

Audit of NSF Practices to Oversee and Manage Its Research Center Programs

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Executive Summary

Background: The National Science Foundation's (NSF) eight research Center programs fund individual research centers in various research fields, such as nanoscale technology, engineering, and the science of learning. The purpose of these Center programs is to exploit opportunities in science, engineering, and technology where the resources needed require advantages available only through an academic research center setting. In Fiscal Year 2006, NSF's 8 Center programs supported 99 individual centers for a total of over \$250 million.

Purpose: The management and oversight provided by NSF is vital to the success of these Center programs. The objective of this audit was to determine if NSF had developed the management and oversight controls necessary to help ensure the success of its Center programs.

Results in Brief: While the National Science Board (Board) and NSF senior management have issued general guidance and principles for Center programs to follow, the eight Center programs have not consistently implemented this guidance. Further, NSF had not incorporated the Board and senior management guidance into its written agency policies and procedures. In addition, NSF lacks a formal mechanism for Center program managers to share information and best practices to enhance their management and oversight of these programs.

Because NSF has not formalized the guidance recommended by the Board and NSF senior management into official NSF policy, it is at risk of having ineffective management and oversight of its Center programs. This may contribute to decreased accountability of the significant federal funds being expended, and may pose a disadvantage to the Center programs and the centers themselves in terms of achieving goals.

Recommendations: In order for NSF to mitigate these risks and effectively enhance stewardship of its Center programs, we recommend that NSF issue a written policy that includes the Board and senior management's guidance and principles for Center programs. In addition, we recommend that NSF establish a permanent forum for the Center programs at which management and other practices can be shared among all Center programs.

Agency Response: NSF generally agreed with our findings and agreed with our recommendation to reinstitute a forum through which Center program managers can identify and exchange promising practices as well as discuss common issues. However, NSF did not agree with our recommendation to develop and implement written policies and procedures that formally incorporate the Board and NSF senior management guidance on Center programs. NSF expressed concern that these policies would be inflexible and stifle the development of other innovative management and oversight practices. In response to NSF's comments, we have modified our recommendation to clarify that we do not intend for NSF to issue a prescriptive policy.

Introduction

The National Science Foundation (NSF) supports basic research in a number of fields, including mathematics, computer sciences, and the social sciences. While NSF typically funds research through three-year grants to individuals or small groups of investigators whose research proposals have been selected using NSF's merit review process, NSF also provides funding for large endeavors, including research centers and facilities.

NSF currently supports eight research Center programs that fund individual centers in a variety of research fields, including nanoscale technology, engineering, and the science of learning.¹ These Center programs, based in the various NSF directorates, are designed to exploit opportunities in science, engineering, and technology in which the complexity of the research problem, or the resources needed to solve the problem, require advantages that can only be provided by an academic research center, including equipment, facilities, and students. The Center programs select individual centers for funding using NSF's competitive, merit review process.

In Fiscal Year (FY) 2006, NSF's 8 Center programs funded 99 individual centers for a total of over \$250 million. The funding levels and number of centers funded by each of the eight Center programs are as diverse as the research areas they address. For example, the Biological Sciences Directorate's Centers for Analysis and Synthesis program funds 2 centers for a total of \$6.4 million annually, while the Mathematical and Physical Sciences Directorate's Materials Research Science and Engineering Centers program funds 29 centers for a total of \$53.5 million annually. A description of each of NSF's Center programs can be found in Appendix II.

As shown in the following table, NSF's funding for these eight Center programs represents a substantial investment. In FY 2006, NSF's funding for Center programs represented about 4.4 percent of the agency's total budget and about 6 percent of the Research and Related Activities appropriations account. Over time, NSF has

¹ The eight research center programs are classified in NSF's budget as Center programs. There are other programs funded by NSF that include the word "center" in the program name, such as Federally Funded Research and Development Centers and Industry/University Cooperative Research Centers. Because NSF does not classify these programs in its budget as Centers, we did not include them in the scope of our work.

spent more than \$2.8 billion for these eight research Center programs.

Table One: Information on NSF's Center Programs

Center Program (Cognizant Directorate)	Year Program Started	Number of Current Centers	Average Age of Current Centers	FY 2006 Dollars Spent (millions)	Total Funding Since Inception (millions)
Centers for Analysis and Synthesis (Biological Sciences)	1995	2	6.6	6.4	36.5
Chemical Bonding Centers ¹ (Mathematical and Physical Sciences – MPS)	2004	6	1.6	2.7	4.3
Earthquake Engineering Research Centers (Engineering – ENG)	1986	3	9.0	6.0	106.2
Engineering Research Centers (ENG)	1985	19	5.0	60.2	1,060.6
Materials Research Science and Engineering Centers (MPS)	1994	29	8.9	53.5	602.8
Nanoscale Science and Engineering Centers (Multi-directorate, ENG lead)	2001	17	3.0	40.0	143.7
Science and Technology Centers (Multi-directorate, Office of Integrative Activities lead)	1988	17	3.7	62.6	794.0
Science of Learning Centers (Multi-directorate, Social, Behavioral, and Economics lead)	2003	6	1.0	20.7	80.3
TOTAL		99		252.1	2,828.4

¹Note: The Chemical Bonding Centers program, begun in 2004, made six awards during its initial Phase I competition. In 2006, the program invited three successful Phase I projects to apply for Phase II full-scale center. To date the program has made one Phase II award.

Centers programs are a principal means by which NSF fosters interdisciplinary research and education. As such, they play an important role in helping NSF achieve its mission and vision to promote and advance science and engineering.

