NSB-11-80
December 14, 2011

NATIONAL SCIENCE BOARD
REPORT TO CONGRESS
ON MID-SCALE INSTRUMENTATION AT THE NATIONAL SCIENCE FOUNDATION

In response to
America COMPETES Reauthorization Act of 2010
Section 507

National Science Board

January 3, 2012

The Honorable Ralph M. Hall
Chairman
Committee on Science and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

On behalf of the National Science Board (Board), I am enclosing a report in response to the questions raised in Section 507 of the America COMPETES Reauthorization Act of 2010 (P.L.111-358).

I am pleased to have had the opportunity to participate in the evaluation of mid-scale instrumentation at the National Science Foundation (NSF) in order to prepare this report. The Board appreciates the strong support you and your subcommittee have for NSF and the research and education communities we serve, as well as your interest in the Board's recent activities in science and engineering research and education policy. We look forward to working with you on behalf of the NSF to sustain U.S. leadership in science and engineering for the long term.

If you or your staff have any questions concerning the enclosed responses to your questions or any other matter, please contact Dr. Michael L. Van Woert, Director of the National Science Board Office, by telephone on 703-292-7000 or by e-mail: mvanwoer@nsf.gov.

Sincerely,

Ray M. Bowen

Ray M. Bowen
Chairman

Enclosure

cc: The Honorable Eddie Bernice Johnson
The Honorable John D. Rockefeller
The Honorable Kay Bailey Hutchison

NATIONAL SCIENCE BOARD

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NATIONAL SCIENCE BOARD REPORT TO CONGRESS ON MID-SCALE INSTRUMENTATION AT THE NATIONAL SCIENCE FOUNDATION

Overview

The America COMPETES Reauthorization Act of 2010 (ACRA 2010) Section 507 directed the National Science Board (Board) to "…evaluate the needs, across all disciplines supported by the Foundation, for mid-scale research instrumentation…" and to report its findings and recommendations to the Congress.[1]

Per ACRA 2010 Section 507(a), the Board is pleased to provide its evaluation of the needs for mid-scale research instrumentation across all disciplines supported by the National Science Foundation (NSF, Foundation). We respond to the five ACRA 2010 Section 507(b) areas of inquiry in the sections of this report below.[2]

Definitions. For clarity, throughout this report the term "***research infrastructure***" refers to the ensemble of NSF investments that include multi-user facilities, physical and social measurement instruments and databases, computer models, cyberinfrastructure, and other resources focused on supporting the scientific enterprise. Within research infrastructure, "***mid-scale research instrumentation,***" as defined by NSF and the ACRA 2010 directive, comprises projects across all the above investment types at the cost-scale between the Major Research Instrumentation (MRI) and Major Research Equipment and Facilities Construction (MREFC) programs.

In accordance with NSF's mission to *promote the progress of science* and its strategic goal to *transform the frontiers,*[3] the Board underscores the critical importance of investment in research infrastructure in balance with support for research and human development to advance and maintain the Nation's leadership in science and engineering. Indeed, from the beginning of the NSF's existence, the Foundation has funded a great variety of research infrastructure across many scales from small to very large in support of the evolving needs of, and to create opportunities for research by, the U.S. scientific community.

At the same time, the Board remains mindful of economic challenges that have put pressure on the anticipated growth of the NSF budget. The Board is committed to ensuring that NSF continues on a sound and stable trajectory relative to the important balance in investments among research, infrastructure, and people. Consequently, the Board continually reviews the balance among NSF investments in core research, education and human resources, and research infrastructure, and periodically updates its guidelines and expectations for NSF's prioritization of investments.

In particular, the ACRA 2010 directive provides a timely opportunity to revisit the mid-scale research instrumentation component of the Board's previous evaluation of NSF investments and policy on research infrastructure, summarized in the 2003 report, *Science and Engineering Infrastructure for The 21st Century: The Role of the National Science Foundation.*[4] In that report, the Board recommended that NSF should strive to increase its research infrastructure investments to the higher end of the historic 22 percent to 27 percent share of its annual budget,

as feasible within the future growth of the NSF Budget. The Board also recommended that NSF give special emphasis to four areas of infrastructure needs: instrumentation, research and development of data and computational tools, "mid-size" infrastructure, large facility projects, and advanced cyberinfrastructure. The Board also observed that several other relevant prior reports[5] emphasize the critical importance of research infrastructure in general and recommend sustained funding and management of mid-scale research instrumentation and facilities in particular.

