanged. In addition, although the absolute number of highly-rated proposals has grown, the proportion of all proposals that were highly-rated has remained fairly steady (20.6% in FY 1997 vs. 19.2% in FY 2006). Thus, it does not appear that there has been any significant "grade inflation"[15] with respect to proposal ratings between FY 1007 and FY 2006. This outcome is most likely due to an increase in the number of high quality proposal submissions without a corresponding increase in the ability to fund them. In FY 2006, proposals that were highly rated but ultimately declined represent a total of $2B in requested research support.[16]

With respect to impacts on transformative research, a widely-held concern is that as funding rates drop, reviewers become more conservative and less receptive to revolutionary ideas that challenge existing paradigms. This in turn discourages PIs from submitting proposals containing

[13] Shown in Figure 12 in the Report to the National Science Board on the National Science Foundation's Merit Review Process: Fiscal Year 2006 (http://www.nsf.gov/nsb/documents/2007/2006_merit_review.pdf).
[14] The average rating is calculated using the following numerical values: Excellent = 5; Very Good = 4; Good = 3; Fair = 2; and Poor = 1. Note that reviewer ratings are only one component of assessing proposal quality.
[15] "Grade inflation" is a rise in the average grade assigned to students; especially: the assigning of grades higher than previously assigned for given levels of achievement.
[16] Report to the National Science Board on the National Science Foundation's Merit Review Process: Fiscal Year 2006 (http://www.nsf.gov/nsb/documents/2007/2006_merit_review.pdf).

potentially transformative research ideas; as a consequence, support of transformative research decreases. It is difficult to determine if the current funding environment has compromised NSF support of transformative research, in part because it may take years before the transformative nature of a particular avenue of research becomes apparent.

However, IPAMM did attempt to measure the community's attitudes about transformative research and NSF in the 2007 NSF Proposer Survey. The survey results suggested that a significant portion of the community views NSF somewhat favorably in this regard—more than 56% of the respondents believed to a great or moderate extent that NSF welcomes transformative research, although only 42% believed to a great or moderate extent that NSF tended to fund transformative research. When asked where they would submit a transformative research idea, 45% of the respondents chose NSF, far exceeding the number that chose any other of a variety of other potential funding sources. Although the respondents that had served as reviewers tended to believe that transformative research was not prevalent among the proposals that they had reviewed (over 60% indicated that less than 10% of the proposals they had reviewed constituted transformative research), the majority of these reviewers felt that NSF welcomed these proposals (>51%), and that they themselves had recommended transformative research proposals for funding within the past three years (>55%). NSF is currently addressing efforts to enhance support of transformative research, which will be discussed separately with the NSB.

Impact on the Review Process

As shown earlier, the average number of research proposals submitted per PI to obtain an award has increased by 30% since FY 1997 (Figure 4), and the number of PIs submitting proposals has increased by 35% (Figure 7). In the aggregate, this represents a nearly 50% increase in the number of research proposals being submitted to NSF (Figure 3). This increase translates into a 30% increase in PI workload writing proposals, a 50% increase in the number of proposals that have to be processed by NSF, and 50% more review requests and/or panel reviews.

NSF appears to have been able to accommodate the increased workload. Table 2 indicates that from FY 2000 - 2006, during a time of rapidly increasing proposal submissions, NSF increased the percentage of the number of research proposals it processed within six months of receipt. However, there are concerns that NSF staff members and NSF systems are overstressed.

Table 2
Research Proposals Processed within Six Months of Receipt

Fiscal Year	Number of Proposals	% Processed within 6 Months
2006	31,518	78%
2005	31,574	76%
2004	31,553	77%
2003	28,678	77%
2002	25,240	74%
2001	23,096	63%
2000	21,442	54%

NSF has made concerted efforts to expand the number of reviewers in the reviewer pool, both through the actions of the program officers, and by providing information on directorate, division, and program web sites on how to volunteer to be a reviewer. However, the increase in the number of proposals has outpaced the growth in the reviewer pool. Although NSF added new reviewers every year, others dropped out, such that the net change in the number of reviewers used each year increased 15% during the five year period when proposal load increased approximately 50%. The net result is that the increase in proposals outstripped reviewers and therefore the number of proposals each reviewer is evaluating is higher, on average, than in the past.

Concerns have been raised in a number of venues about the increased burden on the reviewer community, and the potential impacts this may have on the reviewers themselves and on the quality of the merit review process. In the 2007 NSF Proposer Survey, nearly 68% of the respondents that had served as NSF reviewers indicated that their overall reviewer workload (including requests to review grant proposals for NSF and other agencies, journal manuscripts, and other types of review) had increased in the last three years. As a consequence, 36% of these respondents said that the time they were able to devote to each proposal review has either greatly decreased or somewhat decreased, while 23% said that the thoroughness of each review had decreased and 16.5% said the quality of their reviews had decreased.

A decade ago, NSF programs relied much more on mail reviews and much less on panels for proposal evaluation.[17] IPAMM believes that the significant increase in the number of proposals contributed to the increasing trend toward panel review only. It is difficult to expect individual mail reviewers to volunteer to do more than a few reviews per year; however panelists are frequently called upon to carry out ten or more reviews for a single panel. Thus, the use of panel reviews is one way to manage an increased proposal review workload. NSF is monitoring the use of the various mechanisms for merit review, to ensure that the quality of the NSF merit review process is maintained.

Impact on Beginning and New Investigators

For the ten years between FY 1997 to FY 2006, new investigators[18] consistently submitted approximately 40% of the proposals received by NSF. During the same period, new investigators comprised between 22 to 24% of all PIs that were submitting proposals. In other words, new investigators are submitting many more proposals per PI than are experienced investigators. As was observed for all other groups, proposal funding rates for new PIs fell in the period between FY 2000 and FY 2005—in FY 2000 proposal funding rates for new PIs were 22%; this rate dropped to 14% in FY 2004-2005, recovering slightly in FY 2006 to 15% (Figure 10).

[17] Report to the National Science Board on the National Science Foundation's Merit Review Process: Fiscal Year 2006 (http://www.nsf.gov/nsb/documents/2007/2006_merit_review.pdf).

[18] New investigators are defined as those that have not previously received an NSF award, and so will include some experienced PIs that are new to NSF as well as PIs that are at the beginning of their careers. However, over 70% of new investigators are within 7 years from their last degree when they receive their first NSF award, thus the "new investigator" cohort predominantly represents early career individuals.

Figure 10
Comparison of Funding Rate Trends for New and Prior PIs

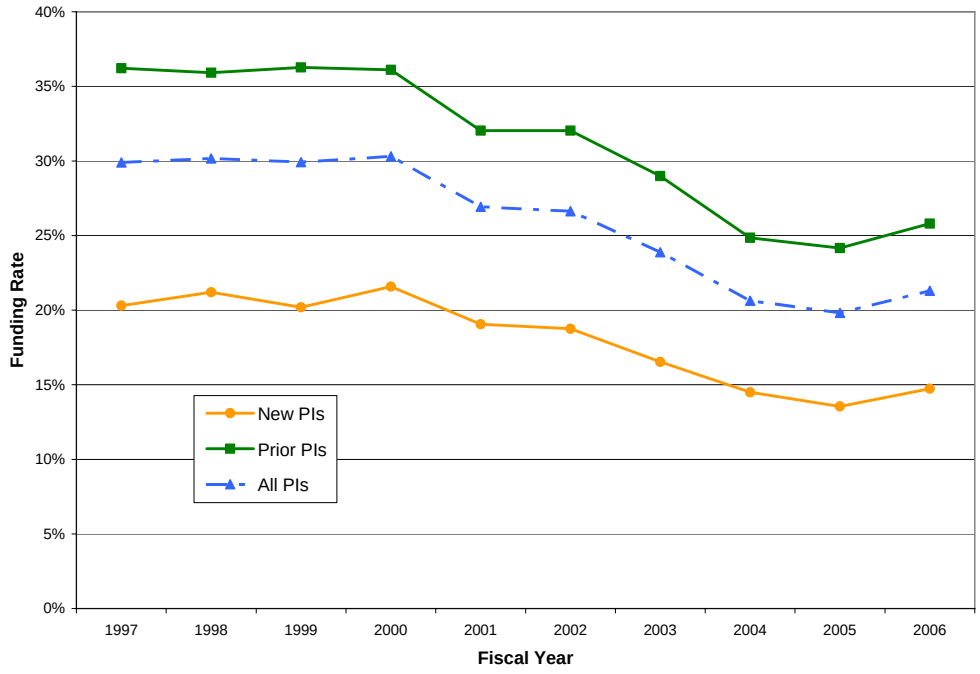


Figure legend: The proposal funding rates for research proposals submitted by new PIs, previously funded (or prior) PIs, and all PIs are shown. The data indicate that proposals submitted by prior PIs tend to be funded at a higher rate than proposals submitted by new PIs; the disparity between these funding rates lessened over time, although both funding rates decreased. Source: NSF's Enterprise Information System

However, there was no evidence that new investigators were disproportionately affected by the low funding rates as compared to the overall population of PIs, nor is it taking longer for new investigators to receive their first NSF award. In fact, as shown in Figure 11, the proportion of research awards belonging to new PIs exceeds their representation in the overall pool of PIs, and has remained constant at 27-28% of the full portfolio of research awards for ten years (between FY 1997 and FY 2006). In addition, the percentage of PIs who received their first award within seven years of getting their degree remained fairly constant from FY 1997 to FY 2006 (Table 3).

Table 3
Cumulative Percentage of PIs Receiving Their First NSF Research Award Within Seven Years of Their Last Degree (Comparing FY 1997 and FY 2006)

	FY 1997	FY 2006
NSF	73%	74%
BIO	65%	70%
CISE	88%	81%
ENG	71%	70%
GEO	76%	77%
MPS	72%	75%
SBE	74%	75%

Table Legend: The number of years from last degree was determined for new PIs receiving their first award in either FY 1997 or FY 2006. The data in the table show the percentage of those new PIs that had received their last degree no more than seven years earlier. The differences between the directorates likely reflect differences in career paths for different disciplines (e.g., the extent to which postdoctoral fellowships are required before moving into faculty positions varies significantly between fields). Source: NSF Budget Division

Figure 11
Comparison of the Presence of New PIs in the Award Portfolio in FY 1997 and FY 2006

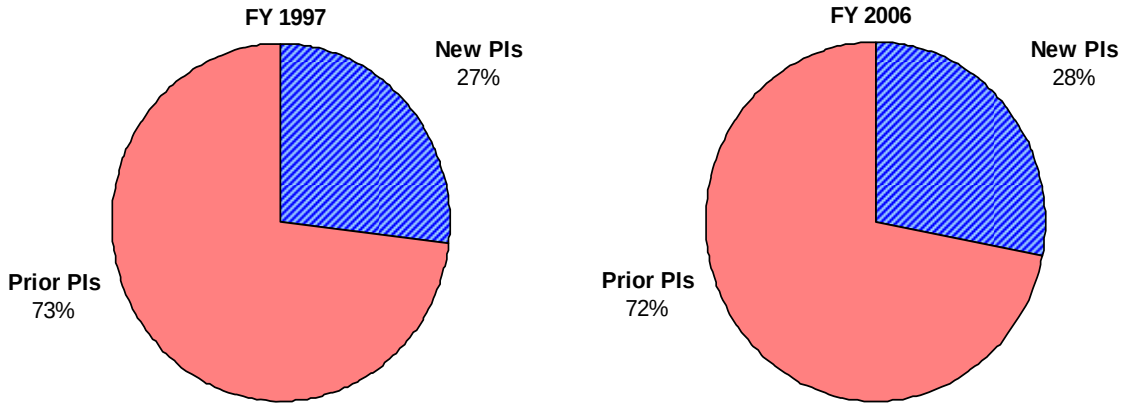


Figure legend: The two pie charts display the proportion of all awards that were given to either new PIs or prior PIs, comparing the distribution in FY 1997 and FY 2006. Source: NSF Budget Division

Another concern related to the potential impact of reduced funding rates on early-career investigators is that their ability to sustain funding may be compromised. To address this question, the funding status of cohorts of PIs who received their first NSF award in either FY 1995 or in FY 2000 was assessed.

Figure 12 shows that, for both cohorts, there is a gradual decline in the number of PIs who sustain funding for the first two years after receiving an award with a significant drop to about 40% after three years, after which the number of PIs with sustained funding declines much more slowly. Given that the average duration of an NSF award is approximately three years, these data suggest that for both the 1995 and 2000 cohorts, between approximately 40% of new PIs are able to secure continued NSF funding (for either the same project or for a new project). The similarity of the profiles of these two cohorts suggests that the ability to maintain funding once

obtained has not changed significantly in recent years. It is not possible to know why some PIs did not sustain NSF funding. It is likely that some tried to renew their NSF funding but were unsuccessful while others left NSF because they secured funding from other sources (these data only reflect NSF funding and will not capture the latter possibility).