Objectives, Scope, and Methodology

The objective of this audit was to determine if NSF has developed management and oversight controls to help ensure the success of its Center programs. In making this determination, we reviewed the eight NSF Center programs in existence during FY 2006.

We researched and reviewed relevant Federal laws and regulations, NSF policies and procedures, prior Office of Inspector

General reports and other pertinent studies addressing management of large center-type research operations.

We developed criteria for what constitutes strong management and oversight of Center programs based on guidance from the National Science Board and NSF's Senior Management Integration Group.² To provide context for the application of these broad criteria in a federal agency, we relied on the Government Accountability Office's *Standards for Internal Control in the Federal Government*,³ which provides an overall framework for establishing and maintaining internal controls and for identifying and addressing performance and management challenges. These internal controls help government agencies to achieve desired program results and ensure the effective stewardship of public funds. To confirm the validity of the criteria, we obtained feedback from NSF program officials. A list of these criteria can be found in Appendix III.

To assess whether NSF Center programs incorporated these criteria into their program activities, we met with appropriate NSF officials to obtain an understanding of each of the Center programs. We reviewed systemic, program-wide documents, such as program solicitations and program terms and conditions that apply to a set of awards made under a given solicitation. In addition, we selected a small judgmental sample of individual awards from each of the eight Center programs, and reviewed relevant documents including the cooperative agreements and site review reports. We did not, however, perform a detailed review of every center funded by each of the NSF Center programs.

We conducted our audit in accordance with generally accepted government auditing standards between September 2006 and July 2007.

² The Senior Management Integration Group, an advisory group composed of agency senior managers, including the Assistant Directors of each directorate, is now referred to as the Senior Management Round Table.

³ U.S. General Accounting Office (now the U.S. Government Accountability Office), *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1, November 1999.

Results of Audit

The National Science Board and NSF senior management have issued general guidance and principles for Center programs that provide a framework to ensure effective management, oversight, and accountability for NSF's eight Center programs. However, not all Center programs have consistently followed this guidance nor has NSF incorporated the guidance into its written agency policies and procedures. As a result, the lack of official guidance for program officials places NSF at risk of not having effective management and oversight practices to ensure the goals of the Center programs are met and to provide accountability for the significant federal funds supporting these programs.

NSF can mitigate these risks and enhance its stewardship of these programs by issuing written policies for the management and oversight of Center programs. In addition, NSF should permanently establish a forum for sharing best management and other practices among the Center programs.

The National Science Board and NSF Senior Management Have Developed Guidelines for Centers

The National Science Board (Board) and NSF have a long-standing commitment to fund Center programs. This mode of funding facilitates scientific research on a scale larger than that which could be accomplished through the traditional NSF programs which fund the research of a single or a small group of investigators. In 1988, the Board formally described a research center, and recognized the value of conducting large-scale scientific research at centers as a means of addressing the growing complexity, cost, and organization of modern research.⁴

The Board augmented its support for center programs with guidance issued in December 2005.⁵ In this guidance, the Board defined four principles that serve as the basis for Center programs. The first principle addressed the issue of portfolio balance. The Board stated that the range of NSF's support for Center programs should be between four and six percent of NSF's overall budget, and between six and eight percent of NSF's Research and Related

⁴ NSB-88-31, February 11-12, 1988.

⁵ NSB-05-166, December 1, 2005.

Activities appropriations account. This account is the primary source of funding for most of NSF's scientific and engineering research activities.

In its second principle, the Board directed NSF to periodically review its investment in Center programs to ensure that no individual center has evolved into activities that could best be done by a single or small group of investigators. It also stated that the Board itself should regularly review Center programs, and centers should not be created and supported without considerable justification by NSF.

In its third principle, the Board reaffirmed its commitment that awards should be re-competed unless it is judged to be in the best interest of U.S. science and engineering not to do so. The Board further stated that continued funding for Center programs should be determined through open, merit-based competition. It also suggested that NSF establish guidelines for the review and renewal of individual centers, including the phase-down of support for centers that are not renewed.

Finally, the Board directed NSF Center programs to implement proven management practices. The Board endorsed the implementation of these practices, including strategic planning, the use of strong cooperative agreements, and the commitment of ample resources for management at the individual centers and within NSF.

Prior to the Board issuing this additional guidance on Center programs, the NSF Director presented a document on principles of centers to a joint session of the Board's Committee on Program and Plans and the Committee on Strategy and Budget held in August 2005. This document, entitled "Principles of National Science Foundation Research Centers," was developed by NSF's Senior Management Integration Group to clarify NSF's concept of the centers mode of support. The document outlined NSF senior management's vision for Center programs, and specified critical elements for them. These elements were based on NSF's Strategic Plan and multiple NSF strategies to facilitate knowledge creation, integration, and transfer.

The critical elements for individual centers include conducting bold and transformative research at the frontiers of knowledge; broadening participation from a diverse set of partner institutions and individuals; and focusing on integrative learning and discovery at all levels, from students to the general public. In addition,

individual centers should maintain organizational linkages between the lead institutions and other schools and sectors (public, private and international). The senior management guidance suggested NSF provide support to individual centers on the order of \$2-5 million annually for a maximum of 10 years. The Center programs should also include a phase-down period whereby NSF funding to an individual center is reduced during the last years of the award period.

When considered collectively, these Board and NSF principles set expectations and policies for Center programs and the individual centers they fund. We grouped these principles into four broad areas:

- Center research and education characteristics;
- Individual center management practices;
- NSF's oversight activities; and
- NSF funding levels and duration of center support.