Summary of conclusions. Overall, the Board finds that the current research infrastructure investments across the Foundation are in alignment with the Board's earlier forecasts and recommendations on funding and prioritization – including for mid-scale research instrumentation. In particular, the Board finds that NSF's current balance of small, medium and large instrumentation is sound, and that the variety of mechanisms by which NSF prioritizes, solicits, evaluates, and supports mid-scale instrumentation – both directly, and indirectly through large centers and facilities – provides flexibility and vigor to NSF's efforts.

Consequently, although the Board's evaluation points to the importance of continuing strongly to support mid-scale instrumentation, *the Board does not recommend that NSF expand existing Foundation-wide programs or create a new Foundation-wide program for mid-scale instrumentation at this time.*

The ensuing sections of this report provide support for the Board's findings in each of the five ACAR 2010 areas of inquiry, and recognizes NSF's significant and diverse array of investments in mid-scale instrumentation, which can serve as a benchmark for future investments in this area.

1. Mid-scale Research Instrumentation Needs at the National Science Foundation

During calendar year 2011, the Board's Committee on Strategy and Budget's Subcommittee on Facilities investigated the means and extent to which the needs of the scientific community are being met by on-going and planned investments in mid-scale instrumentation. The Board's examination comprised an evaluation of mid-scale research instrumentation activities and funding approaches in each of NSF's Science and Engineering directorates and offices, and an analysis of anticipated mid-scale instrumentation needs across NSF-supported disciplines. The Board solicited input from these organizations regarding current mid-scale instrumentation activities, including projects, funding mechanisms, partnering, life cycles and anticipated demands for future mid-scale instrumentation within the science communities served by NSF.

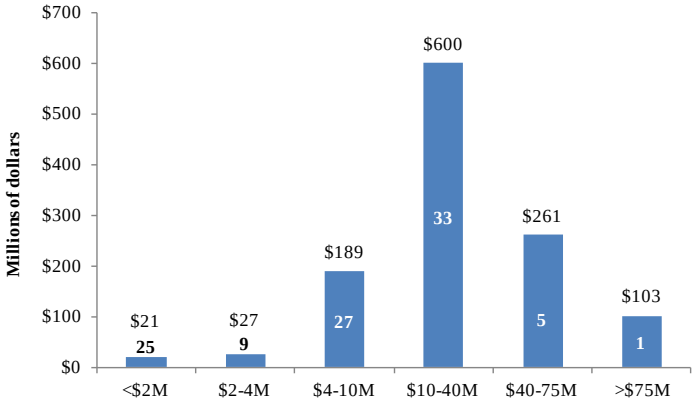
In identifying mid-scale instrumentation activities, the Board was guided by the language of the ACRA 2010 as those mid-scale instrumentation investments falling between the MRI and MREFC programs. One challenge when categorizing and assessing "mid-scale" instrumentation is that this intermediate range of instrumentation investments comprises several orders of cost magnitude spanning the upper half of MRI funding range (which has a present upper limit of $4 million) to the lower end of the MREFC project cost range (which can range the tens to low hundreds of millions of dollars as defined by the proportional threshold for project eligibility of 10 percent of a sponsoring Directorate's or Office's annual budget). The Board's evaluation accordingly included mid-scale instrumentation activities that overlap in cost scale with the MRI

and MREFC cost ranges, but which are not funded by either of these programs. In addition, with regard to lifecycle phases, although MRI is primarily an acquisition program and the MREFC account enables the construction of large facility projects, for completeness the Board's evaluation includes mid-scale instrumentation both in the acquisition/construction stage as well as in the operations lifecycle stage.

Using these boundaries, NSF presently directly supports approximately 100 mid-scale research instrumentation projects, cumulatively representing $1.2 billion of total multi-year value of all active awards as of Fiscal Year (FY) 2011. In FY 2011 alone, approximately $163 million was obligated across these mid-scale instrumentation projects, representing about 10 percent of FY 2011 obligations for all research infrastructure.[6] This compares with FY 2011 obligations of $90 million for MRI (5 percent of research infrastructure) and $117 million for MREFC projects (7 percent of research infrastructure). In addition to these projects, NSF also effectively provides indirect funding for additional mid-scale instrumentation activities through its ongoing direct support to medium and large scale centers and Federally Funded Research and Development Centers (FFRDCs).[7] The quantification of this indirect NSF mid-scale instrumentation investment requires further study that the Board intends to incorporate into its annual review of facilities and other research infrastructure.