Figure 12
Comparison of Trends in Continuation of Funding for New PIs

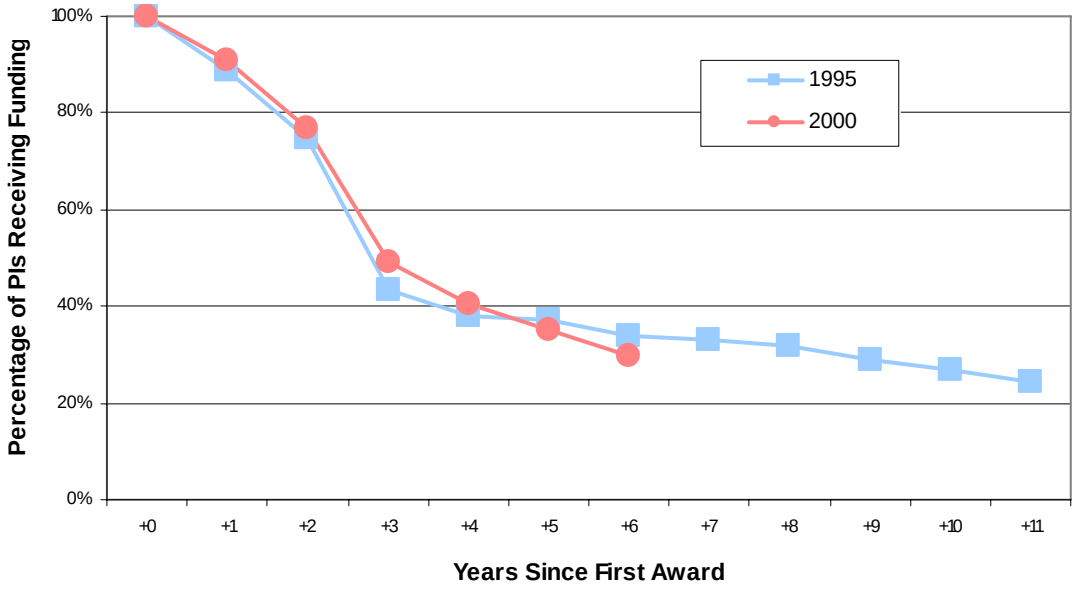


Figure legend: This figure compares the percentage of two cohorts of PIs who maintained funding over several years after receiving their first NSF award—those who received their first award in FY 1995, and those that received their first award in FY 2000. Source: NSF Budget Division

Impact on Underrepresented Groups[19] and Institutions

Women and Minorities

There is no indication that declining funding rates have had, so far, a significant disproportionate impact on support for minorities and women. Figure 13 indicates that during the period between FY 2000 and FY 2006, when the overall funding rate for research proposals dropped from 30% to 21%, the funding rate dropped equivalently for both men (from 30% to 20%) and women (from 31% to 21%).[20] During this same time frame, funding rates for minorities dropped from 26% in FY 1997 to 21% in FY 2006 (recently recovering from a low of 18% in FY 2004).[21] In recent years it appears that the gap between minority groups and non-minority groups has narrowed, a further indication that minority groups have not been disproportionately affected by the decline in funding rate.

[19] For the purpose of this report, the underrepresented groups that were studied included women and racial/ethnic minority groups that are underrepresented in the sciences and engineering (African Americans, Hispanics, Native Americans, Native Alaskans, and Hawaiian/Pacific Islanders). IPAMM was not able to measure the impact on persons with disabilities, as there were insufficient data on this group for a meaningful trends analysis.
[20] During the period FY 1997-2006 the number of proposals with for which the PI did not report their gender increased (growing from 0.2% in FY 1997 to 0.8% in FY 2006), making the interpretation of the data less certain.
[21] During the period FY 1997-2006 the number of proposals for which the PI did not report their race/ethnicity increased (growing from 3.2% in FY 1997 to 7.0% in FY 2006), making the interpretation of the data less certain.

Figure 13
Comparison of Funding Rate Trends for Underrepresented Groups

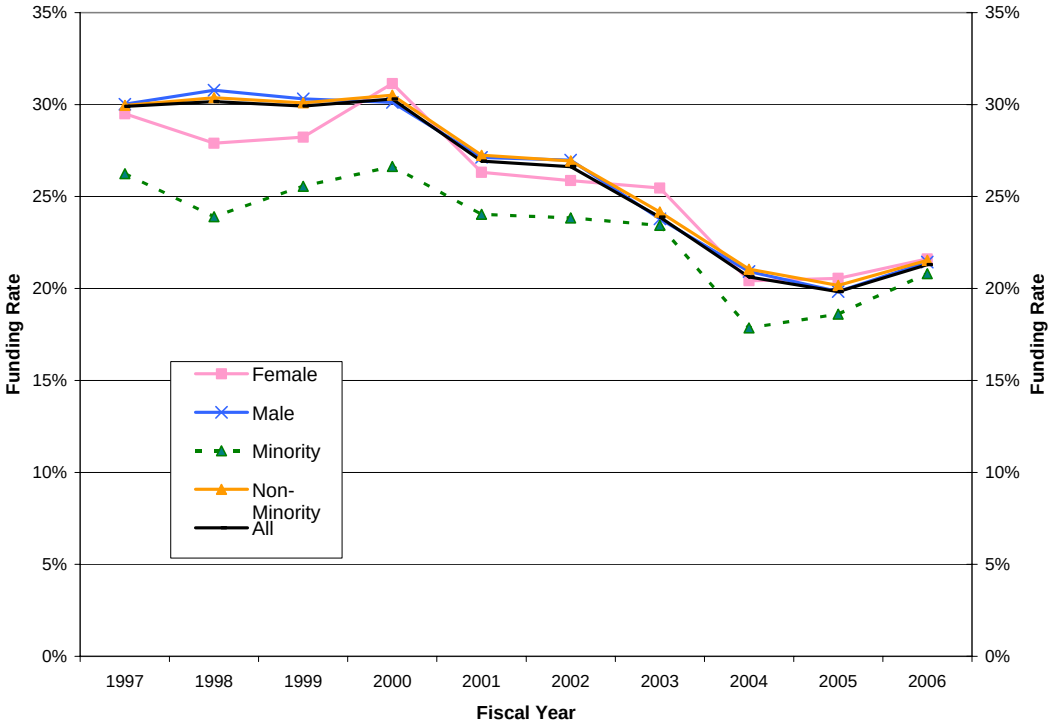


Figure legend: The proposal funding rates for research proposals submitted by all PIs, female PIs, male PIs, minority PIs, and non-minority PIs are shown. All groups experienced reduced funding rates over time. Note that data for PIs of unknown gender (growing from 0.8% to 4.3% of all PIs between FY 1997 and FY 2006) and unknown race/ethnicity (growing from 3.2% to 7.0% of all PIs between FY 1997 and FY 2006) have been excluded from the graph. Source: NSF Enterprise Information System

An additional concern is that, although the overall funding trends do not show evidence of a disproportionate impact on underrepresented groups, there may be hidden impacts on their ability to either get first-time funding, or to get subsequent funding. To address this issue, the funding trends for new and prior female or minority PIs were compared to those for new and prior male or non-minority PIs. As shown in Figure 14, women are slightly more successful at getting their first research award than men or minority PIs, and are equally likely to get subsequent funding as compared to male PIs. Minority PIs lagged slightly behind non-minority PIs in getting their first research award between FY 1999 and FY 2002, but have closed the gap in recent years. Between FY 1997 and FY 2002, minority PIs were less successful as prior PIs than their non-minority counterparts, however in recent years (when the overall funding rate was decreasing) that disparity has disappeared. Thus, these data also support the conclusion that women and minorities have not been disproportionately impacted by the declining funding rates, either as new or prior PIs.

Figure 14
Trends in Proposal Funding Rates for New and Prior PIs within Underrepresented Groups

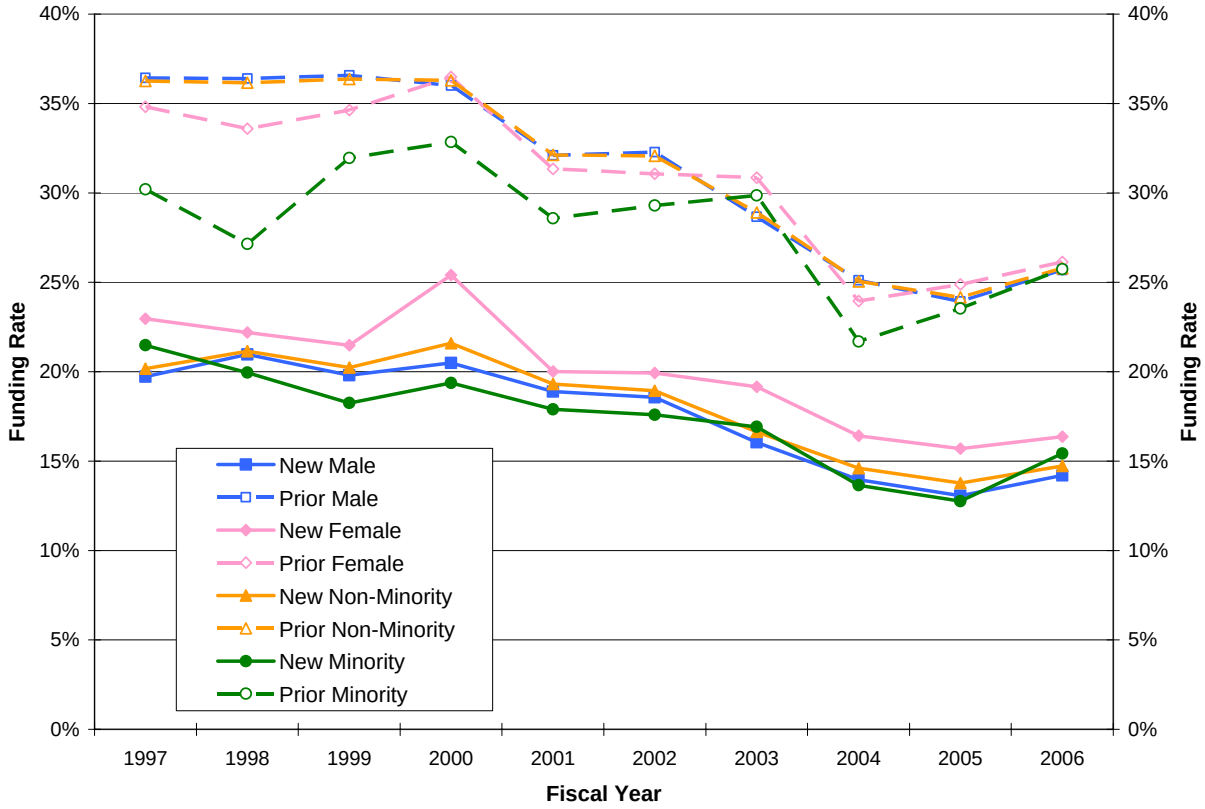


Figure legend: The proposal funding rates for research proposals submitted by new male PIs, prior male PIs, new female PIs, prior female PIs, new minority PIs, prior minority PIs, new non-minority PIs, and prior non-minority PIs are shown. Note that data for PIs of whose gender or race/ethnicity were not reported have been excluded from the graph. Source: NSF Enterprise Information System

Table 4 indicates that the representation of underrepresented groups in both the award and proposal portfolios has remained relatively stable between FY 1997 and FY 2006, and in fact shows some growth in recent years. However, we note that the numbers of proposers not reporting gender and/or race/ethnicity have grown over time. The size of the pool of proposals on which race/ethnicity is not reported is now comparable to the number of proposals known to come from members of minority groups. It is not clear how this may complicate our understanding of these data.

Table 4
Presence of Underrepresented Groups in the Proposal and Award Portfolios from FY 1997 to FY 2006

A.

	PI Race/Ethnicity											
	Minority				Non-Minority				Not Reported			
FY	Proposals		Awards		Proposals		Awards		Proposals		Awards	
1997	922	4.6%	242	4.1%	18,379	92.2%	5507	92.4%	634	3.2%	212	3.6%
1998	912	4.7%	218	3.8%	17,686	92.0%	5372	92.7%	620	3.2%	206	3.6%
1999	943	4.7%	241	4.0%	18,583	92.4%	5594	92.9%	592	2.9%	184	3.1%
2000	1,025	4.8%	273	4.2%	19,813	92.4%	6046	93.0%	604	2.8%	179	2.8%
2001	1,140	4.9%	274	4.4%	21,010	91.0%	5725	92.1%	946	4.1%	219	3.5%
2002	1,229	4.9%	293	4.4%	22,638	89.7%	6097	90.7%	1,373	5.4%	331	4.9%
2003	1,391	4.9%	326	4.8%	25,643	89.4%	6194	90.4%	1,644	5.7%	328	4.8%
2004	1,669	5.3%	298	4.6%	27,871	88.3%	5868	90.2%	2,012	6.4%	342	5.3%
2005	1,720	5.4%	320	5.1%	27,691	87.7%	5584	89.2%	2,163	6.9%	354	5.7%
2006	1,822	5.8%	379	5.6%	27,474	87.2%	5915	88.1%	2,222	7.0%	418	6.2%

B.

	PI Gender											
	Female				Male				Not Reported			
FY	Proposals		Awards		Proposals		Awards		Proposals		Awards	
1997	3,146	15.8%	928	15.6%	16,622	83.4%	4,990	83.7%	167	0.8%	43	0.7%
1998	3,592	18.7%	1,002	17.3%	15,484	80.6%	4,766	82.2%	142	0.7%	28	0.5%
1999	3,613	18.0%	1,020	16.9%	16,364	81.3%	4,961	82.4%	141	0.7%	38	0.6%
2000	3,786	17.7%	1,179	18.1%	17,498	81.6%	5,271	81.1%	158	0.7%	48	0.7%
2001	3,766	16.3%	991	15.9%	19,056	82.5%	5,170	83.1%	274	1.2%	57	0.9%
2002	4,400	17.4%	1,138	16.9%	20,468	81.1%	5,522	82.2%	372	1.5%	61	0.9%
2003	4,867	17.0%	1,239	18.1%	23,207	80.9%	5,521	80.6%	604	2.1%	88	1.3%
2004	5,651	17.9%	1,154	17.7%	24,956	79.1%	5,221	80.2%	945	3.0%	133	2.0%
2005	5,909	18.7%	1,214	19.4%	24,590	77.9%	4,878	77.9%	1,075	3.4%	166	2.7%
2006	5,961	18.9%	1,288	19.2%	24,212	76.8%	5,189	77.3%	1,345	4.3%	235	3.5%

Table Legend: The race/ethnicity (A) and gender (B) demographics of the PIs on all research proposals that were submitted and all awards that were funded between FY 1997 and FY 2006 were determined. These tables display the number of proposals submitted and awards made by PIs in each race/ethnicity category (minority, non-minority, and not reported) as well as in each gender category (male, female, and not reported), and their proportion of the total number of proposals submitted and awards made in each fiscal year. This demographic information is provided to NSF on a voluntary basis, and some PIs choose not to identify their gender and/or their race or ethnicity. Note that there has been an increase in the tendency to not report gender and race/ethnicity information over time; the gender not reported category grew from 0.8% to 4.3% of all PIs between FY 1997 and FY 2006, and the race/ethnicity not reported category grew from 3.2% to 7.0% of all PIs between FY 1997 and FY 2006.