Appendix III contains details on the principles and practices that comprise each of these areas.

NSF's Implementation of Board and Senior Management Guidance Has Been Inconsistent

The Board and NSF senior management outlined principles and practices that, when implemented, provide the NSF Center program staff with a framework for managing and overseeing each of the Center programs funded by NSF. These principles and practices also help to minimize the financial and management risks inherent in these large-scale, long-term endeavors.

In comparing each NSF Center program with these principles and practices, we found that all of these programs require that each individual center they fund include activities that address the research and education characteristics outlined by the Board and NSF senior management. However, managers of the eight Center programs have not consistently implemented the Board and senior management guidance addressing other management and oversight practices.⁶

⁶ See Appendix IV for an analysis comparing each of the eight Center programs with the Board and senior management principles.

All of NSF's Center Programs Incorporate Research and Education Characteristics into Their Programs

The Board and NSF senior management principles outlined the research and education characteristics that help define a project as being a center. These characteristics include conducting innovative research that is beyond the abilities of a single or small group of researchers, broadening participation of underrepresented groups, incorporating educational components into the work of the center, and establishing organizational linkages with other institutions and public and private organizations.

All of the Center programs require individual centers to address these characteristics. By requiring individual centers to include these research and education components in their operations, staff for NSF's Center programs are taking an important step in ensuring that the most appropriate research endeavors are funded. The most recent solicitations for all eight Center programs outlined and defined these components. Furthermore, during the merit review process, panels of expert reviewers assessed proposals for centers using many of these criteria.

Not All NSF Center Programs Incorporate Requirements for Management and Oversight Practices at Individual Centers

Strong management and oversight practices at the individual centers funded by NSF's eight Center programs should include a variety of activities. While all of the NSF Center programs require individual centers to outline a management plan or positions and to have an external advisory board, not all NSF Center program staff have included requirements for such basic management activities as strategic planning and performance reporting activities at the individual centers their Center programs fund.

For individual centers, ***strategic planning*** is a management practice of particular importance because it communicates a center's goals for its research program, elicits feedback to promote coordination among the various components that comprise the center, and helps ensure that those involved in an individual center have a common understanding of the vision and mission for an integrated, comprehensive center. Directors of some of the Center programs noted the various benefits that strategic planning provides, and strategic planning is also one of the management

strategies explicitly noted by the Board in its guidance on Center programs.

We found that six NSF Center programs require individual centers to develop strategic plans for their center activities and operations. However, two Center programs, the Chemical Bonding Centers (CBC) and the Materials Research Science and Engineering Centers (MRSEC), do not. In FY 2006, these two programs, which are part of NSF's Mathematical and Physical Sciences Directorate, collectively funded 35 individual centers for a total of \$55 million, or 22 percent of NSF's Center funding for the year.

For the CBC program, its director noted that developing a strategic plan was suggested but not required by NSF. For the MRSEC program, its director noted that this program does not require formal strategic planning because a center's original proposal outlines its plan, and a center's annual report contains information about the planned work for the next year. The program director further explained that this approach permits the centers to re-invent themselves as needed and to focus on productivity.

By not requiring a strategic plan, both of these programs may not be capitalizing on the benefits of strategic planning noted by other Center programs. For example, a strategic plan can provide a blueprint for how an individual center will eventually operate without NSF funds. This could benefit the MRSEC program by making clear to a center that it should not expect indefinite funding. Currently, the average age of an individual MRSEC center is 9 years, and 17 of the 29 centers (59 percent) have received or will receive MRSEC funding beyond the 10 years maximum recommended by NSF senior management.

Collecting and reporting on performance data is another effective management and oversight tool that can help ensure the success of Center programs. Performance data, and the accompanying performance measures, provide NSF and the individual centers with the information they need to assess the progress and achievement of the program as well as identify areas for improvement.

Six of the eight NSF Center programs require the individual centers they fund to collect and report performance data. However, two center programs, the Centers for Analysis and Synthesis (CAS) and the CBC programs, do not. In FY 2006, the CAS program funded 2 centers for a total of \$6.40 million, and plans to fund a new center

for up to \$10 million annually. In the same year the CBC program funded 6 center awards for a total of \$2.7 million.

The CAS program director explained that it is a challenge to develop adequate quantitative, statistical assessment tools that can be applied across centers and it is difficult to extract data from the annual report for analysis and comparative purposes. Yet even with this challenge, the program director is considering how to develop a more uniform reporting format that could be applied across all three centers. Similarly, the CBC program director explained that the program still needs to identify what performance measures and data they should collect and then determine how to collect and compile the data.

Not All NSF Center Programs Have Implemented Principles for NSF Oversight

The staffs of NSF's eight Center programs have a variety of oversight practices available to help ensure the success of their programs. These practices include the merit review of proposals, annual site reviews, critical site reviews to determine if funding will be continued, the collection of performance data, and reviews by Committees of Visitors and other external evaluators. However, of all these practices, the merit review of proposals is the only one adopted by the staff of all Center programs.

Annual site visits by NSF staff to the individual centers are one important step to help ensure accountability and oversight of a center's activities. Some NSF Center program staff noted that annual site visits provide a means to obtain timely information about the management, operations, and performance of individual centers, and are particularly useful in helping to identify individual centers that are not performing as planned or expected. The information collected during annual site visits not only provides an assessment of current conditions, but allows for timely corrective actions to be taken. The information also provides a benchmark for future reviews to determine if the center is continuing to perform as expected, whether necessary improvements are being implemented, or, in extreme situations, if NSF should withhold or terminate funding.