NSF's mid-scale instrumentation portfolio represents a great diversity of science disciplines, project types and cost scales across the science disciplines and is heavily used by the respective scientific communities. As illustrated in Figure 1, NSF mid-scale instrumentation projects are distributed across the full range of cost scales from within the MRI funding level to the lower eligibility MREFC level.[8]

Figure 1. NSF Mid-scale Instrumentation Investments

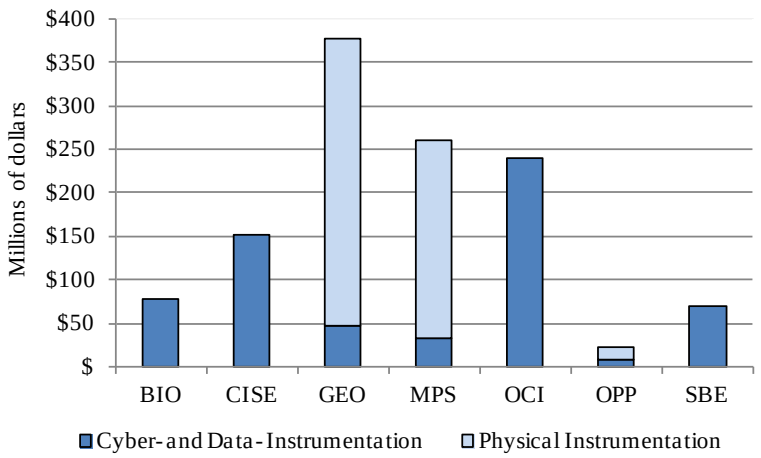


Individual Project Funding
(total value of all active awards)
Numbers of projects also shown for each bar.

Regarding types of projects, the Mathematical and Physical Sciences (MPS) and Geosciences (GEO) Directorates have historically been the organizations with the largest investments in physical measurement instrumentation systems and facilities, and their predominant investment in this important class of "traditional" physical measurement instrumentation trend continues

today (see Figure 2). In addition, as the Board's 2003 report on research infrastructure foresaw[9], there has been sustained growth in investments in cyber-infrastructure and data archiving and analysis systems across many disciplines. As Figure 2 indicates, cyber-infrastructure and data-management activities are the predominant focus of mid-scale instrumentation funding in the Directorates of Biological Sciences (BIO), Computer and Information Science and Engineering (CISE), and Social, Behavioral and Economic Sciences (SBE) Directorates, as well as by the Office of Cyberinfrastructure (OCI).[10] The Board notes that these mid-scale cyber-infrastructure and data-management investments are taking place in parallel with major investments in the creation and support of large-scale cyber-enabled and data-intensive research platforms across NSF, as represented by the Network for Earthquake Engineering Simulation (ENG), EarthScope (GEO), Ocean Observatories Initiative (GEO), and the National Ecological Observatory Network (BIO). Similarly, the Board also notes that the modest investments in mid-scale research instrumentation by the Office of Polar Programs (OPP) shown in Figure 2 takes place within the context of OPP's very large sustained support for instrumentation, facilities, logistics and research in the Arctic and Antarctic regions.