Institution Type

As shown in Figure 15, of the research proposals submitted to NSF in FY 1997, 66% came from the research intensive (RI) institutions[22], compared to 65% in FY 2006. There were no significant percentage shifts in proposal submissions from other institution types. Since NSF

[22] Research intensive (RI) institutions represent the group of one hundred Ph.D. granting institutions that received the most research funding from NSF in that year.

proposals increased by 50% over this period, the numbers of proposal submissions from all groups increased significantly and at similar rates. Figure 15 demonstrates that the profile of institutions receiving NSF awards has not changed much in the past decade. Of the research proposals awarded in FY 1997, 75% went to the research intensive institutions, compared to 74% in FY 2006. There were no significant shifts in support for other institution types.

Figure 15
Comparison of Institution Types in the Proposal and Award Portfolios in FY 1997 and FY 2006

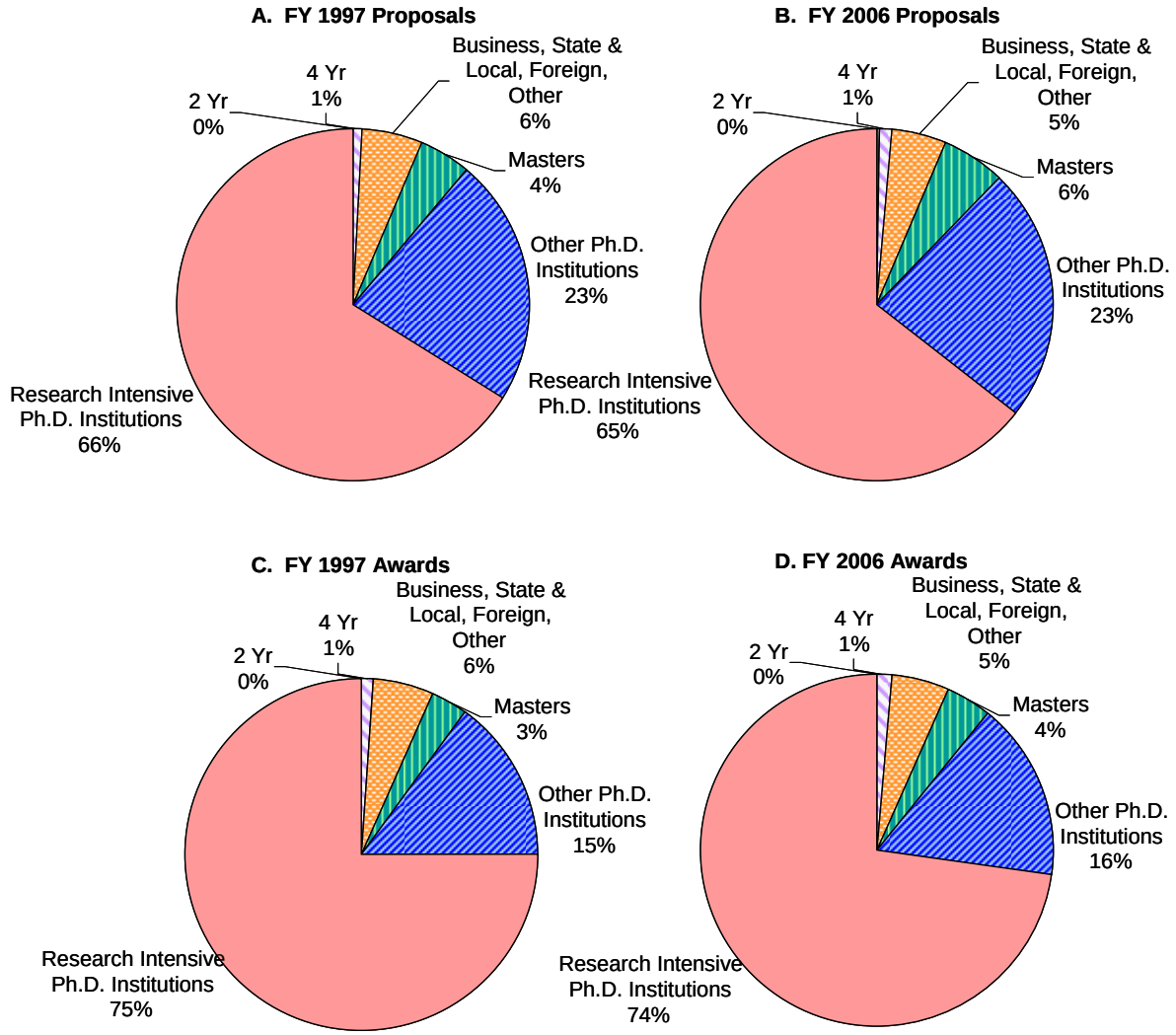


Figure legend: The pie charts display the proportion of all proposals (A and B) and awards (C and D) categorized by institution type, comparing the distribution in FY 1997 (A and C) and FY 2006 (B and D). The percentage of proposals and awards that are associated with 2-year institutions is less than 0.1%, and so does not appear in the charts. Source: NSF Budget Division

A similar analysis was done for institutions in EPSCoR jurisdictions[23] with similar outcomes. In FY 2006, institutions in EPSCoR jurisdictions submitted 16% of the proposals and received 13% of the awards. These percentages are unchanged from FY 1997.

Impact on Different S&E Communities

As noted earlier, NSF currently supports over 50% of the Federal non-medical fundamental research at U.S. colleges and universities. That proportion is even higher for some communities, such as computer science, mathematics, and non-biomedical biology. PIs in S&E communities that are highly dependent on NSF for funds tend to continue to submit proposals to NSF after repeated declines for a much longer period of time than do PIs with alternate funding sources. For example, PIs who submit proposals to the Division of Mathematical Sciences (DMS) represent a community highly dependent on NSF support whereas those that submit proposals to the Division of Chemistry (CHE) are not as dependent on NSF support. To measure the rates at which these two communities leave NSF if unsuccessful at obtaining funding, IPAMM looked at the submission histories for PIs that had submitted proposals to either CHE or DMS between FY 1997 and FY 2006, and identified a population of individuals for each division that had never received an award. The submission histories for these two populations of PIs were compared to determine how many proposals each PI submitted during that ten year period. As shown in Figure 16, over 90% of the never-awarded CHE PIs submitted only one proposal to NSF, with fewer than 10% making multiple attempts. For the never-awarded DMS PIs, 63% submitted only one proposal, with 37% making multiple attempts.

Figure 16
Number of Proposals Submitted by PIs that Never Received an Award

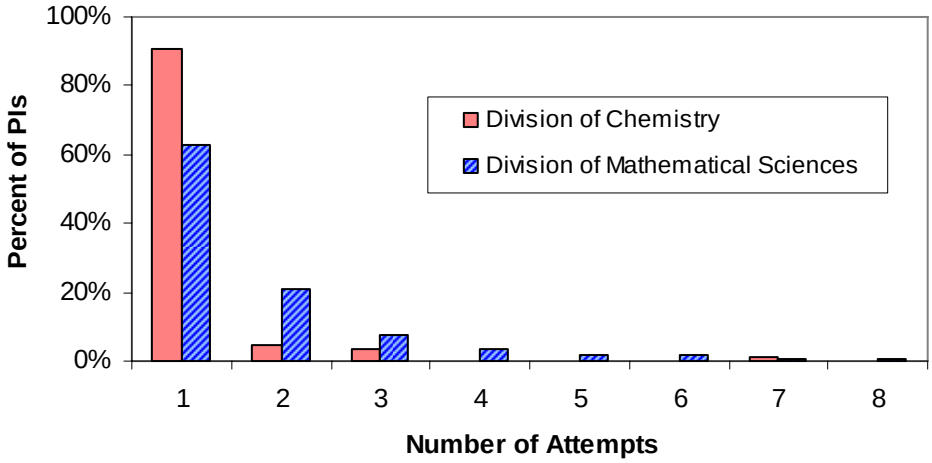


Figure legend: Over the past ten years, 88 PIs submitted proposals to the Division of Chemistry without receiving an award, while 118 PIs submitted proposals to the Division of Mathematical Sciences without receiving an award. The submission histories of these PIs were compared to determine how many proposals each person submitted during that time period. Source: NSF Budget Division.

[23] The mission of the Experimental Program to Stimulate Competitive Research (EPSCoR) is to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education. A list of the jurisdictions that are eligible for the EPSCoR program can be found at http://www.nsf.gov/od/oia/programs/epscor/statewebsites.jsp.

In the 2007 NSF Proposer Survey, respondents were asked the degree to which they depended on NSF as the prime source of potential funding. Overall, nearly 47% of the respondents indicated that they relied on NSF for 50% or more of their research funding. This percentage varied widely across the different communities that NSF serves, ranging from only 26% for respondents that usually submitted proposals to ENG to approximately 55% for respondents that usually submitted proposals to OPP, MPS or GEO. Although low funding rates have created stress in all of the communities that NSF serves, the negative impacts may be greater on S&E communities that are highly dependent on NSF support, and on communities with fewer academic positions and more soft-money positions. These groups may be more likely to lose research funding due to a lack of alternative funding options, and be more inclined to continue submitting proposals in the face of declining funding rates.

Conclusions

IPAMM undertook a thorough analysis of the potential impacts of declining funding rates on beginning investigators and underrepresented groups (defined by gender, race/ethnicity, institution type, or EPSCoR status), one of the concerns that motivated this study. The data show no evidence that any of these groups has been disproportionately disadvantaged by declining funding rates. Although all groups experienced lower funding rates, the presence of beginning investigators and underrepresented groups in the NSF portfolio was maintained and, in some cases, even slightly improved.

IPAMM also did not find evidence to substantiate the concern that the increasing proposal submission rate would lead to a deterioration in the overall quality of the proposals submitted, or of the awards that were being made. However, there is evidence that more high quality proposals are being declined. These unfunded proposals represent lost opportunities to advance knowledge, which may ultimately impact the nation's competitive edge. Nonetheless, these analyses indicate that the excellence of NSF's portfolio of awards has been maintained.

The largest impact that was identified was the increased work for all involved – the PI community, the reviewer community, and the NSF staff. 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; responses from reviewers to the 2007 NSF Proposer Survey suggest that they are overworked and that their reviews may be diminishing in quality. Although the survey indicated that PI satisfaction with NSF's proposal submission and review processes was reasonably high, many respondents expressed concerns about the quality of the reviews. The survey also reflected the growing anxiety of the community—although NSF has maintained both the percentage of proposals that are processed within six months and the average time to decision since FY 2002, there is growing dissatisfaction with the time to decision, which is likely related to the desire to revise and resubmit declined proposals at the next earliest opportunity. In the long-term, the increasing amount of time that is being spent on efforts associated with obtaining funds will detract from the nation's scientific and engineering enterprise.

IV. CAUSAL FACTORS

As already noted, NSF's proposal funding rate represents the number of awards divided by the number of proposal submissions. Anything that causes the numerator (awards) or the denominator (proposal submissions) to change will cause the funding rate to change. Since NSF receives more high quality proposals than can be funded, the chief factors affecting the numbers of awards are financial factors such as the funds available and the size of the awards. The factors that affect the numbers of proposal submissions are more varied. Anything that either attracts a larger pool of applicants or that causes individual PIs to send in more proposals per unit of time will increase proposal submissions. Some of these factors are internal to NSF (e.g., NSF outreach efforts) while others are external (e.g., pressure on PIs to win grants to help support their labs and universities, and/or decreased availability of funds from other granting agencies). In this section, we examine a number of factors thought to be important drivers of increased proposal submissions and declining funding rates.

Financial Factors Affecting Numbers of Awards Made

Over the FY 2000-2006 period, as funding rates dropped from 30% to 21%, the NSF budget, average award sizes and numbers of proposals received were all rising. Below we simulate what would have happened had each of these key factors been held constant over that period. These analyses suggest that the nearly 44% growth in the NSF budget over this period would have been sufficient to sustain a relatively stable funding rate coupled with either increasing award sizes or significant growth in the number of proposal submissions, but not both.[24]

Award Size

Holding NSF's mean award size constant at FY 2000 levels while the NSF budget and number of proposals submitted increase at actual rates, assuming a similar distribution of standard and continuing awards each year, the overall number of awards increases at the rates illustrated in Table 5. Funding rates decline from 30% to 27% rather than from 30% to 21%. However, it should be noted that the effective award size would have decayed due to inflation.

Table 5
Funding Rate if Award Size is Held Constant

Fiscal Year	Mean Award Size in thousands (held constant)	Number of Awards (projected)	Number of Research Proposals (actual)	Funding Rate (projected)
2000	$101.2	6,498	21,442	30%
2001	$101.2	7,110	23,096	31%
2002	$101.2	7,146	25,240	28%
2003	$101.2	8,014	28,678	28%
2004	$101.2	8,484	31,553	27%
2005	$101.2	8,340	31,574	26%
2006	$101.2	8,598	31,518	27%

[24] The simulation Tables 5, 6 and 7 are based on Table 1 in Section 1 of this report, which reports the actual numbers in all the relevant categories.

Proposal Submissions

Table 6 shows that, if the number of proposals received is held constant at FY 2000 levels while the NSF budget and award size increase at their actual rates, funding rate is relatively stable, fluctuating between 28 and 31%. The resulting total number of awards is slightly lower than actually occurred (6,468 rather than 6,712).

Table 6
Funding Rate if Research Proposal Submissions are Held Constant

Fiscal Year	Mean Award Size in thousands (actual)	Number of Awards (projected)	Number of Research Proposals (held constant)	Funding Rate (projected)
2000	$101.2	6,498	21,442	30%
2001	$108.1	6,656	21,442	31%
2002	$108.3	6,678	21,442	31%
2003	$130.9	6,196	21,442	29%
2004	$136.4	6,294	21,442	29%
2005	$142.7	5,914	21,442	28%
2006	$134.5	6,468	21,442	30%

Funding Rate

Table 7 shows the effect on award sizes when the funding rate is held constant at FY 2000 levels while the NSF budget and the number of proposals received increase at the actual rates. Maintaining a 30% funding rate results in a 46% increase in the number of awards (9,455 rather than the actual 6,712) and a 9% decrease in the mean award size ($92,000 rather than the actual $134,500) by FY 2006.