Six of the eight NSF Center programs perform annual site reviews of the individual centers they fund; the MRSEC and CBC programs do not. The MRSEC program staff instead waits until the third year of the award, half way through the award period, to conduct such

visits. According to the MRSEC program director, the program officers review annual reports submitted by the centers and meet with all of the center directors twice a year, either at NSF or at a MRSEC facility. However, more frequent on-site reviews at each center could provide the MRSEC program with the means to observe and document the actual conditions at the center and verify the information that the center provided in reports and off-site meetings.

The CBC program staff stated that they plan to conduct an on-site review during the first year of a center's operation and an external site review during the second year. However, these plans were not conveyed in the program solicitation or the cooperative agreement, which are two significant ways of communicating these important oversight activities to the individual centers.

In addition, the CBC program is the only Center program where staff has not outlined or communicated plans for **critical reviews** of its new centers. According to the CBC program director, the program is developing an oversight plan which will include a critical review of a center's operations. However, these expectations should be articulated at the onset of the program to help convey the fact that the renewal of funding for a center will be merit-based rather than automatic.

Another means of providing external feedback to a Center program is through a **review conducted by a Committee of Visitors** (COV). A COV review, conducted by independent external experts, provides NSF program managers with an objective assessment of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions. This includes addressing the integrity and efficiency of the processes used by NSF to solicit, review, recommend, and document proposal decisions and actions. A COV review also comments on how the research results have contributed to the attainment of NSF's mission and strategic outcome goals. NSF policy requires that a COV review be conducted every 3 years.

Seven of the eight NSF Center programs have held a COV review or are scheduled to hold their first one. However, the Science and Technology Centers (STC) program, which began in 1987, has never held a COV review. In FY 2006, the STC program funded 17 centers for approximately \$63 million, or 25 percent of NSF's total Center program funds. According to the STC program director, this program is a multi-directorate program whereby the proposal review process is solely managed by the Office of Integrative

Activities (OIA). After the STC awards are made, primary responsibility for the oversight of the individual center award rests with a given division within one of NSF's scientific directorates. As such, these individual STC awards are included in the division's research awards portfolio that will be examined by a COV for that division.

However, part of the COV review includes examining the process used to make the awards, which for the STC program is managed by OIA. Because OIA is not organizationally a part of any of the scientific directorates within NSF, its initial administration of the STC award process falls outside the purview of any other COV review. As a result, the STC program is missing an opportunity for external assessments to validate or improve the STC award process. Furthermore, COV reviews are performed for other multi-directorate Center programs. For example, the Nanoscale Science and Engineering Centers program, whose individual center awards are managed in various directorates, held a COV review in 2006. The other multi-directorate program, the Science of Learning Centers, began in 2003 and is scheduled to hold its first COV review in 2008.

Finally, **external evaluations** of the NSF Center programs provide important information to NSF and other stakeholders beyond that provided through the COV process. COV reviews examine the program operations related to the award decision-making process and consider how the portfolio of individual projects has contributed to NSF's mission and goals. External evaluations can assess the longer-term performance, outcomes, and impacts of a given program. Such evaluations should ideally be planned for and implemented at the start of a program so as to capture baseline and annual data, and to identify and address issues affecting the program and its outcomes.

While five of the eight NSF Center programs have had external evaluations conducted of their programs, the CAS, CBC, and Earthquake Engineering Research Center (EERC) programs have not. According to the CAS program director, the combination of site visits, COV reviews, and community involvement provides sufficient feedback for the program. The CAS program plans, however, to ask the next center it funds to include assessment procedures in its activities. The CBC program director indicated that they are planning for an evaluation but have not yet taken steps to implement this plan. The EERC program director noted that, pending availability of funding, NSF is considering conducting a summative assessment of the impact of the three EERCs.

Not All NSF Center Programs have Adopted Recommended Funding Levels and Award Durations of NSF Support

In their principles and guidance for Center programs, the Board and NSF senior management also addressed NSF's support for individual centers by recommending funding levels and award durations. This included NSF funding individual centers in the range of \$2–5 million annually and NSF not providing funding for an individual center for more than 10 years.

However, 2 of the 8 NSF Center programs have not incorporated the funding range of \$2–5 million annually into their practices. In the MRSEC program, 18 of the 29 current awards are for \$2 million or less annually, while at the other extreme, one CAS center is scheduled to be funded for up to \$10 million annually. By funding individual centers outside of the \$2–5 million range annually, these programs may be supporting activities that would be more appropriately funded by other NSF programs that are intended for small investigator awards or, alternatively, for large facilities or other unique research endeavors.

In addition to the recommended range of funding for individual centers, the NSF senior management also noted that funding for an individual center should not continue for more than 10 years, with the expectation that NSF funding will be phased down in the last few years of the award. This principle of limiting NSF support helps mitigate a variety of risks that would undercut the concept of using Center programs to fund research. These risks include funding that continues indefinitely; projects evolving into work that is more appropriately funded by awards to single investigators or small groups of investigators; and having adequate funding available for other new and innovative center projects. The 10-year limit can also spur existing centers to evaluate their future, pursue other sources of funding, and consider other new research opportunities and initiatives in anticipation of NSF's termination of center funding.

Although 6 of the 8 NSF Center programs have followed senior management funding duration guidelines, the MRSEC and CAS programs have not. Of the 29 current MRSEC centers, 17 have already received or will receive NSF funding for more than 10 years and, under the terms of their current cooperative agreements, may receive NSF funding for between 14 and 16 years. In the CAS program, one center recently received an \$18 million award that extends its cooperative agreement to 16 years.