Figure 2. NSF Investment in Mid-scale Instrumentation



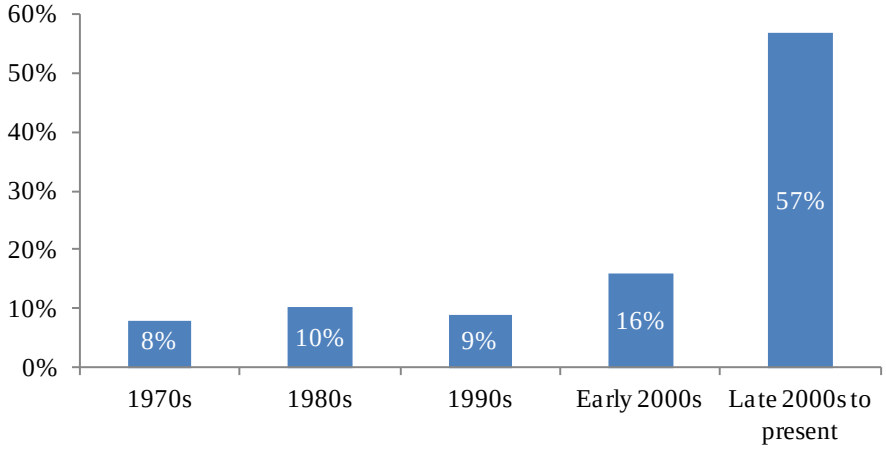
Interdisciplinarity and partnering are hallmarks of mid-scale instrumentation activities. The Board's 2003 report on science and engineering infrastructure recognized that collaboration and multidisciplinarity are burgeoning across disciplines: As research questions drive the need for multidisciplinary approaches, there is concomitant increasing need for access by multidisciplinary teams to the most cutting-edge tools. The 2005 National Research Council (NRC) report, *Midsize Facilities: Infrastructure for Materials Research,* found that facilities that provide state of the art instrumentation and professional staff greatly enhance the effectiveness of interdisciplinary techniques. And the 2006 NRC report, *Advanced Research Instrumentation and Facilities,* observed that "many important scientific and technological opportunities lie at the intersection of traditional disciplines."[11] Indeed, today over two-thirds of NSF mid-scale instrumentation activities involve financial partnering, either via interdisciplinary co-funding within the Foundation (11 percent), external co-funding partnerships (44 percent) or both (13 percent).

Project origin and lifetime are additional important dimensions for characterizing the variety in NSF mid-scale instrumentation activities. Although most mid-scale instrumentation projects originate within programs and divisions, there are a great many pathways by which these projects take shape across NSF. New activities often build on previously funded instrumentation through upgrading or expansion of existing instruments, and NSF funds are leveraged in diverse ways to construct, acquire, or piece together instrumentation capabilities.

Mid-scale instrumentation lifetime also varies greatly across projects (see Figure 3). Many smaller mid-scale research instrumentation activities are short-term and may have predetermined schedules for phase-out or completion. However, NSF's mid-scale instrumentation activities are heavily represented by long-lived facilities that are designed to openly serve multiple and evolving users rather than fixed single investigators and closed groups. These mid-scale multi-user facilities typically have much longer lifecycles, over which time earlier investments are leveraged with new investments and competitions to maintain and advance the state of the art. The larger of these mid-scale multi-user facilities also draw relatively more on internal agency staff time to implement enhanced planning, management and oversight processes necessary to ensure positive outcomes of these more complex construction and operation activities.

On the other hand, many of the individual instruments needed to advance an important scientific endeavor are research and development (R&D) projects in their own right – focused on advancing the state-of-the-art or inventing completely new measurement capabilities. Consequently, mid-scale R&D is also an important component of overall mid-scale funding programs for a discipline, as distinguished from projects focused on acquisition and construction (such as those funded via the MREFC and MRI programs).

Figure 3. Project Initiation Date of Current Mid-scale Instrumentation Activities



The great variety in purpose, type, origin, duration and partnering of NSF mid-scale instrumentation projects is represented by an equally great variety of award mechanisms and approaches employed by directorates and offices to support the creation and operation of these activities and to accommodate co-funding with other stakeholders. In particular, single mid-scale awards are typically not separated according to defined project lifecycle stages

characteristic of larger (e.g., MREFC) projects, but rather cover a combination of acquisition or construction, operations, and scientific research. In addition, the technical and programmatic complexity and longer duration of mid-scale multi-user facilities have led NSF to often fund these activities through Cooperative Agreements (CAs)[12] which enable NSF to provide additional stewardship and oversight for these projects.

The Board was provided with information from NSF directorates and offices on the anticipated requests for future mid-scale research instrumentation. As might be expected, these anticipated future requested activities vary concomitantly with the types and level of current instrumentation investments in these different disciplines: NSF organizations which are heavily invested in mid-scale instrumentation (and research infrastructure in general), such as GEO and MPS, stressed the importance of continuing to fund new instrumentation projects at both the smaller and larger scales within a portfolio of research infrastructure. Steadily growing needs in funding cyberinfrastructure and data systems – at the mid- and also large-scales were cited across the other directorates and offices that predominantly support those activities.