Table 7
Award Size if Funding Rate is Held Constant

Fiscal Year	Mean Award Size in thousands (projected)	Number of Awards (projected)	Number of Research Proposals (actual)	Funding Rate (held constant)
2000	$101.2	6,498	21,442	30%
2001	$103.9	6,929	23,096	30%
2002	$ 95.5	7,572	25,240	30%
2003	$ 94.3	8,603	28,678	30%
2004	$ 90.7	9,466	31,553	30%
2005	$ 89.1	9,472	31,574	30%
2006	$ 92.0	9,455	31,518	30%

Factors Affecting Numbers of Research Proposals Received

If either a given set of PIs sends in more NSF proposals per unit time or a new pool of PIs is attracted to the Foundation (or both), numbers of proposals will increase. Below, we explore the major forces internal and external to NSF that may be leading to larger PI pools and/or to increased numbers of proposals per PI.

Investigators' Expectations

All else equal, if PIs expect that their chances of being funded at NSF have improved, or if they expect to receive larger awards from NSF, they should become more likely to submit proposals. Budgets, funding rates and award sizes are all potentially visible signals to PIs of the probability and potential payoff associated with submitting a proposal.

IPAMM conducted regression analyses using division-level data to see whether these three signals – budgets, funding rates, and award sizes – do, in fact, lead to increases in proposal submissions.[25] The regressions included a control variable ("year") to capture the year-to-year variance in submission rates not accounted for by the other three variables but still isolatable in the model. Specifically, the regression assessed change in numbers of proposals received by a division as a function of the percent change in budget from the prior year, previous year funding rate, previous year average award size, and "year".

The regression results (shown in Appendix C) indicate that none of the signaling variables had a significant effect on submission rates. The only significant effect was the control variable ("year"). Furthermore, the entire model accounted for only about 30% of the change in proposal submission rate. IPAMM concludes that other drivers – either outside forces or other NSF actions (i.e., other than funding rates and award sizes) – are responsible for far more of the change in submissions than are these signaling variables.

However, feedback from the 2007 NSF Proposer Survey suggests that PIs perceive these factors to be important to their decisions to write proposals, even though it could not be detected in the historical data. When asked if any of these factors influenced their decision to submit proposals to particular funding agencies (including NSF), respondents indicated that they considered program budgets (55%), expected funding rates (75%) and award sizes (67%) to a great or moderate extent when making this decision.

Institutional Pressures

Between 1998 and 2003, a greater number of academic institutions became involved in federally-supported research, and more schools expanded their research and development activities than those that reduced them. Overall, academic institutions increased their research space by 21% during this period. This growth in physical research infrastructure was accompanied by a growth in the scientific and engineering workforce. There was greater growth in postdoctoral positions, part-time appointments and other full-time positions than in regular full-time faculty positions.[26]

[25] For this analysis, we used information about unsolicited proposals only. Information about the budgets, award sizes and funding rates for special solicitations was not available. We also excluded the O/D offices, OPP, and EHR as these had so few unsolicited research proposals.

[26] Science and Engineering Indicators 2006, Chapter 5 (Academic Research and Development) Highlights; http://www.nsf.gov/statistics/seind06/c5/c5h.htm

These positions are often "soft money" positions that need to be supported with extramural funds. These trends are all important components of the increasing pressure to compete for research funds.

Over this same period, support for basic research at U.S. universities and colleges increased by almost 60%, and NSF's research budget grew by nearly 59%. A speculative scenario is that increases in Federal research budgets and relatively high funding rates may influence universities to hire personnel and expand research infrastructure, creating increased volumes of researchers and proposals. The impact may not be felt for several years at NSF, by which time the budget scenario and/or proposal funding rates may have changed for any number of reasons.

Anecdotal reports from several sources indicate that PIs have been experiencing more pressure from their institutions to submit proposals and receive awards. IPAMM explored this issue in the 2007 NSF Proposer Survey. Respondents indicated that, beyond their motivation to contribute to their area of research, building and/or maintaining their own research infrastructure (students, lab space, etc.) motivated them to either a great extent (63%) or to a moderate extent (22%) to submit research proposals to any funding source, including NSF. The pressure to build a funding record to support academic tenure and/or promotion was another significant institutional pressure motivating PIs to submit proposals, with 64% indicating that this motivated them to either a great extent (38%) or a moderate extent (26%). Not unexpectedly, PIs who were within seven years of their degree were much more likely to identify this as a significant driver than those that had received their degree more than seven years ago.

Increases in the Applicant Pool

The number of academic researchers grew by 13% between 1999 and 2003.[27] This increase in the size of the scientific and engineering workforce by itself is not enough to explain NSF's increase in proposal submissions. IPAMM investigated the degree to which increasing involvement by underrepresented groups, the effects of special proposal competitions, and/or changes in funding availability from non-NSF sources may have led to increases in the NSF applicant pool.

NSF Outreach

NSF has, over the past decade, been committed to encouraging greater participation by scientists and engineers from groups currently underrepresented in science and engineering and also from scientists and engineers working in nontraditional institutions (i.e., other than Ph.D. granting universities). NSF regularly conducts outreach through a variety of organized efforts, including semiannual Regional Grants Workshops, outreach workshops to minority-serving institutions, and multiple "NSF days" each year. In addition, many of the directorates, divisions and programs conduct outreach workshops, and the NSF Program Officers frequently make outreach visits at conferences and institutions across the country on an *ad hoc* basis. One goal of these outreach efforts is to help underrepresented groups understand NSF's proposal submission and review processes, and to ensure that they recognize that they are welcome and valued members of the NSF community. To the extent NSF has succeeded in these efforts, the pool of applicants has increased.

[27] Science and Engineering Indicators 2006; http://www.nsf.gov/statistics/seind06/

IPAMM examined submission rates for two groups that have been of particular importance in NSF's outreach efforts: groups underrepresented in science and engineering (including women and minorities) and investigators from universities and colleges other than the traditionally research-intensive institutions.

Underrepresented Groups

Nationally, the number of academic science and engineering (S&E) faculty members holding a Ph.D. increased 3.2% biennially between 1997 and 2003. Within this pool, the male population had an average biennial increase of 0.9% while the female population had an average biennial increase of 10.5%.[28] At the same time, the underrepresented minority population of academic S&E full-time faculty members holding a Ph.D. increased, on average, 0.63% biennially.[29] At NSF, the number of proposals from female and minority PIs showed an average annual increase of 8.9% and 0.12%, respectively, between FY 2001 and FY 2004. Although the growth in the female population among NSF proposers is similar to the overall growth of the national female faculty member population, the growth of minority proposal submissions appears to lag behind the growth of the national minority full time faculty member population. However, NSF's demographic data related to minority status are imprecise because a large number of proposers choose not to report their race or ethnicity.

Proposals from Research Intensive and Other Institutions

To determine if the rise in proposal submissions was driven in part by greater participation from a wider range of institutions, IPAMM determined the rate at which proposal submissions increased from various institution types. During the five year period between FY 2000 and FY 2004, the proposals from RI institutions increased by 42% while proposals from all other sources increased by 58%. Nonetheless, in absolute numbers, most of the proposals submitted over that time period were accounted for by RI schools (as shown in Figure 15).

Table 8
Increase in Research Proposal Submissions from Research Intensive and Other Institutions

Fiscal Year	Total increase in proposals	Increase from RI Institutions	Increase from other Institutions	% of increase accounted for by RI Institutions
2000	1,324	1,138	186	86%
2001	1,653	922	731	56%
2002	2,145	1,454	691	68%
2003	3,438	2,198	1,240	64%
2004	2,875	1,545	1,330	54%

Table 8 looks more closely at the increase, to determine the contribution of RI or other institution types. In FY 2000, most of the increase in proposal submissions over the previous year was due to submissions from RI institutions. By FY 2004, nearly half of the increase was due to submissions from other types of institutions. This suggests, in part, that NSF outreach efforts to

[28] Science and Engineering Indicators 2006; http://www.nsf.gov/statistics/seind06/
[29] Science and Engineering Indicators 2006; http://www.nsf.gov/statistics/seind06/

these institutions was successful. It also suggests that pressure on faculty members to submit proposals may be growing at these other institutions.[30]

Special Proposal Competitions

NSF uses a variety of mechanisms to generate proposals, including Dear Colleague letters, Program Descriptions, Program Announcements, and Program Solicitations.[31] Most NSF research proposals are received either as "unsolicited" submissions to programs that invite scientists and engineers to propose whatever they consider to be a promising or important research idea in a general disciplinary area; or they are submitted in response to a "solicitation" wherein, most often, NSF asks the community to address some specific topic, tool or problem.[32] Program solicitations that focused on specific areas of research were used increasingly between FY 2000 and FY 2005 as part of a strategic effort to stimulate interest in, and foster the development of, emerging research areas such as information technology, nanotechnology, and cyberinfrastructure. It is possible that responses to this type of funding mechanism created dynamics that account for some increases in proposals overall since solicitations may attract new researchers into the NSF community and/or may attract extra effort from PIs who are already active within the Foundation.

As shown in Figure 17, the number of solicitations with specific research foci increased by more than 50% in just two years, between FY 2000 and FY 2002. Proposals responding to these specific solicitations increased as a percentage of the overall proposal portfolio in proportion to the number of solicitations, from 14% in FY 2000 to a peak of 29% in FY 2003 (Figure 18). A comparison of the funding rate trends for unsolicited and solicited proposals is shown in Figure 19. For unsolicited proposals, which represent the majority of NSF's research awards, funding rates declined from 31% to 21% between FY 2000 and FY 2005. Funding rates for solicited proposals seesawed between 24% and 18% between FY 2000 and FY 2002, and then declined steadily to 16% in FY 2005. Although the funding rates associated with solicitations were generally lower than for unsolicited proposals, funding rates for both types of proposals declined over the FY 2000-2005 period. Thus the decline in NSF's overall funding rate was not due solely to the lower funding rates for the solicitations.

[30] See Figure 15 in Section 2 of this report for a complete description of proposals by institution type.

[31] Dear Colleague letters are intended to provide general information to the community, and may be used to draw attention to new or existing funding opportunities, but are not used in and of themselves to solicit proposals. Program Announcements (broad, general descriptions of programs and activities in NSF Directorates/Offices and Divisions) and Program Descriptions (formal NSF publications that announce NSF programs) are the primary mechanisms used by NSF to communicate opportunities for research and education support, as well as to generate proposals. Program Announcements and Program Descriptions utilize the generic eligibility and proposal preparation guidelines specified in the Grant Proposal Guide (GPG) section of the Proposal and Award Policies and Procedures Guide (PAPPG) and incorporate the NSB approved merit review criteria. Program Solicitations are formal NSF publications that encourage the submission of proposals in specific program areas of interest to NSF. Program Solicitations are also issued when the funding opportunity includes guidance that deviates from the generic eligibility and proposal preparation guidelines specified in the GPG. Full definitions for these mechanisms are defined in the Part I.A, Chapter I.C of the PAPPG; http://www.nsf.gov/pubs/policydocs/papp/gpg07140.pdf.

[32] For the purpose of this analysis, although the Program Solicitation mechanism can be used for a wide variety of activities, only those solicitations that requested proposals in a targeted research area have been called out.

Figure 17
Trends in the Use of Solicitations with Targeted Research Foci

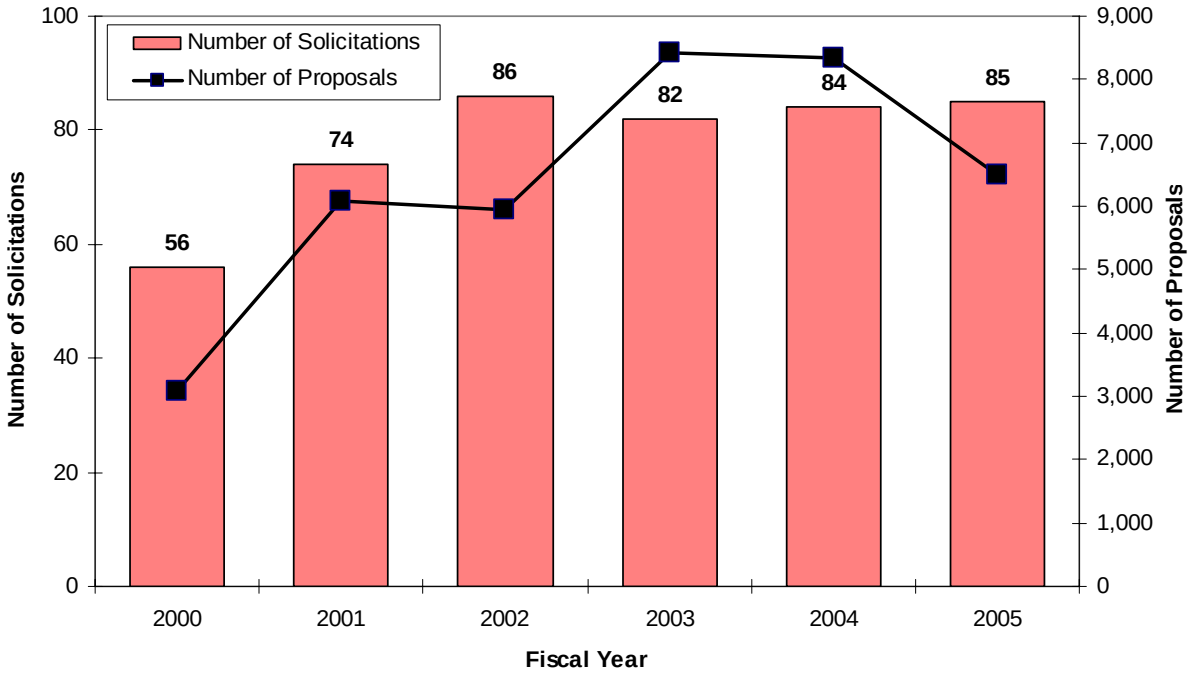


Figure legend: The number of proposals awarded or declined in each fiscal year is shown with the number of solicitations associated with those proposals.