NSF Needs to Clearly Communicate Expectations for Center Programs to Adopt Board and Senior Management Principles and Practices

NSF's eight Center programs cover a wide range of scientific disciplines and primarily reside organizationally in the directorate and program area that is most appropriate for the research being conducted. Because of the decentralized management of the Center programs within NSF, it is imperative that the agency establish, and communicate to its directorates, offices, and staff, an overall policy of how the Center programs will adopt and implement the Board and senior management principles for management and oversight.

However, NSF has not incorporated these principles and guidance into written policy and procedures to be followed by each of its Center programs. As a result, the eight Center programs have not consistently adopted these principles, leading to differences among the Center programs in important areas such as strategic planning, reporting requirements, funding levels, and duration of NSF support.

A written policy and procedures would clarify NSF's basic expectations of how the Center programs will incorporate the Board and senior management principles and provide for management and oversight procedures to ensure their implementation. A clear policy would provide broader guidelines for those instances when different management approaches may be needed to carry out the varying nature and types of research. Such a policy could also document successful management and oversight practices that have been identified in the 20-plus years that NSF has funded Center programs.

In addition, a written policy and procedures for Center programs would help ensure that the Board's and NSF's management directives are carried out and that the Center programs best support the agency's mission. Such documentation would also provide a framework for the effective stewardship of the significant financial investment NSF has in these programs.

Finally, a written policy and procedures would allow NSF to review all Center programs using a consistent set of baseline criteria. By applying these criteria to each program, NSF could decide whether

changes should be made to a Center program in order to meet the criteria, or if funding for the program should be reclassified in NSF's budget and management structure.

A Formal Mechanism for Sharing Information Across Center Programs Could Enhance Center Management and Oversight

In addition to lacking a written agency-wide policy for Center programs, NSF currently has no formal mechanism for sharing information and experiences across the Center programs. Such a means for communication would allow for the exchange of information across Center programs to better plan, coordinate and manage activities to achieve program and agency objectives. This communication would also help facilitate management oversight and improve accountability of center awards.

NSF has taken a decentralized approach to managing Center programs, delegating oversight responsibility for individual Center programs to staff in the cognizant directorate. Nevertheless, NSF, through the Office of Integrative Activities, organized a series of forums in 2003 and 2004 for effective center practices in which lessons learned in managing all types of Center programs and other large groups were shared by NSF attendees.

These forums have not been held recently because of a perception that there are a limited number of topics to cover. However, there is still a demand for this method of sharing information. Individual NSF managers of Center programs that we interviewed stated that it would be useful to them to continue to have such forums periodically because sharing experiences across programs can lead to more successful oversight and overall programs. For example, many NSF Center program directors spoke about the challenges of not having ample staff, funding, and/or time for managing their program and centers effectively, and each NSF program director utilized different strategies to try to overcome these challenges. With group meetings, these NSF program directors would have an efficient means for sharing practices that could be applied or modified for each Center program. The Center programs may fund very different types of research, but their need for effective management and oversight practices are the same.

Conclusion

NSF's Center programs are a principal means of fostering interdisciplinary research and provide a mechanism for conducting large-scale research while incorporating educational goals and encouraging partnerships with multiple organizations. This method of funding, however, poses inherent risks that NSF must address because of the large amount of taxpayer dollars used to fund the work, the decentralized management of the Center programs, and the need to rely on strong management practices at each of the individual centers funded by the programs.

Guidance on Center programs issued by the Board and NSF senior management in 2005 outline principles and practices that can help address these risks. These include implementing proven management principles, such as strategic planning, and having uniform and explicit procedures that address the review, renewal, and phase-down of individual centers.

However, not all directorates have incorporated these principles into their own Center programs because of the lack of a written agency-wide policy and procedures for Center programs. As a result, the Center programs have inconsistently adopted Board and senior management principles. Implementing a policy for Center programs could help NSF staff control for the programmatic, administrative, and fiscal risks inherent in its eight Center programs; provide a framework for NSF staff to develop strong program requirements; and provide strong oversight to the programs. Such a policy would also assist in the effective stewardship and accountability of the significant financial investment NSF has and continues to make in these programs. These actions, in turn, can provide a structure that helps NSF in ensuring the success of its Center programs.

Finally, a permanent forum within NSF for discussing issues related to Center programs and individual centers would greatly benefit NSF staff charged with managing these programs. Without such a forum, NSF loses the opportunity to leverage resources, share best practices, and address common problems in managing programs that are very similar in mission.

Recommendations

The Board and NSF have made a commitment to using research centers as a mode of funding research on the frontiers of science and engineering. While many of NSF's eight Center programs have independently developed management and oversight controls to help ensure their success, NSF should strengthen its management and oversight policies and practices across the programs to help facilitate their success and ensure accountability for this significant commitment of taxpayer dollars. Therefore, we recommend that the Director, NSF:

1. Develop and issue a written policy for Center programs that includes the Board guidance and senior management principles, and explains NSF's expectations of how these are to be used by Center programs.
2. Reinstitute the centers working group to share learning experiences, address joint issues, and document promising practices that would help to ensure the success of individual centers and the Center programs.