2. Setting Priorities for Mid-scale Instrumentation

Considering the great diversity of NSF's mid-scale instrumentation activities and their continuing evolution highlighted above, the Board was pleased to note the strong efforts of NSF programs to identify and respond to community requirements for mid-scale instrumentation. NSF directorates and offices employ many mechanisms to ensure broad community input to set priorities for mid-scale instrumentation within overall program planning and evaluation. These include responding to advice and guidance provided by their advisory committees and extramural expert panels such as those organized by the National Academy of Sciences, sponsoring workshops and focused studies, as well as issuing targeted solicitations and responding to un-solicited proposals. Many NSF organizations actively and regularly conduct strategic planning that includes research infrastructure. This planning typically ensures that infrastructure investments are in balance with support for individual investigator research grants. In some cases, mid-scale instrumentation support is funded out of a single program, but as noted earlier, mid-scale activities are often collaborative efforts. Moreover, since most mid-scale instrumentation activities serve multiple users and can have significant budgetary impact, ensuring broad community support is as important for mid-scale instrumentation projects as for the large multi-user facility projects.

It is clear to the Board that the range and diversity of mid-scale instrumentation activities across the Foundation poses a challenge to establishing a single agency-wide process for setting priorities for this specific class of investments. In evaluating the manner in which priorities are set for mid-scale instrumentation, *the Board finds that NSF directorates and offices are in the best position to flexibly assess and respond to the needs of the individual communities they serve.* Maintaining this flexibility is particularly important in periods of budget uncertainty to ensure NSF's continued ability to nimbly support the broad scientific community. Consequently, *the Board and NSF management are in strong alignment on the need to preserve discipline-specific flexibility on setting priorities while continuing to maintain a high priority on funding of core research in balance with research infrastructure investments in the approximately 75 percent - to - 25 percent ratio specified in the Board's earlier guidance.*

3. Examination of Expanding Existing Programs to Accommodate Mid-Scale Instrumentation Projects

The Board examined the advantages and disadvantages of expanding the existing MREFC and MRI programs to support more instrumentation at the mid-scale. For this exercise, the Board requested and received analysis from the cognizant NSF program officers and other staff responsible for administering these activities.

At the lower scale, the MRI program is primarily focused on enabling instrument acquisition or construction for single investigators and groups, and is limited to funding instrument projects up to $4 million dollars. The Board finds that expanding the MRI program by increasing the dollar cutoff threshold is limited in viability for two reasons. First, the MRI cost sharing requirement imposes a dollar commitment on the awardee institution, which tends to be prohibitive to the institution as the project cost increases to the current MRI limits. Second, projects proposed at the higher end of the MRI cost range typically have the characteristics of multi-user facilities and therefore beyond the well-defined goals and scope of the MRI program.

At the higher scale, the MREFC program is designed to enable the creation of unique major national and international-scale facilities serving significant portions of a scientific field or fields. The MREFC program limits eligibility to projects whose anticipated total cost exceeds ten percent of the sponsoring directorate's or office's annual budget – a threshold which translates to a cost range from the high tens to low hundred million dollars across NSF directorates and offices. Several features of such major undertakings limit the utility of expanding the MREFC program to support larger mid-scale projects. First, although many of the larger mid-scale activities certainly share some of the national-level features that are common to "big science" projects, most mid-scale activities are more modest in scope, goals and lifetime. Second, MREFC projects are associated with an extensive development and implementation time (typically decades), including high-level NSF and Board review and approval, interagency and Administration involvement, a two-step appropriation process, and extended commitment to long-term construction and operational phases. These features would be overwhelming for most mid-scale projects. Furthermore, as noted earlier, many mid-scale projects are not suitable to a purely acquisition/construction program as these projects comprise a mix of research and instrument development and operations.

In summary, the Board did not find a convincing rationale for expanding either the MRI or MREFC programs to meet anticipated mid-scale research instrumentation requests. The Board finds that the MREFC and MRI programs are specifically designed to target defined classes of instrumentation acquisitions/construction, and the potential risks to these programs of expanding them outweigh the limited advantages of modifying funding thresholds to accommodate some mid-scale activities. Consequently, *the Board does not recommend that NSF modify the existing Foundation-wide construction/acquisition programs for research infrastructure to specifically accommodate mid-scale instrumentation at this time.*

4. Consideration of the Potential Need for and Appropriateness of a New, Foundation-Wide Program or Initiative in Support of Mid-scale Instrumentation

The Board examined whether the creation of a dedicated Foundation-wide program or initiative would be appropriate to address anticipated requests for mid-scale instrumentation; and further identified the required design features for any such program.