Figure 18
Solicited vs. Unsolicited Proposals within the NSF Research Proposal Portfolio

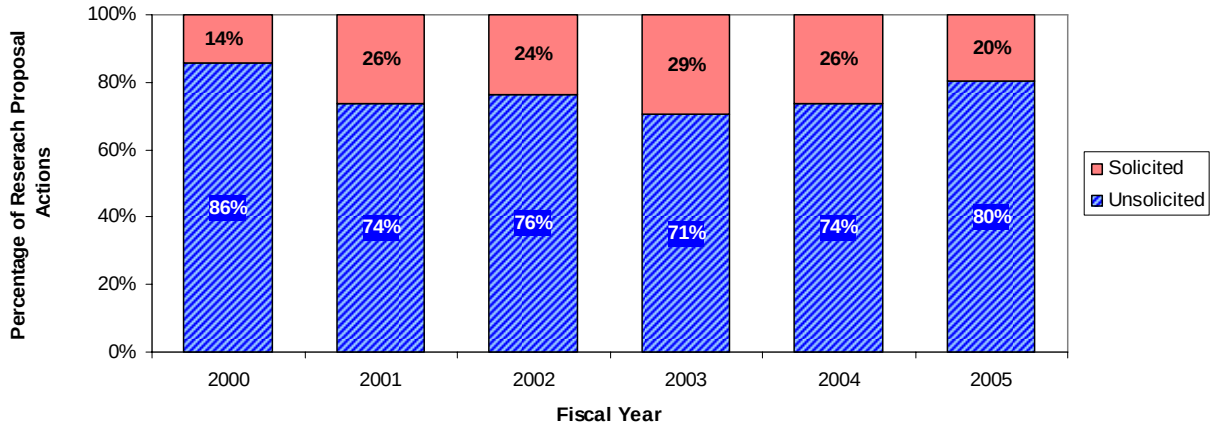


Figure legend: The percentage of all of the proposals processed each fiscal year responding to a solicitation with a targeted research focus compared to the percentage of all proposals processed for unsolicited research areas.

Figure 19
Funding Rates for Solicited and Unsolicited Research Proposals

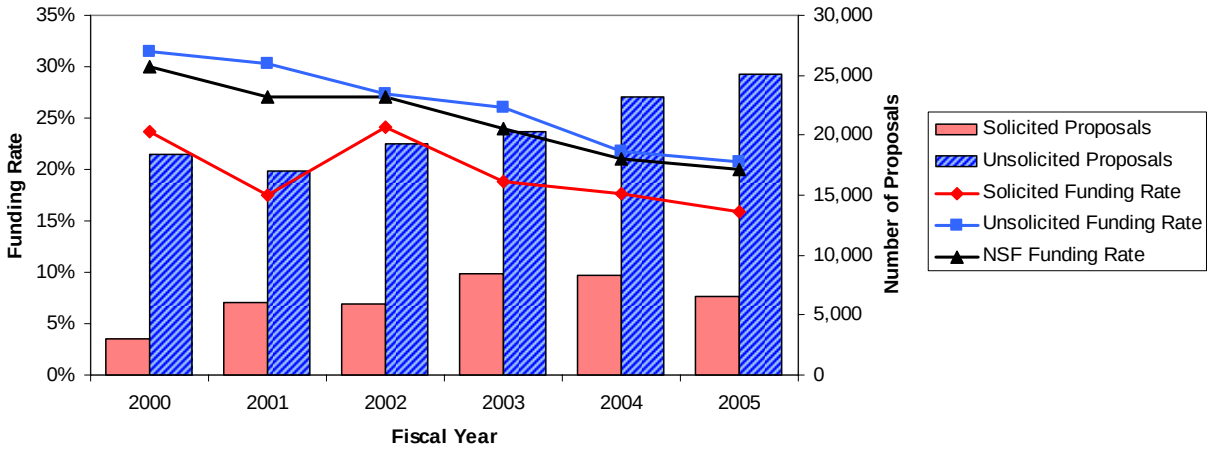


Figure legend: Funding rates for proposals processed in response to a solicitation with a targeted research focus compared to the funding rate for proposals processed for unsolicited research areas. The funding rate for all research proposals is also shown. Also shown are the trends in the number of proposals processed each fiscal year for solicited proposals and unsolicited proposals.

A further analysis of the impact of the solicitations on the increase in total proposals received each year from FY 2000-2005 is shown in Figure 20, which looks at the change each year in proposal submissions to standing or "unsolicited" funding opportunities vs. proposals submitted for special "solicitations". The data in this figure display an interesting seesaw effect, such that in some years the overall increase in proposals was due primarily to an increase in the number of proposals responding to solicitations, while in other years increased numbers of unsolicited proposals drove the overall increase.

IPAMM notes that the Biocomplexity in the Environment and the Information Technology Research Priority Areas were first funded in FY 2000, the Nanotechnology Priority Area was first funded in FY 2001, and the Mathematical Sciences and the Human and Social Dynamics Priority Areas were first funded in FY 2003. The launch of these Priority Areas corresponds closely to the years in which the overall increase in proposals was largely driven by increases in solicited proposals. In the years following the debut of these high-profile solicitations, unsolicited proposals in related areas increased (primarily in CISE, ENG, and SBE), suggesting that PIs who become active with NSF in a special solicitation may remain as members of its submitting pool, and perhaps that declined priority area proposals were revised and submitted to related core programs.

Figure 20
Numeric Changes in Proposals Received (Solicited vs. Unsolicited)

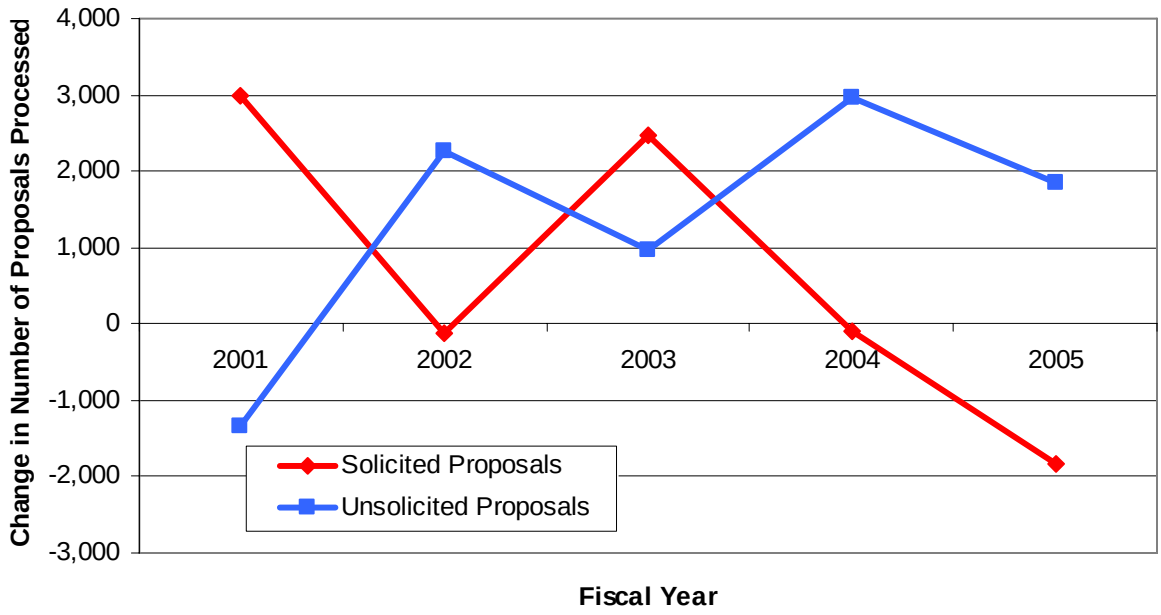


Figure legend. This graph displays the change in the number of solicited and unsolicited proposals processed each fiscal year. It is important to note that the graph shows *increases* in proposals. I.e., in FY 2001, the number of solicited proposals processed increased by ~3000 over the number processed in FY 2000; at the same time the number of unsolicited proposals processed in FY 2001 decreased as compared to FY 2000. After a given increase, that additional volume will reappear in the following year (thus, the baseline volume grows each year). Source: NSF Budget Division

Changes in Funding from non-NSF Sources

Several sources, including some Advisory Committees, suggested that proposal submission to NSF increased because other funding sources, governmental and/or industrial, either reduced their research funding or refocused it in ways that excluded certain existing research communities. IPAMM sought hard data to back up systematically the anecdotal stories shared with us on this topic. In most cases, support from other agencies does not map one-to-one with programs at NSF, making it difficult to compare the consequences of changes. IPAMM looked at three cases that were raised as possible examples:

(1) National Aeronautics and Space Administration (NASA) Funding for Fluid Dynamics: Approximately $35M in annual funding for grants in fluid mechanics, combustion, and transport phenomena was eliminated in NASA's program restructurings between FY 2002 and FY 2005. Between FY 2002 and FY 2006, the number of proposals processed in the Transport and Thermal Fluids Phenomena cluster of programs in ENG (which supports research in the same area as those affected by NASA's cuts) nearly tripled, and funding rates dropped from 35% to 14%.

(2) National Institute of Mental Health (NIMH) Funding for Social Psychology: In FY 2003, NIMH (one of the institutes at the National Institutes of Health; NIH) underwent a

reorganization that included elimination of funding for social psychology. The next year, NSF's Social Psychology program experienced a 116% increase in proposals and a concomitant decrease in funding rates from 21% to 13%. Although these data are suggestive, this same program experienced a similar large influx of proposals in FY 2002, unassociated with any known change in available funding sources.

(3) NIH Funding for Biology: Between FY 1999 and FY 2003, the NIH budget doubled, growing from $13.2B to $27.2B; for the last three years the NIH budget has had only small increases that have not kept pace with inflation. It has been hypothesized that changes in proposal load in the BIO directorate would show an inverse correlation to the changes in the NIH budget. In contrast to this hypothesis, during the five years that the NIH budget was doubling (FY 1999-2003) proposal loads in the BIO directorate grew by 26%; in the past three years, the number of proposals in BIO has continued to grow at approximately the same rate. In comparing proposal numbers in the Division of Environmental Biology (DEB, which is distantly related to most NIH programs) with proposal numbers in the Division of Molecular and Cellular Biosciences (MCB, which is more closely related to NIH programs), we found that both divisions experienced significant growth between FY 1999 and FY 2006, although with different profiles. Proposal submissions to DEB grew substantially in FY 2000 and 2001, and then again in FY 2005 and 2006, for an overall increase of about 61%, while MCB showed a steadier rise in proposal submissions beginning in FY 2001, for an overall increase of approximately 42%.

Based on these analyses, case study #1 seemed to support the perception that decreased funding from other sources was a potential driver for increasing proposal submissions to NSF. However, no clear cause-and-effect relationship could be seen in the NSF data for the other two cases. To gain more insight into community attitudes on this issue, the 2007 NSF Proposer Survey asked PIs to indicate the extent to which decreased funding available from other sources influenced their decision to submit a proposal to NSF in the last three years. 54% of the respondents indicated that they had been influenced to a small (23%), moderate (20%), or great extent (11%) by decreases in funding from other sources. In addition, PIs submitting to either the Social Psychology program or to MCB were more likely than the overall respondent population to indicate that decreased funding elsewhere had moderately or greatly influenced their decision to submit a proposal to NSF (49% and 47%, respectively, as compared to 31%).

Other NSF Internal Activities

Technology: It has been suggested that the use of electronic submission (FastLane) may contribute to increased submission rates. Between FY 1998 and FY 2002, the number of proposals processed by NSF within six months increased by about 30%, due in part to increased efficiencies gained by the shift to electronic proposal processing within NSF. Because NSF was getting proposal decisions to PIs sooner, this may have contributed to increased numbers of resubmissions. NSF does not track the submission of revised proposals, and thus it was not possible to test this hypothesis quantitatively. However, over two-thirds of the respondents to the 2007 NSF Proposer Survey indicated that FastLane made the resubmission process faster, clearer, and easier.

Conclusions

Many factors influence proposal submissions and proposal funding rates. Based on the analyses described in this section, no single factor was identified as the primary contributor.

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 resulted from both an increased applicant pool and an increased number of proposals per applicant. There are a number of reasons for the expanded applicant pool, including increased capacity of the research community, increased NSF use of targeted solicitations in new areas, and increases in the NSF budget. The growth in the intellectual capital of the nation is a positive outcome of Federal investments in building the nation's capacity. This is a factor that will need to be incorporated into strategic planning by all funding agencies, including NSF.

The use of special solicitations has contributed to the increase in proposal submission rate, and appears to impact submission rates of unsolicited proposals to the core programs as well. This "halo" effect on increasing proposal submissions to other related programs is an important consequence of using special solicitations, which should be considered as part of the planning during their development. Although the funding rate for solicited proposals was generally lower than that for unsolicited proposals, this was not a major factor in reducing the overall funding rate.

In a few instances the reasons for increased submissions can be traced directly to decreases in funding levels in other Federal agencies. Anecdotal reports suggest that increased submissions may also result from some institutional pressures on faculty members in academic institutions, including valuation of an NSF grant in promotion and tenure, and inclusion of proposal submissions (in addition to receiving awards) in annual performance evaluations. These may be important drivers, but there are not sufficient data to fully assess their role in proposal submissions. Feedback from the 2007 NSF Proposer Survey suggests that some of these increasing institutional pressures, compounded by the declining funding rate, are likely contributors to the growth in the number of proposals per applicant.

V. ASSESSMENT OF NSF EFFORTS TO MANAGE PROPOSAL SUBMISSIONS AND FUNDING RATES

Many in the S&E community have voiced concerns about the impact of declining proposal funding rates on the research infrastructure (including both physical infrastructure and human resources). For example, of 35 Committees of Visitors (COV)[33] reports submitted between 2003 and 2006, 80% expressed concern about declining funding rates. Some of these reports recommended strategies to deal with the issue, such as reducing the number of solicitations, providing more information about program research priorities, and providing more constructive feedback to proposers.