Agency Response and OIG Comments

NSF generally agreed with our findings and agreed with our recommendation to reinstitute a forum through which Center program managers can identify and exchange promising practices as well as discuss common issues. However, NSF did not agree with our recommendation to develop and implement written policies and procedures that formally incorporate the Board and NSF senior management guidance on Center programs. According to NSF, incorporating this guidance into written policies would, in effect, transform the guidance into requirements that all Centers must follow. NSF contends that each of the Center programs has different goals and different characteristics and therefore may need different management practices. Flexibility may be stifled by requiring that all Center programs "adopt and incorporate" this guidance. Appendix I contains the agency's response in full.

We agree with NSF that each of its eight Center programs is different and unique. However, we do not believe that documenting and formalizing existing principles and guidance into written policy would transform such guidance into "requirements." Further, this

guidance need not stifle experimentation and innovation in the management and oversight of Center programs. Rather, written policy and procedures communicate broad performance expectations. They are intended to provide a framework and a baseline from which NSF Center program managers can innovate and experiment with differing and evolving management and oversight practices for carrying out program operations.

NSF, in this policy document, can clearly make known that the principles are not prescriptive and that it does expect variations among the Center programs in how and the extent to which each of these programs brings the Board's and senior management's guidance and principles to life. We believe it is important that NSF communicate to its Centers staff and management at individual centers its intentions for how these principles and guidance should be used and implemented. We further believe that written policy and procedures can be especially helpful to new Center programs as they manage new challenges. Finally, we believe that Center programs should document reasons for variations from the guidance and should share this information with other Center programs that may be facing similar issues.

Therefore, to clarify that we do not intend for NSF to issue a prescriptive policy, we have modified our recommendation to reflect that that NSF should develop and implement a written policy that includes the principles and guidance set forth by the Board and NSF senior management and explains NSF's expectations of how these are to be used by Center programs in carrying out their operations.

In addition to commenting on the audit report recommendations, NSF also provided the comments regarding information contained in Appendix IV of the report, which contains a comparison of the eight Center programs with Board and senior management principles and practices. The following is a summary of NSF's comments and the OIG response to these comments.

Centers for Analysis and Synthesis (CAS):

Summary of NSF comments: This program consists of two centers that were created approximately a decade apart at the urging of the research community, and these centers are managed as individual centers rather than a Center program.

OIG response: Whether these centers are managed individually or as a Center program, the management and oversight practices should be similar. Therefore, we have not altered our findings as reported.

Chemical Bonding Centers (CBC):

Summary of NSF comments: The characteristics for which the program received “No” in Appendix IV have now been incorporated in the program or are under consideration.

OIG response: At the time of our audit, the CBC program managers had not yet implemented their proposed actions. We noted this on pages 9 and 10 of our report, and we commend the CBC program for moving ahead with these actions.

Materials Research Science and Engineering Centers (MRSEC):

Summary of NSF comments: Centers may differ in character, and while NSF has identified the MRSEC program as a Center program, the size and duration of awards made by this program, along with other management and oversight tools, do differ from other Center programs.

OIG response: We concur that Center programs may differ in character. However, when a program such as MRSECs differs so significantly from the principles and guidance for Center programs set forth by the Board and senior management, it is appropriate to consider whether MRSECs should continue to be classified as a Center program for budget and management purposes.

Science and Technology Centers (STC):

Summary of NSF comments: This program has not had a Committee of Visitors (COV) review but has been evaluated in numerous other ways.

OIG response: We note on page 27 of the report that this program has had external evaluations. We recognize the unique challenges presented when responsibility for the management and oversight of individual centers is separate from the management of the overall program. Nevertheless, we maintain that the program can benefit from regular COV reviews, particularly for activities such as the proposal review process managed within NSF’s Office of Integrative Activities.

Nanoscale Science and Engineering Centers (NSEC):

Summary of NSF comments: Issues of re-competition of center awards and conditions for center phase-out are under consideration.

OIG response: At the time of our audit work, program managers were considering these issues but had not yet implemented their proposed actions. We commend the program for moving ahead with these plans.

Appendix I: Agency Response

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230



OFFICE OF THE
DIRECTOR

MEMORANDUM

DATE: November 2, 2007

TO: Deborah H. Cureton
Associate Inspector General for Audit

FROM: Kathie L. Olsen, Deputy Director *KLO*
National Science Foundation

RE: NSF Comments on the OIG Draft Report: Audit of NSF Practices to
Oversee and Manage Its Research Center Programs

NSF is committed to providing effective oversight and management of its Center programs and the Centers supported through these programs. The OIG report "Audit of NSF Practices to Oversee and Manage Its Research Centers Programs" provides a comprehensive overview of these NSF practices. NSF appreciates the thoroughness of the OIG in gathering information for this report by reviewing NSF documents and interviewing NSF staff. NSF also appreciates the opportunity to comment on the draft.

This response is divided into two sections: I) Comment on the Audit Report Recommendations; and II) Comment on the Summary of Practices across Center Programs.

I. Comment on the Audit Report Recommendations

NSF agrees with the recommendation that NSF reinstitute a forum through which Center program managers can identify and exchange promising practices, as well as discuss common issues. NSF also agrees that it is important that NSF staff involved with Center programs be fully aware of the two documents referenced in the Audit Report; that is, *Principles of National Science Foundation Research Centers* (Senior Management Integration Group, 2005) and *National Science Board Guidance for National Science Foundation Centers Programs* (NSB 05-166).

However, NSF does not agree with the Report recommendation to develop a written policy, with procedures for its implementation, which would in effect transform the Board guidance and senior management principles into requirements for each Center program. It is NSF's position that the above two documents are intended to provide guidance for Center management, but not intended to specify practices that all Center programs must adopt. Each of the NSF Center programs has different goals and different characteristics. This may result in the need for different management practices from one Center program to another.