A number of directorates and offices have defined and developed their own dedicated mid-scale instrumentation programs over the years, and NSF also has extensive and positive experience with agency-wide funding programs for defined classes of investments in addition to the MRI and MREFC programs (e.g., Computer-enabled Discovery and Innovation (CDI) program, Science and Technology Centers (STCs) program). These existing disciplinary and cross-Foundational programs can inform consideration of the potential benefits of NSF-wide mid-scale instrumentation funding approaches. For instance, creation of a multi-disciplinary NSF-wide mid-scale instrumentation program might promote the sharing of scientific and technical advances in instrument development across the funded awardee organizations.

As is clear from the foregoing review of current NSF mid-scale instrumentation activities, any dedicated program would need to be flexible enough to accommodate directorate- and office-level prioritization, and to admit many different models and approaches for R&D, acquisition, construction, and operation. Funding strategies and profiles must facilitate interdisciplinary approaches and enable a wide variety of partnerships, and to the latter point must be flexible enough to accommodate the funding strategies of external partnering organizations. For larger facility activities, a dedicated funding program should (partially or fully) accommodate the associated longer-term lifecycles and the use of Cooperative Agreements as award instruments. Program staff also emphasized that success with NSF-wide programs has followed from ensuring that proper mechanisms are in place to solicit and review proposals, perform active and effective post-award monitoring, and oversee appropriate close-out activities.

The Board finds that the potential efficiencies and other advantages of creating a new program for mid-scale instrumentation must be carefully weighed against the merits of other activities and priorities within the Foundation. Although NSF organizations noted shortfalls in their ability to meet all requests for mid-scale instrumentation, they are also mindful of the many demands on resources that compete with support for research infrastructure. Moreover, NSF program staff universally expressed the need to preserve the great creativity and flexibility currently exercised in funding mid-scale instrumentation to accommodate the wide variety of mid-scale activities, including, for instance, operations and maintenance costs, cost-sharing, and collaboration with outside stakeholders.

Thus, in light of the Board's satisfaction regarding NSF's present discipline-level prioritization approach and current allocation of funds for mid-scale research instrumentation, the Board does not recommend that NSF create a new Foundation-wide program to support mid-scale instrumentation at this time.

5. Consideration of Other Options for Supporting Mid-scale Research Instrumentation at the Foundation

In discussions with NSF staff, the Board found that there may be opportunities to foster integration and collaboration on mid-scale activities across the Foundation. For example, advances in cyberinfrastructure have relevance to and importance for research infrastructure in all other research areas, as represented by ongoing and growing collaborations between OCI and other directorates on research infrastructure at all scales. In addition, as noted earlier, many mid-scale activities are undertaken by large NSF-supported centers and facilities.

To ensure the maximum efficiency in mid-scale instrumentation investments to strengthen science, NSF should continue to explore and thoroughly exploit opportunities for sharing technology and gathering lessons learned in the development and operation of mid-scale instrumentation through proactive coordination and communication within the Foundation and with NSF awardees.

Conclusion

This assessment has stimulated the Board's thinking about the importance of maintaining flexible processes for prioritizing and supporting mid-scale instrumentation and for promoting cooperation and collaboration across NSF and with other agencies and partners. The Board continues to see a critical role for NSF mid-scale instrumentation across a wide variety of scientific disciplines, and believes that the scientific enterprise is best served by maintaining strong support for this instrumentation in balance with the many other investments pursued by NSF.

Going forward, the Board will continue to work with NSF management and staff to capture, assess, prioritize and support anticipated needs for mid-scale instrumentation as part of NSF's research infrastructure investments. The Board's Annual Portfolio Review of facilities may provide an appropriate forum for assessing the evolving needs of the research community for mid-scale instrumentation and incorporate these needs into the Foundation's strategic planning and priority setting.[13]

Endnotes

[1] Section 507 of Public Law 111-358 (America COMPETES Reauthorization Act of 2010), 124 STAT. 4008.

[2] ACRA 2010 Section 507 specifies five areas of inquiry: (1) evaluation of mid-scale instrumentation needs, including differences across disciplines and Foundation research directorates; (2) how the Foundation should set priorities for mid-scale instrumentation across disciplines and Foundation research directorates; (3) appropriateness of expanding existing programs, including the MRI and MREFC programs, to support more instrumentation at the mid-scale; (4) need for and appropriateness of a new, Foundation-wide program or initiative in support of mid-scale instrumentation; and (5) other options for supporting mid-scale research instrumentation at the Foundation.