Equally concerned with this issue, various NSF organizations have implemented a variety of practices to improve management of increasing proposal submissions and declining funding rates. One of the main strategies has been to enhance communication with external research communities. Directorates and divisions examined solicitations to ensure that they sharply delineated requirements and focus areas. Program officers were encouraged to consult with investigators about taking the time to revise declined proposals significantly before resubmitting them. In addition, a number of practices that limited proposal submissions in some manner (reducing the number of targeted program solicitations, reducing the number of proposal submission target dates per year, replacing open submission of unsolicited proposals with a submission window, limiting the number of proposal submissions an institution and/or PI can submit, placing restrictions on the resubmission of declined proposals and/or requiring preliminary proposals) and/or increased the pool of funds available for a particular competition (increasing the length of the competition cycle and/or increasing the out-year mortgage level) were employed by one or more NSF directorates/offices.

In the following sections, IPAMM looked in more detail at several practices that either limited proposal submission or increased the availability of funds for a given competition.

Limiting Proposal Submissions

Of the various practices mentioned above, the ones that have elicited the most comments are those that limit proposal submissions. As a general rule, NSF does not set any limits on the number of proposals that an institution can submit to NSF. However, submission limitations can be established for specific funding opportunities; if so, NSF policy requires the use of a program solicitation that specifies the submission restriction.[34] In practice, most funding opportunities do not impose submission limitations; when they are used, there are specific reasons for asking the PI or institution to focus their efforts when submitting proposals. As is shown below, only a small proportion of the solicitations that limit submissions are focused on research. However,

[33] All NSF research programs are regularly evaluated by external Committees of Visitors (COVs) to help the Foundation maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. COVs for divisions or programs meet once every three years. COV reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the results generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals. See http://www.nsf.gov/about/performance/advisory.jsp.

[34] Proposal and Award Policies and Procedures Guide, Part I.A (GPG), Chapter I.C.4.

because the issue of limiting proposal submissions is of particular concern to the scientific and engineering communities, for the purpose of this analysis, all funding opportunities were included, not just those focusing on research activities.

IPAMM analyzed the use of three primary mechanisms that can be used to limit submission of a full proposal: requiring the submission of a preliminary proposal[35], limiting the number of proposal submissions from a given institution, and limiting the number of proposal submissions authored by individual investigators. At present, there are over 350 active funding opportunities to which proposers may submit proposals. Of these, 12 require the use of preliminary proposals, 33 limit proposal submissions from a single institution, and 59 limit proposal submissions by an individual investigator. These are not mutually exclusive sets—14 funding opportunities use some combination of two or all three limitations. It should be noted here that when submission limits by PI or institution are used, they apply only to the specific funding opportunity listing the limitation, and do not prohibit submissions of additional proposals to other programs within NSF. In addition, the stringency of the submission limit by PI and/or institution varies. For example, in some solicitations, individuals are limited to submitting one proposal as PI, co-principal investigator (co-PI) or senior personnel while in others the limit is set at two per PI with no limit on the number of proposals an individual can participate in as co-PI or other senior personnel. Similarly, the limit on submission by institutions varies from one proposal in any capacity, to as many as four proposals as the lead institution with no limit on the number of proposals an institution may participate in as a non-lead partner.

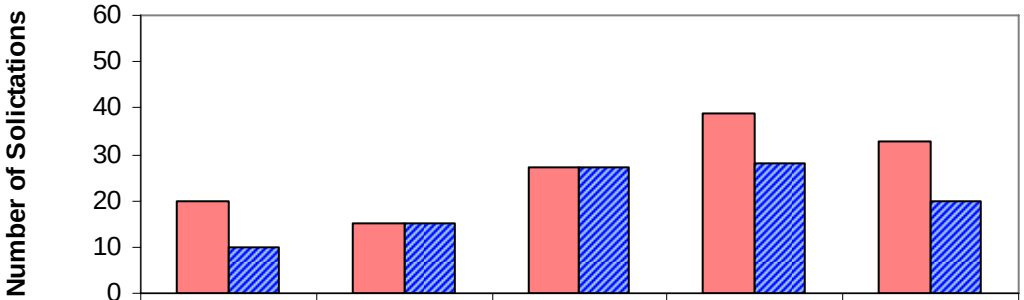
In the 2007 NSF Proposer Survey, of those respondents who had been required to submit a preliminary proposal, 55% agreed that preliminary proposals would subsequently save time when preparing a full proposal, 42% agreed that they would save resources, and 48% agreed that they would help increase the quality of the full proposal. Many of the respondents who were aware that NSF had limited the number of proposals that their institution could submit to a particular funding opportunity felt that this practice had a negative impact on their motivation to seek future NSF funding (41%) and on the fair representation of their fields of research (45%). Nonetheless, most believed that these limitations had either a neutral (36%) or a positive (28%) impact on the quality of the proposals submitted.

Over the last several years, the number of solicitations that limit submissions by institution has been decreasing, while solicitations that limit submissions by PI are a relatively new but growing phenomenon (Figure 21, compare A and B).

[35] The intent of preliminary proposals is to limit the burden imposed on proposers and the community and/or to increase the quality of the full proposal. One of the following two types of decisions may be received from NSF upon submission of a preliminary proposal. A *binding* (invite/non-invite) decision is the type of mechanism used when the NSF decision made on the preliminary proposal is final, affecting the PI's eligibility to submit a full proposal. A *non-binding* (encourage/discourage) decision is the type of mechanism used when the NSF decision made on the preliminary proposal is advisory only. This means that submitters of both favorably and unfavorably reviewed proposals are eligible to submit full proposals.

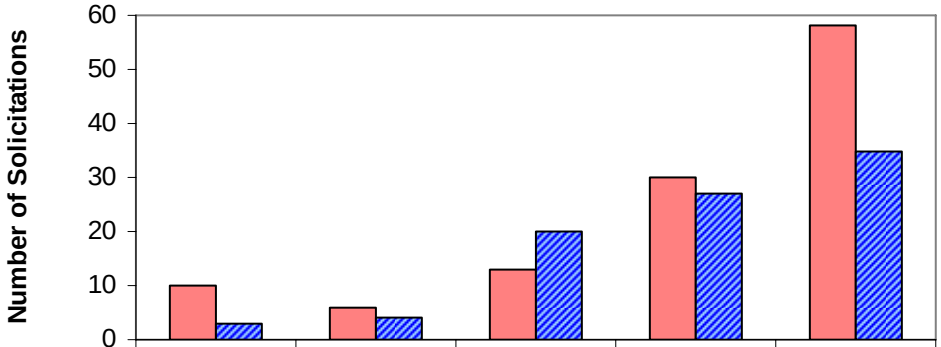
Figure 21
Trends in the Use of Solicitations that Limit Submissions by Institution or PI

A. Trends in the Use of Submission Limitations by Institution



	2003	2004	2005	2006	2007*
Active**	20	15	27	39	33
Issued	10	15	27	28	20

B. Trends in the Use of Submission Limitations by PI



	2003	2004	2005	2006	2007*
Active**	10	6	13	30	58
Issued	3	4	20	27	35

Figure legend. The number of funding opportunities limiting submissions by institution (A) or by PI (B) that were active or were issued in each fiscal between FY 2003 and FY 2007 are shown. For a funding opportunity to be counted in the "active" dataset, it had to have a submission date within the respective fiscal year, regardless of when the opportunity was first issued. The "issued" dataset identifies how many funding opportunities with submission limits were issued each year, whether or not they are still active. *FY 2007 data include all solicitations issued as of June 20, 2007. **Only those funding opportunities that are published in PIMS (the Program Information Management System initiated in FY 2000) are accessible for this analysis. Any funding opportunities that were published prior to FY 2000 and that were still active between FY 2003 and FY 2007 could not be included. Thus, the number of active funding opportunities shown in these two charts may be an underestimate, however the number of funding opportunities reported in the "issued" dataset is highly reliable.
Source: Program Information Management System (PIMS).

The majority of NSF programs that limit proposal submissions by institution are institution-level awards that focus on building infrastructure, establishing research centers, broadening participation, and/or improving or expanding educational opportunities (Figure 22A). These

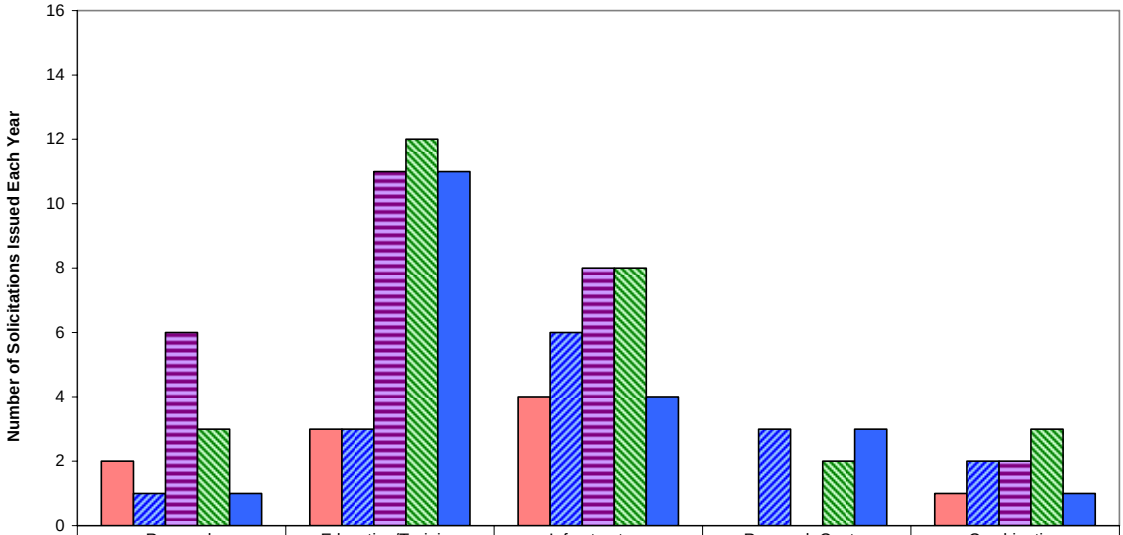
programs generally limit submission because proposals to build large infrastructure, develop broad partnerships, and/or establish research centers ought to be done in the context of an institution's longer-term strategic priorities to ensure that these efforts will be sustained beyond the life of the NSF award. Similarly, scholarships, fellowships and training programs are institutional-level awards, and proposals to establish these programs need to fit within the goals of the institution. For programs with very broad appeal, imposing institutional submission limitations helps to broaden participation to include more, diverse institutions. A concern associated with this practice is that some institutions may not have a credible internal system to evaluate and rank proposals.

Only a small number of research programs impose limits on proposal submissions by institution; these tend to support the development of multidisciplinary centers and/or multi-institutional partnerships. In contrast, funding opportunities that limit the number of submissions by PI are more likely to be focused on research (Figure 22B). This particular mechanism has been employed more heavily in the directorates that experienced very high proposal loads and/or very low funding rates.

There are balancing trade-offs associated with limiting proposal submissions by PI. One rationale for implementing this practice was the hope that PIs would focus their efforts on their strongest ideas and projects, thus increasing the quality of the proposals being submitted. Potential concerns were that PIs would tend to submit "safer" projects, and/or that there could be an unintended negative impact on a PI's willingness to collaborate (i.e. be a co-PI) on proposals.

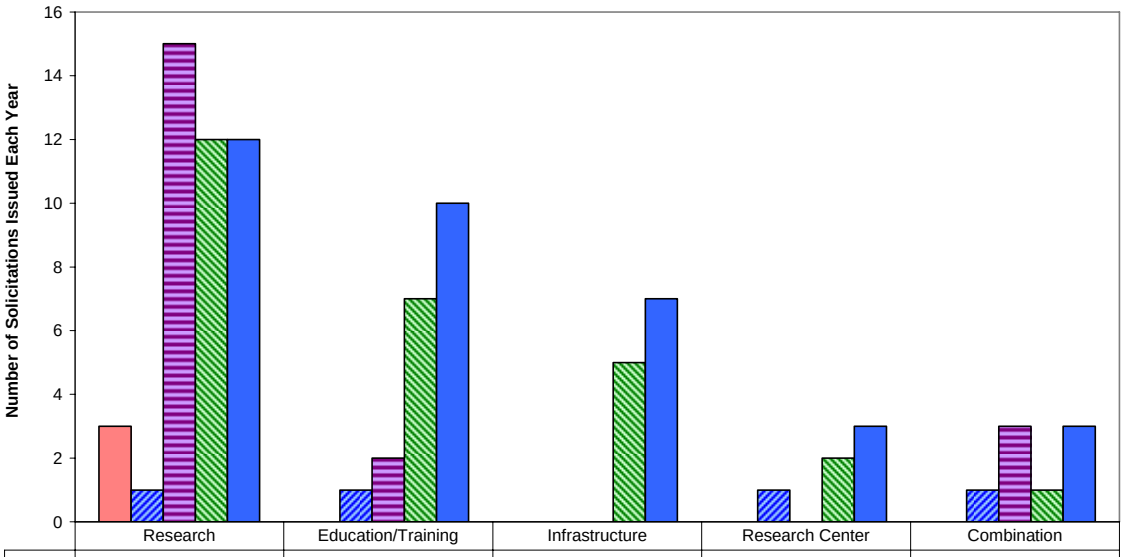
Figure 22
Types of Solicitations that Limit Submissions by Either Institution or PI

A. Types of Solicitations that Limit Submissions by Institution



	Research	Education/Training	Infrastructure	Research Center	Combination
2003	2	3	4	0	1
2004	1	3	6	3	2
2005	6	11	8	0	2
2006	3	12	8	2	3
2007*	1	11	4	3	1

B. Types of Solicitations that Limit Submissions by PI



	Research	Education/Training	Infrastructure	Research Center	Combination
2003	3	0	0	0	0
2004	1	1	0	1	1
2005	15	2	0	0	3
2006	12	7	5	2	1
2007*	12	10	7	3	3

Figure legend. The solicitations limiting submissions by institutions (A) or by PI (B) issued each fiscal year are grouped into categories, characterized by the focus of the solicitation. The "combination" category includes solicitations that have elements of two or more of the other categories (for example, one component focuses on research projects and another component focuses on education and training). *FY 2007 data include all solicitations issued as of June 20, 2007. Source: Program Information Management System (PIMS).