Furthermore, NSF wishes to promote experimentation and innovation in the management and oversight of its Center programs. In fact, through this experimentation, current practices have evolved. NSF wishes to keep open the possibility of discovering more effective management practices, but this experimentation may be stifled by requiring that all Center programs "adopt and incorporate" principles as recommended in the Audit Report.

II. Comment on Summary of NSF Practices across Center Programs

The Audit Report provides descriptive text of the practices used in the NSF center programs, with this information summarized in the Appendix IV Table: *Comparison of Eight Center Programs with Board and Senior Management Principles and Practices*. NSF considers the text as providing a more accurate portrayal of the situation than does this table.

Centers for Analysis and Synthesis (CAS). CAS consists of two centers (NCEAS and NESCent) that were created approximately a decade apart at the urging of the research community. NCEAS has been assessed every three years as part of a COV, had external site visit reviews conducted annually, major evaluations every three years, and two reviews conducted in the eleventh year of the project. NESCent is beginning its third year and has undergone annual site visit reviews. As indicated in the Audit Report, a third center is expected to be funded by the Biological Science Directorate. In summary, these centers are managed as individual centers rather than as a center program, as suggested in Appendix IV.

Chemical Bonding Centers (CBS). As noted in the Audit Report, the CBS Program was being developed while this review was conducted. The areas identified as "N" in the table have now been incorporated in the Program or are under consideration.

Materials Research Science and Engineering Centers (MRSEC). As stated in the NSB Report 05-166, "NSB recognized that the NSF's funding modes are not discrete, but rather form a continuous spectrum of activities." Consequently, it is expected that Centers may differ in character depending on where they are along this "continuous spectrum of activities." NSF has identified the MRSEC as a Center program, although the MRSEC program has goals and characteristics that distinguish it from other Center programs. For these reasons, MRSEC have different budget and duration conditions than other Center programs. MRSEC also uses a different mechanism for annual project

reviews than site visit reviews; and, although MRSEC projects conduct strategic planning, projects are not required to produce a strategic plan document.

Science and Technology Centers (STC). As noted in the Audit Report, the STC program does not have a COV evaluation. However, the STC program is evaluated in several other ways. Each directorate Advisory Committee reviews the Centers managed through that directorate. The management of the STC program was reviewed by National Academy of Public Administration. The National Academies of Sciences conducted a review of the program, an STC Advisory Committee conducted a review of the program, and an external review of the program is underway. The evaluation materials from these reviews are provided to NSB and inform NSF management.

Nanoscale Science and Engineering Centers (NSEC). Issues of re-competition of center awards and conditions for center phase-out have, in fact, been under consideration by NSF for NSEC. The NSF-Wide Nanoscale Science and Engineering Working Group is now developing a policy similar to that used in the Engineering Research Center program.

Appendix II: Description of Each Center Program

In fiscal year 2006 NSF supported eight research Center programs. These programs funded a total of 99 individual centers, in a variety of research fields, for a total of over \$250 million.

The two **Centers for Analysis and Synthesis** are designed to develop new tools and standards for managing biological information. The National Center for Ecological Analysis and Synthesis promotes integrative studies of complex ecological questions and serves as a locus for the synthesis of large data sets. The National Evolutionary Synthesis Center is working to foster a greater conceptual synthesis in biological evolution by bringing together researchers and educators, extant data, and information technology resources.

The six **Chemical Bonding Centers** are designed to support major, long-term "big questions" in basic chemical research. These questions include the activation of strong bonds as a means to decrease energy requirements in chemical processing, the design of self-replicating biological molecules, and the synthesis of "smart materials."

Three **Earthquake Engineering Research Centers** focus on reducing earthquake losses, integrating research and education, and developing partnerships with industry and public agencies responsible for earthquake hazard mitigation. NSF concluded this program in FY 2006.

Nineteen **Engineering Research Centers** focus on innovation by bridging academia's intellectual curiosity with the real-world applications of industry-focused research. The centers educate a technology-enabled workforce with hands-on, real world experience. They create an environment that catalyzes the development of marketable technologies to generate wealth and to address engineering grand challenges. Examples of areas addressed by these centers include biomedical healthcare innovations and multimedia information systems.

Twenty-nine **Materials Research Science and Engineering Centers** support interdisciplinary, cutting-edge research in polymers, structural materials, organic systems and colloids, and other areas. The research at these centers has potential technological impact to computers and communications, transportation, energy storage, structural engineering, and health and medicine.

Seventeen **Nanoscale Science and Engineering Centers** address science and engineering at the atomic, molecular and supramolecular levels. Research and education at these centers attempt to advance basic understanding of specific

phenomena and novel concepts for processing at the nanoscale. The long-term goal is a foundation for the ultra-small technology exploiting nanoscale behavior that will transform electronics, materials, medicine, environmental science and many other fields.

Seventeen **Science and Technology Centers** advance discovery and innovation in a diverse array of science and engineering disciplines. Focus areas for these centers include cyber-security, materials and technologies for monitoring water resources and water quality, medical devices, and modeling and simulation of complex earth environments for improving their sustainability and weather/climate prediction.

The six **Science of Learning Centers** represent a synergistic research effort to address questions central to understanding learning and its societal implications. Examples of research topics include the influence of interplay between informal and formal environments on learning processes, modeling and experimental studies of brain and behavior toward learning, and the processes involved in learning visual languages and their applications for language processing.