[3] *Empowering the Nation Through Discovery and Innovation*, the NSF Strategic Plan for Fiscal Years (FY) 2011-2016, (NSF-11-047), http://www.nsf.gov/news/strategicplan/nsfstrategicplan_2011_2016.pdf.

[4] *Science and Engineering Infrastructure for the 21st Century: The Role of the National Science Foundation*, 2003, (NSB-02-190), available online at http://www.nsf.gov/nsb/documents/2002/nsb02190/nsb02190.pdf.

[5] Science and Engineering Infrastructure for the 21st Century: The Role of the National Science Foundation, 2003, (NSB-09-190) available online at http://www.nsf.gov/nsb/documents/2002/nsb02190/nsb02190.pdf; *Midsize Facilities: Infrastructure for Materials Research*, NRC, 2005; *Advanced Research Instrumentation and Facilities*, National Academy of Sciences, 2006; *New Worlds, New Horizons in Astronomy and Astrophysics*, NRC, 2010.

[6] The preceding amounts of mid-scale instrumentation funding are exclusive of support for operation of major multi-user facilities and FFRDCs, whose size and cost place them in a class beyond mid-scale research instrumentation. These major facility and FFRDC investments however form part of the total annual funding NSF research infrastructure, which for FY 2011 (current plan) was $1,581 million. This latter amount was used as the base for the percentages provided in this paragraph of the text.

[7] Examples include the National Center for Atmospheric Research, national centers that manage astronomical observatories, organizations responsible for operation of the academic research fleet, and the Polar Logistics Support Contracts. Long-term funding provided to these organizations has allowed for sustained efforts to develop, deploy, and operate a range of mid-scale instrumentation projects.

[8] As before, the amounts presented in the figure represent the total multi-year value of active awards for each project as of FY 2011. This figure represents only identified mid-scale activities, including a number of activities which are funded at similar levels as – but not through – the MRI program.

[9] The Board's 2003 report on science and engineering infrastructure addressed the importance of cyberinfrastructure as a catalyst to scientific progress across all disciplines stating "nothing has come close to matching the impact of information technology (IT) and microelectronics" and that IT ability "has acted like adrenaline to all of science and engineering." The Board also notes that the 2004 report, *Setting Priorities for NSF Large Facilities* by the NRC, discusses the heavy influence on large facilities of the accelerating development of IT.

[10] This figure showing directorate/office investments in mid-scale instrumentation excludes ENG, which indicated that it does not invest substantially in instrumentation at this middle scale.

[11] *Advanced Research Instrumentation and Facilities*, NRC, 2006

[12] The Cooperative Agreement (CA) is an award mechanism for financial assistance that is used when "substantial involvement is expected between the executive agency and the … recipient" during performance of the funded activity. The Federal Grant and Cooperative Agreement Act (31 U.S.C. 6301-08) governs the use of grants, cooperative agreements and contracts. OMB Circular A-110 provides Federal agencies with guidance on the use of the different award mechanisms with research institutions and other non-profit organizations.

[13] The Board appreciates the efforts of many individuals who contributed to the development of this report. We are particularly indebted to NSF staff members Drs. William L. Miller and Robert M. Robinson for assistance in planning and contributing to the evaluation and report development; and Drs. Asha Balakrishnan and Gina Walejko and Ms. Kristen Koopman at the Institute for Defense Analyses, Inc. (IDA) Science and Technology Policy Institute (STPI) for their expert analytical work supporting this evaluation. The Board also acknowledges the essential support provided by the National Science Board Office (NSBO), and especially recognizes Mr. Blane Dahl, NSBO staff lead for the Subcommittee on Facilities, for his diligent oversight of this effort; Ms. Jennie Moehlmann for policy guidance and critical review of the report drafts; and Ms. Ann Ferrante for editorial assistance. The Board also thanks Dr. Michael L. Van Woert, Executive Officer of the Board and NSBO Director, for the essential guidance and support he provided throughout this effort. Finally, the Board expresses its deep appreciation to NSF management and program staff for their contributions to this evaluation, and for their uncompromising efforts to ensure the Nation's leadership in science and engineering research and instrumentation.