Increasing the Available Pool of Funds for Specific Activities

Another strategy that was employed in various units to increase funding rates was to increase the pool of available funds to allow more awards. Some funding opportunities were organized so that they crossed fiscal years, allowing the use of two years of funds to support proposals submitted to a single competition. In other cases, increased availability of funds in the current year was gained by adjusting the balance of standard and continuing grants[36] within a given program or portfolio. NSF's long-standing practice of using both funding mechanisms allows greater flexibility in balancing current and future obligations, and can provide a buffer at times when there are greater constraints on the budget. As shown in Table 9, in FY 2006 NSF devoted 22% of its total budget to new standard grants and 17% to new continuing grants.

[36] Grants can be funded either as standard awards, in which funding for the full duration of the project (generally 1-5 years) is provided in a single fiscal year, or as continuing awards, in which funding of a multi-year project is provided in increments (usually one year). For the latter mechanism, the initial funding increment is accompanied by a statement of intent to continue funding the project in yearly increments (called "continuing grant increments", or CGIs) until the project is completed.

Table 9
Percentage of NSF Budget by Type of Award

Fiscal Year	2002	2003	2004	2005	2006
New Standard Grants	26%	23%	23%	21%	22%
New Continuing Grants	21%	21%	17%	16%	17%
Continuing Grant Increments	35%	36%	39%	43%	41%
Centers, Facilities, and Other	18%	20%	20%	20%	20%
100% = $Billion	$4.77	$5.37	$5.66	$5.49	$5.65

Table legend. The distribution of NSF funds by award mechanism is shown here. New grants can be funded as either standard or continuing awards. The continuing grant increments row represents payments for continuing awards that were made in previous fiscal years. Centers and facilities are generally funded through cooperative agreements. The "other" category includes contract activities to support organizational excellence, including program evaluations. Source: NSF Enterprise Information System.

Within the core programs, program directors have the ability to change the percentage of program research funds (mortgage rate) that are committed to future year budgets, by altering the ratio of standard vs. continuing grants in their portfolios. This provided some flexibility in responding to increased proposal submissions, and potentially averted a steeper drop in funding rates. However, increasing the number of new continuing grants as a strategy to increase funding rates can only be employed for a limited time and must be used with discretion. If care is not taken, a large mortgage on future year funds could be accumulated that would severely hamper the capacity to make new awards.

Case Studies

To gain some additional insight into the significant contextual factors involved in making decisions about implementing these various practices, and the desire to understand how various NSF organizations used integrated approaches to the issue, IPAMM identified several "case studies" to review. In its review, IPAMM focused on the following questions:

- Were the practices implemented in a sound and equitable manner?
- Was the external community consulted?
- Were the practices effective in accomplishing their objectives?
- What are the pros and cons of each of the practices?
- Which "preferred practices" should be considered for future use?

1. Human and Social Dynamics Priority Area (HSD)

In FY 2004, a new priority area in Human and Social Dynamics (HSD) was launched. The response to the first solicitation was very high: PIs submitted a total of 694 projects[37] and while reviewers placed 113 projects in the "highly recommended/must fund" category, only 37 of these were awarded. As a result, the proposal funding rate for the HSD program was only 5.3%.

[37] A total of 1061 letters of intent were submitted to HSD in FY 2004, far exceeding NSF expectations based on previous Priority Area competitions.

In FY 2005, NSF significantly increased the HSD budget (from $17.5M to $32.5M) to better meet this demand. In addition, HSD management implemented several changes to increase proposal funding rates. These were:

- Requiring all projects to have three or more senior personnel from at least two different disciplines;
- Limiting researchers to a single HSD submission (i.e., allowing any one person to serve as a PI, co-PI, or other senior researcher on only one HSD proposal);
- Eliminating the infrastructure component from the competition; and
- Setting a deadline earlier in the fiscal year (January/February) in order to allow the use of both FY 2005 and FY 2006 funds to fund worthy projects submitted in FY 2005.

In FY 2005, 93 of the 363 projects submitted were awarded, resulting in a funding rate of 25.6%. HSD Program Officers were able to fund all of the projects in the "highly recommended/must fund" category. The number of submissions was much lower than in FY 2004; the reduced proposal pressure was likely a result of both the changes outlined above but also the low funding rate in FY 2004.

A comparison of the range of institutions that submitted proposals in FY 2004 and FY 2005 indicated that the overall distribution of institution types (top 100 research intensive Ph.D. institutions, non-research intensive Ph.D. institutions, masters, 4-year, 2-year, and business/other) was similar in both years. However, while the number of top 100 institutions that submitted proposals in FY 2005 did not drop appreciably as compared to FY 2004 (approximately 3% decrease), significantly fewer institutions in each of the other categories submitted proposals in FY 2005 as compared to FY 2004 (ranging from 23% to 56% decrease).

2. Integrative Graduate Education and Research Traineeship Program (IGERT)

IGERT proposals are reviewed using a two-stage competition format in which the first stage is the submission of preliminary proposals. The preliminary proposals are merit reviewed, after which invitations for full proposals are sent to the selected principal investigators. From the outset in FY 1998, when the program was initially established, a proposal submission limitation was included such that an institution could not submit more than two single institution full proposals and one multi-institution proposal (where that institution served as the lead institution; there were no limits on the number of multi-institutional proposals an institution could participate in as non-lead partners). Although the number of submissions from a given institution is limited in these solicitations, the number of active awards that an institution may have at any one time is not.

From FY 2000 to 2006, the number of preliminary proposals submitted annually to IGERT nearly doubled. The increase in proposal load raised concerns about potential impacts on the merit review process.[38] To effectively manage the increasing proposal submissions, and to encourage PIs and institutions to think strategically about their goals and investment priorities, a few additional limitations were introduced over time, as follows:

[38] For example, creating effective review panels was increasingly difficult because the reviewer pool became taxed beyond its capacity with regard to conflict of interest issues and reviewer expertise.

- Instituted in FY 2004: In addition to the institutional submission limits, principal investigators or co-principal investigators were limited to participating in only one proposal submission. This limitation applied to both preliminary proposals and full proposals.

- Instituted in FY 2006: In addition to the institutional submissions limits on full proposals, a new limit on the number of preliminary proposals was included, such that no more than four preliminary proposals could be submitted by an institution as the lead institution.

There was no significant negative feedback from the community on the PI limitations instituted in FY 2004. The preliminary proposal submission limitation instituted in FY 2006 has resulted in institutions that historically submitted multiple preliminary proposals now using internal competitions to decide which preliminary proposals should be submitted to the IGERT program. The program officers report that this activity has had the effect of enhancing the focus on the IGERT program's goals in the preliminary proposals that are now being submitted to NSF.

Since IGERT's inception, a funding rate of 25-30% (based on the full proposal count) has been the target range.[39] As Figure 23 shows, this was largely accomplished.

Figure 23
Trends in Funding Rates for IGERT Full Proposals

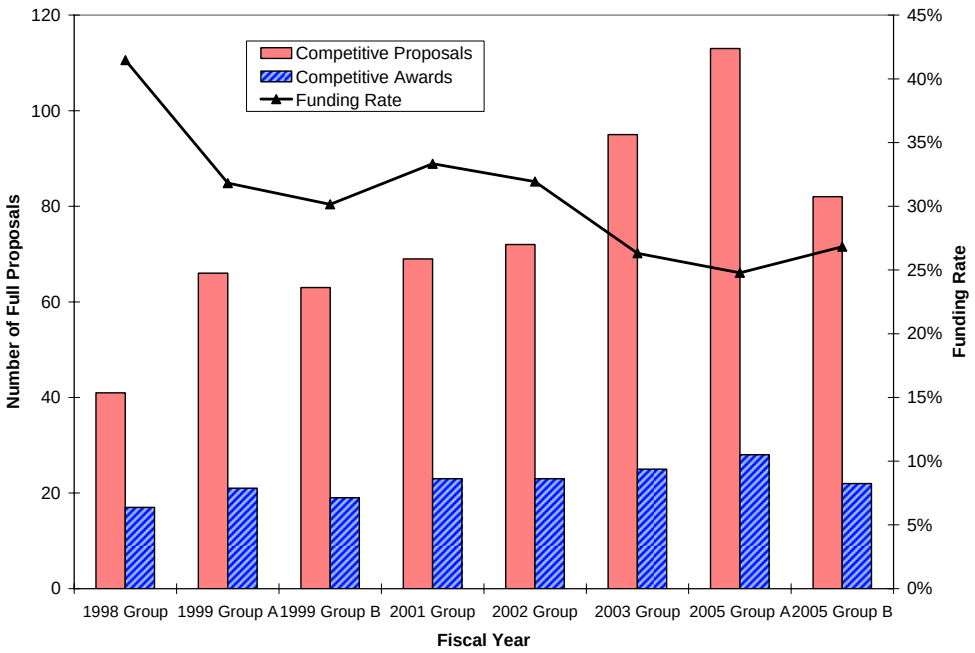


Figure legend: Data shown here reflect the number of full proposals and awards that were made per competition. Note that two sets of proposals were received in FY 1999 and FY 2005—in both cases the latter set were received near the end of the fiscal year and were funded in the subsequent year (i.e., FY 2000 and FY 2006, respectively).
Source: NSF Budget Division

[39] This target was based on historical experience plus discussions with the community.

3. CISE/Division for Information and Intelligent Systems (IIS)

From FY 2000 to 2004, IIS received large numbers of proposals (as did all divisions in CISE) submitted to the Information Technology Research (ITR) Program, a Foundation-wide Priority Area for which CISE served as the lead. At the same time, there was a threefold increase in the number of proposals submitted to the division's core programs. During this period, the overall research proposal funding rate in the core programs declined from 26% in FY 2000 to 10% in FY 2004 (see Figure 24).

During this period, IIS developed and used a number of strategies to manage increasing proposal submissions in ITR and its core programs. The proposal management strategies implemented by IIS over this period were intended to balance the needs of its scientific and engineering communities with rising proposal submission rates and declining funding rates.

In 2001, the division published a "Dear Colleague" letter announcing a shift from two target dates per year to two deadlines within the core programs.[40] As anticipated, the reaction of the scientific communities to this new policy was negligible. By decreasing the uncertainties related to when proposals were submitted, staff members were better able to manage the merit review process.

By 2003, it was apparent that two deadlines per year had not curbed the rise in proposal submissions. In anticipation of the continuing increase in submissions and to further help balance workload, IIS changed from two deadlines a year to one deadline. In addition, the division developed program announcements for all of its core programs.[41] Principal investigators could still submit to multiple programs in IIS (as well as across the Foundation) and there were no additional restrictions. The feedback from the research communities was mixed; the switch to using announcements met with favor because more information was now available about the programs, but the single deadline meant that submission opportunities within a particular program were limited to one time a year, which may or may not be convenient for any given PI.

Proposal actions continued to rise in FY 2004, and then held steady in FY 2005. In an attempt to encourage PIs to prioritize their research efforts, and simultaneously help ease the proposal submission pressure, IIS limited the number of proposals a PI could submit to a single solicitation to two. This change resulted in mixed reactions from the research communities. Some thought that it helped them better focus on their highest quality proposals; others felt that the policies were too constraining. To increase the funding rate for proposals submitted to the FY 2005 competition, program funds from FY 2005 and FY 2006 were used to fund FY 2005 awards. In 2007, IIS held another competition for its core programs, and will use program funds from FY 2007 only to make awards. It is not yet clear what the effect will be on division funding rates.

[40] Target dates allow proposals to be submitted for a short period of time after the published date (as well as on or before the date). Deadlines require that proposals be submitted on or before the published date. Proposals submitted after the deadline are "late" and are returned without review.

[41] At the time, this practice was a general trend throughout the NSF.

Figure 24
Trends in Funding Rates for the Core Programs in CISE/IIS from FY 2000 to FY 2006

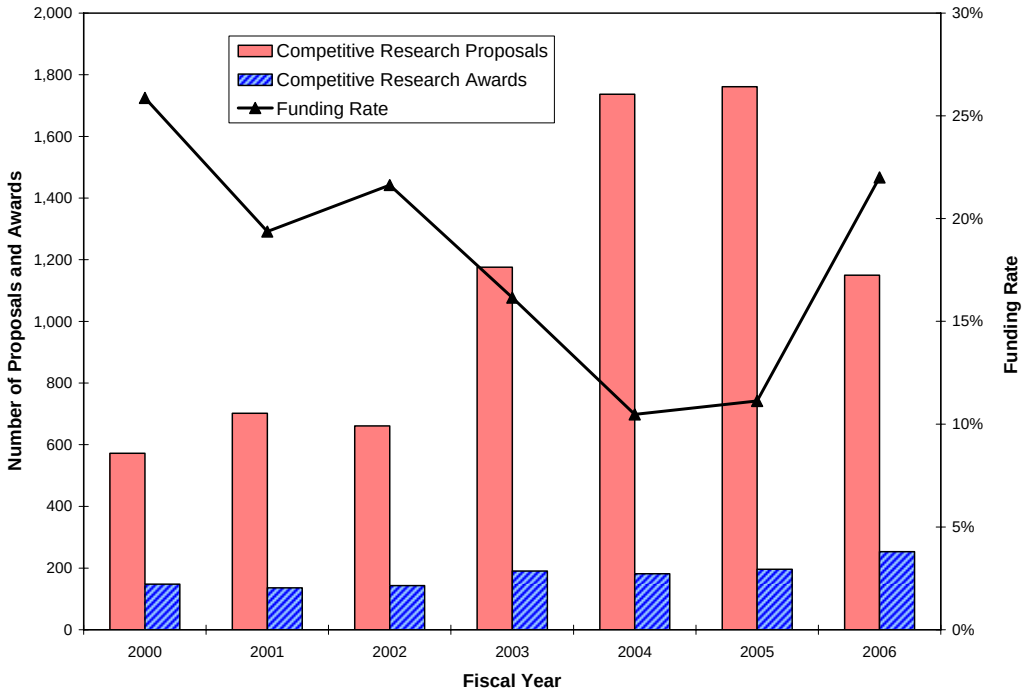


Figure legend. Data shown here reflect the number of research proposals and awards for the core programs in CISE/IIS, excluding any of the ITR proposals, shown by the fiscal year of decision. Source: NSF Budget Division

4. Directorate for Engineering (ENG)

As shown in Figure 8, the proposal funding rate in ENG is among the lowest; for the last four years ENG has received the largest number of proposals (Figure 9). Concerned about this trend, ENG leadership discussed the issue with the ENG Advisory Committee and several internal management groups.