Appendix III: National Science Board and Senior Management Principles for Center Programs

In 2005, the National Science Board and NSF senior management issued general guidance and principles for Center programs that provide a framework to ensure for the management, oversight, and accountability for NSF's eight Center programs. The Board and senior management principles, when examined together, address four broad areas that provide guidance and expectations regarding management practices at individual centers, NSF's own oversight activities of its Center programs, funding levels and duration of NSF support, and research and education characteristics of individual centers. These practices can help mitigate management and performance risks associated with these large investments. The following is a summary for each of these areas.

1. Management practices at the individual centers should include:⁷
 - Strategic planning,
 - Specified management positions or management plans,
 - An external advisory board providing feedback to an individual center, and
 - Collecting and reporting of performance data.

2. NSF own oversight practices for individual centers and the related Center program should include:
 - Reviewing center proposals for merit, including criteria of the added value of supporting frontier research using the center mode of support,
 - Conducting annual site reviews of the individual centers to ensure that the centers are proceeding towards their goals and objectives as set forth in their cooperative agreements, and are meeting the more general requirements of the research center program,
 - Performing critical reviews of individual centers as part of the process to determine if funding will be continued for the project,
 - Requiring that centers report on performance data, and
 - Conducting Committee of Visitors reviews and other external evaluations of the Centers programs.

⁷ While the Board principles specifically mention strategic planning, neither the Board nor NSF has further defined the "effective management practices" mentioned in the Board guidance. In these cases we relied on the U.S. Government Accountability Office's *Standards for Internal Control in the Federal Government*, which provides an overall framework for establishing and maintaining internal controls and for identifying and addressing performance and management challenges.

3. Funding levels and duration of NSF support to individual centers should:
 - Range from \$2-5 million annually,
 - Not exceed 10 years,
 - Include conditions for the phase out of NSF support, and
 - Include recompetition of awards.

4. Education and research characteristics of a center should include:
 - Exploiting opportunities provided by an academic research setting,
 - Focusing on research at the frontiers of knowledge,
 - Broadening participation among underrepresented groups,
 - A comprehensive and integrative educational component,
 - Developing organizational linkages within and between campuses, schools and other sectors (i.e., public, private, international), and
 - Creating a legacy in people, ideas, new instrumentation and innovative technologies that transcend the life of NSF support.

Appendix IV: Comparison of Eight Center Programs with Board and Senior Management Principles and Practices

The following table provides details of our analysis of whether each of NSF's Center programs incorporated the Board and NSF senior management principles and practices, which are outlined in detail in Appendix III.

These abbreviations are used for the Center programs:

CAS – Centers for Analysis and Synthesis

CBC – Chemical Bonding Centers

EERC – Earthquake Engineering Research Centers

ERC – Engineering Research Centers

MRSEC – Materials Research Science and Engineering Centers

NSEC – Nanoscale Science and Engineering Centers

STC – Science and Technology Centers

SLC – Science of Learning Centers

Center Program:	CAS	CBC	EERC	ERC	MRSEC	NSEC	STC	SLC
Principle:								
Management practices at the individual centers should include:								
Strategic planning	Y	N	Y	Y	N	Y	Y	Y
Specified management positions or management plans	Y	Y	Y	Y	Y	Y	Y	Y
External advisory board providing feedback to an individual center	Y	Y	Y	Y	Y	Y	Y	Y
Collecting and reporting of performance data	N	N	Y	Y	Y	Y	Y	Y
NSF's oversight practices for individual centers and the related Center program should include:								
Merit review of center proposals	Y	Y	Y	Y	Y	Y	Y	Y
Merit review includes added criteria to reflect center attributes	Y	Y	Y	Y	Y	Y	Y	Y
Conducting annual site reviews of individual centers	Y	N	Y	Y	N	Y	Y	Y
Performing critical reviews of individual centers as part of the	Y	N	Y	Y	Y	Y	Y	Y

Center Program:	CAS	CBC	EERC	ERC	MRSEC	NSEC	STC	SLC
Principle:								
process to determine if funding will be continued								
Requiring centers report on performance data	N	N	Y	Y	Y	Y	Y	Y
Conducting Committee of Visitors review of the Center programs	Y	Y	Y	Y	Y	Y	N	Y
Conducting other external evaluations of the Center programs	N	N	N	Y	Y	Y	Y	Y
Funding levels and duration of NSF support to individual centers should:								
Range from \$2 -5 million annually	N	Y	Y	Y	N	Y	Y	Y
Not exceed 10 years	N	Y	Y	Y	N	Y	Y	Y
Include conditions for the phase out of NSF support	Y	N	Y	Y	Y	N	Y	Y
Include recompetition of center awards	N	N	N*	Y	Y	N	Y	Y
Education and research characteristics of a center should include:								
Exploiting opportunities provided by an academic research setting	Y	Y	Y	Y	Y	Y	Y	Y
Focusing on research at the frontiers of knowledge	Y	Y	Y	Y	Y	Y	Y	Y
Broadening participation among underrepresented groups	Y	Y	Y	Y	Y	Y	Y	Y
Comprehensive and integrative educational component	Y	Y	Y	Y	Y	Y	Y	Y
Developing organizational linkages within and between campuses, schools and other sectors (i.e., public, private, international)	Y	Y	Y	Y	Y	Y	Y	Y
Creating a legacy in people, ideas, new instrumentation and innovative technologies that transcend the life of NSF support.	Y	Y	Y	Y	Y	Y	Y	Y

*The EERC program has ended.