As a result, ENG leadership is currently implementing the following practices:

- Improve proposal-generating documents. All documents used to communicate with the researchers are carefully crafted, more focused, and reviewed on a regular basis for relevance and the potential elimination of dated or imprecise text.

- Reduce the number of solicitation topics to improve communications among similar efforts and reduce possible duplication of efforts.

- Publish no more than five to six new ENG solicitations (with two to four interdisciplinary solicitations) per year. $3 million is the minimum investment in a solicitation. Solicitations that involve only a single ENG division are being discouraged.

It is too soon to fully evaluate the success of these measures. The recent trends are somewhat promising, in that they show that, while ENG research proposal submissions steadily increased from 3,997 in FY 2000 to 6,610 in FY 2005, they leveled off in FY 2006 to 6,628. In addition,

while the ENG proposal funding rate steadily declined from 24% in FY 2000 to 13% in FY 2005, it increased in FY 2006 to 14%.

5. The Mathematical Sciences Priority Area (MSPA)

The NSF-wide MSPA was active between FY 2003-FY 2006. During this time it was able to maintain an overall funding rate above 20%, while similar programs experienced rapidly rising proposal submissions and falling funding rates. From the beginning, the MSPA was managed by a working group (MSPA-WG) composed of representatives from all NSF directorates in research and education. During the initial planning activities held in late FY 2000, the MSPA-WG developed a draft management plan that stated:

> "Funding will be through multiple, distinct, focused sub-competitions in the overall program announcement. Each sub-competition will be a collaboration between one or more of the S&E directorates and MPS/DMS and each will target the most compelling research areas that have been identified."…. "The various collaborative activities should be partitioned to target the various communities with special focus aimed at a discipline or a specific type of research topic common to a group of disciplines and each competition should have a separate budget *in order to foster more responsive proposals and higher funding rates.*"

Because of budgetary uncertainties during the initial year of the MSPA (FY 2003), funds were targeted to existing solicitations and collaborative funding of unsolicited proposals. For FY 2004, the MSPA-WG produced an "umbrella" solicitation, *Mathematical Sciences: Innovations at the Interface of the Sciences and Engineering* (NSF 04-538) that described all opportunities, new and ongoing, for the MSPA. The new activities described by this solicitation covered competitions for both FY 2004 and FY 2005, with a revised solicitation (NSF 05-622) issued for FY 2006.

These competitions were conceived with the philosophy that different interdisciplinary interactions might require a diversity of approaches. A serious attempt was made to craft the competitions to (a) avoid receiving huge numbers of proposals resulting in an unacceptably low funding rate and (b) keep the workload of the community (both investigators and reviewers) and the NSF staff at a reasonable level.

The overall funding rate for the seven competitions was around 20% from FY 2004 to FY 2006. There was considerable variation in proposal submission and funding rate by competition, however no competition received more than about 140 proposals.

6. GEO Division of Earth Sciences (EAR)

In 1997 EAR instituted a policy intended to encourage investigators to take the time to significantly revise declined proposals rather than rush to resubmit for the next deadline. EAR has two proposal submission deadlines per year, but requires the PI to skip the next deadline before submitting a revised proposal. This policy was implemented to avoid the hasty revision of proposals in order to meet a deadline which followed very shortly after notification of a declination.

Annual proposal actions decreased by nearly 16% for the four years following the implementation of this policy (an average of 1430 per year between FY 1994 and FY 1997,

compared to an average of 1235 per year between FY 1998 and FY 2001). Program staff reported that the quality of revised proposals was better, and that more thought and care has been taken by the PI in responding to reviewer criticisms and suggestions. EAR PIs initially expressed concern with this policy but they rapidly adjusted to it; those concerns have virtually disappeared.

Dissemination of Information

The charge to IPAMM included the following question: *How can NSF data regarding funding rates, award amounts, and award duration be disseminated more effectively?*

Many proposers to NSF take such 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 Budget Internet Information System (BIIS). Proposers also often take anecdotal data into account, which may or may not be accurate. The research community needs access to official data developed by NSF using standard definitions, to avoid misconceptions about NSF statistics. As Figure 25 shows, respondents in the 2007 NSF Proposer Survey for the most part underestimated the funding rates of the programs to which they had submitted their most recent proposal.

Figure 25
Perceived vs. Actual Funding Rates

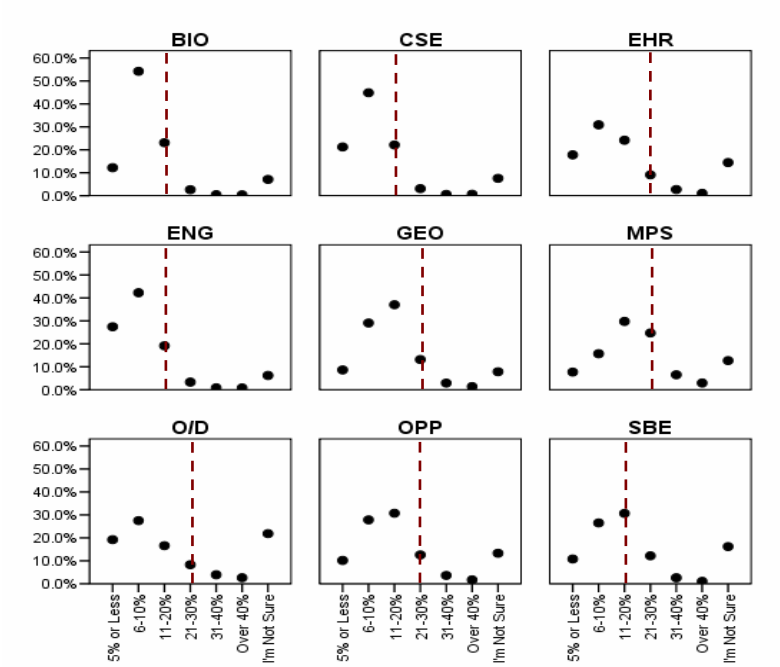


Figure legend. The plots show the responses, sorted by directorate/office, to the 2007 NSF Proposer Survey question "Reflecting on your most recent proposal submitted to NSF, what do you think the success rate was for the program you submitted to?" The funding rate ranges that the respondents could choose are shown on the X axis (5% or less, 6-10%, 11-20%, 21-30%, 31-40%, over 40%, or "I'm Not Sure"), and the percentage of respondents choosing each option is indicated on the Y axis. The dotted red line shows the actual weighted average funding rate for each directorate/office. With the exception of SBE, the majority of respondents for all other directorates/offices underestimated the actual funding rate of the programs reviewing their proposals.

The annual Report to the National Science Board on the NSF's Merit Review Process contains a number of charts and tables showing funding trends. In addition, the BIIS provides interactive access to NSF statistical and funding information. However, both of these resources appear to be underutilized by both the NSF staff and the external research community.

Conclusions

While it is difficult to single out one particular proposal management practice as better than another, there are a number of preferred practices with respect to the *implementation* of these practices. They include the following:

- Because of important contextual factors[42] the decision to use any of the practices described above should be made on a case-by-case basis among the program, division, and/or directorate leadership.

- NSF management should inform the appropriate internal and external communities when implementing new proposal management practices and should monitor the concerns of the communities during the implementation phase.

- In many cases, the use of multiple management strategies may be necessary; integrating these strategies with one another can be effective in achieving the desired outcomes. Changes to these strategies should be based upon annual evaluations of proposal data and feedback from the research community.

- Preliminary proposals can be a useful management tool and save the research community from a burdensome process when there is little chance of success. However, they increase the complexity of the review process (and possibly NSF and reviewer workload). The decision to use preliminary proposals should be made after a careful evaluation of the trade-offs.

[42] Important contextual factors include program staff workload, the budget environment, and the need to preserve the agility and responsiveness of NSF to emerging needs and opportunities.

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."[43] 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

[43] 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.

APPENDICES

APPENDIX A. CHARGE TO IPAMM

DATE: March 22, 2006

TO: NSF ADs

FROM: Deputy Director, NSF

SUBJECT: NSF Working Group on the Impact of Proposal and Award Mechanisms

Introduction: Effective immediately, the Working Group on the Impact of Proposal and Award Management Mechanisms is established to recommend policies and preferred practices within NSF to improve the management of program announcements, solicitations, and unsolicited proposals, particularly with respect to community expectations vs. funds availability, while maintaining the robustness of the scientific and engineering community.

Background: In recent years, many NSF programs have experienced low and declining proposal funding rates, resulting in increased workload, diminished S&E capacity, and program imbalances. A number of NSF organizations have attempted to manage workload and community expectations through variety of approaches, such as restricting the number of program solicitations and solicitation target dates, and limiting the number of proposal submissions. While these attempts are laudable, there are some concerns within the S&E community that such practices may sometimes have unintended consequences for the scientific community or for NSF.

Charge: The Working Group is responsible for recommending policies and preferred practices to improve NSF program announcement and solicitation processes in ways that achieve appropriate balances between proposal funding rates, award sizes and award duration in the various types of awards that comprise the total NSF portfolio, with the emphasis on individual, investigator-initiated grants. In doing so, the group will address the following issues:

- What do the current and historical data indicate in terms of trends and problem areas? Are there unexplained or unanticipated imbalances; for example, between solicited and unsolicited proposals, new and experienced investigators, directorates and major disciplines, and special programs and standard disciplinary programs?

- What have been or would be anticipated to be the impacts of changing funding rates, award amounts, or award durations on NSF and the S&E community? How is the workload and infrastructure affected? What S&E capacity/innovation is being lost or diminished? What is the effect of trade-offs between funding rates, average award size, and award duration? How have perceptions affected NSF's relationship with the S&E community?

- What are the reasons for recent declines in funding rates? Why has the number of proposal submitted to NSF substantially increased over the past few years? Is it possible to determine whether there have been impacts to NSF of budget reductions in the science programs of other Federal agencies?

- What has been the impact of NSF policies, strategies and practices to act on these issues? Have they worked? Are they administered in a reliable and equitable manner? Are there new approaches that should be tried?

- How can NSF data regarding funding rates, award amounts, and award duration be disseminated more effectively? Should NSF establish standards for reporting data to the external community?

Membership: The membership of the working group is as follows:

Adnan Akay, ENG
Paul Herer, O/D, (Exec. Secretary)
Suzi Iacono, CISE
Dan Litynski, EHR
Jacqueline Meszaros, SBE
Jarvis Moyers, GEO
Vernon Ross, BFA
Bill Rundell, MPS
Neil Swanberg, OPP
Rita Teutonico, BIO
Joanne Tornow, EHR/BIO (Chair)

Operation: The Working Group, including representative Program Officers and Division Directors from across the foundation, will meet regularly and establish a liaison with the Office of the Director. It will produce reports and presentations as needed to keep NSF senior staff and the NSB informed of its progress. Within six to twelve months, the working group will produce a final report and/or a series of reports that address the issues described above.

The success of the Working Group depends on the participation and assistance of the NSF staff. Staff members are encouraged to assist the Working Group as opportunity permits.

Kathie L. Olsen

APPENDIX B. TERMS AND ACRONYMS

BIIS	Budget Internet Information System
BIO	Directorate for Biological Sciences
CISE	Directorate for Computer and Information Sciences and Engineering
CHE	Division of Chemistry
Co-PI	Co-Principal Investigator
COV	Committee of Visitors
DEB	Division of Environmental Biology
DMS	Division of Mathematical Sciences
EAR	Division of Earth Sciences
EHR	Directorate for Education and Human Resources
EIS	Enterprise Information System
ENG	Directorate for Engineering
EPSCoR	Experimental Program to Stimulate Competitive Research
FY	Fiscal Year
GEO	Directorate for Geosciences
GPG	Grant Proposal Guide
GPRA	Government Performance and Results Act
HSD	Human and Social Dynamics Program
IGERT	Integrated Graduate Education and Research Training Program
IIS	Division for Information and Intelligent Systems
IPAMM	Impact of Proposal and Award Management Mechanisms working group
ITR	Information Technology Research Program
MCB	Division of Molecular and Cellular Biosciences
MPS	Directorate for Mathematical and Physical Sciences
MSPA	Mathematical Sciences Priority Area
MSPA-WG	Mathematical Sciences Priority Area Working Group
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NIMH	National Institute for Mental Health
NSB	National Science Board
NSF	National Science Foundation
O/D	Office of the Director
OCI	Office of Cyberinfrastructure
OISE	Office of International Science and Engineering
OPP	Office of Polar Programs
PAPPG	Proposal and Award Policies and Procedures Guide
PI	Principal Investigator
PIMS	Program Information Management System
R&D	Research and Development
RI	Research Intensive
R&RA	Research and Related Activities
SBE	Directorate for Social, Behavioral and Economic Sciences
S&E	Science and Engineering
SRS	Science Resources Statistics

APPENDIX C. REGRESSION TABLES: PREDICTING CHANGES IN SUBMISSIONS

Regression Analysis: Changes in proposal submissions as a function of funding rates, award sizes, budget changes, and year (division-level data, unsolicited proposals only)

Variables Entered:

- Dependent variable
  - Change in proposals (ch props)
- Independent variables
  - Percent change in budget (% ch budg)
  - Previous year average award size (prvyrsz)
  - Previous year funding rate (prvyrfundrt)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.367[a]	.134	.035	310.398

a. Predictors: (Constant), FY, % ch budg, prvyrsz, prvyrfundrt

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	523567.089	4	130891.772	1.359	.268[a]
	Residual	3372151.311	35	96347.180		
	Total	3895718.400	39			

a. Predictors: (Constant), FY, % ch budg, prvyrsz, prvyrfundrt
b. Dependent Variable: ch props

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-135066.314	75725.944		-1.784	.083
	Prv yr sz	.000	.000	-.106	-.597	.555
	Prv yr fundrt	-2.585	7.029	-.069	-.368	.715
	% ch budg	-1.096	1.836	-.099	-.597	.554
	FY	67.570	37.772	.306	1.789	.082

a. Dependent Variable: ch props

National Science Foundation
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