College of Charleston
66 George Street
Charleston, South Carolina 29424-0001

July 26, 2005

The Honorable Arden L. Bement, Jr.
Director
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

Dear Dr. Bement:

We are pleased to submit the report of the Advisory Committee for GPRA Performance Assessment (AC/GPA) for 2005. It was the unanimous judgment of the Committee that NSF has demonstrated significant achievement for all indicators in the Ideas and Tools goals and also for the merit review indicator of the Organizational Excellence outcome goal. The Committee concluded that NSF demonstrated significant achievement for indicators P1-P4 of the People goal, but has not done so with respect to P5. The Advisory Committee on Business and Operations concluded that NSF demonstrated significant achievement for the other indicators of the Organizational Excellence goal.

The Committee also concluded that the four outcome goals are mutually reinforcing and synergistic. They represent an integrated framework that combines research and education in a positive way and also provides the organizational infrastructure to advance the national scientific, technological, engineering, and mathematics enterprise. Thus, all four goals should always be considered as an integrated whole when assessing NSF's performance.

The Committee appreciates the continued improvement in the AC/GPA process this year. Not only were we again able to do much of our work in advance of the meeting, but NSF also provided periodic updates on the progress of each subgroup in its analyses of indicators. This Committee, with NSF's invaluable assistance, has, we believe, modeled the very organizational excellence behavior that we seek from NSF. We also note that this committee is, perhaps, unique within the Federal government. We commend you and your predecessors for both foresight and commitment to an assessment process that is both thorough and impactful.

This report represents the collective work of a large group of individuals, the members of the Committee, all of whom worked with a level of commitment and diligence that we have rarely encountered. Each of them made significant contributions to the report and collectively we believe they have demonstrated that advisory committees can themselves demonstrate organizational excellence and become "learning committees." NSF is indeed fortunate to have such people in its "corner" and it was an honor and a privilege for us to lead this effort. In addition, many members of the NSF staff, especially Marilyn Suiter and Craig Robinson, were instrumental in enabling our work and we are truly grateful for their assistance.

We would be happy to talk with you or others about any aspect of this report. We hope it will be helpful to NSF as it completes its Performance and Accountability Report.

Sincerely,

Norine E. Noonan

Norine E. Noonan, Ph.D.
Dean
School of Science and Mathematics
College of Charleston
Chair, AC/GPA

Carolyn W. Meyers

Carolyn W. Meyers, Ph.D.
Provost and Vice Chancellor for
Academic Affairs
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REPORT OF THE ADVISORY COMMITTEE FOR GPRA PERFORMANCE ASSESSMENT

Submitted: July 20, 2005
Norine E. Noonan, Ph.D.
Chairman

Table of Contents

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Advisory Committee for GPRA Performance Assessment (AC/GPA)

* Absent on June 17, 2005
** Absent on June 16 and 17, 2005

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Timothy W. Tong
Dean, School of Engineering and Applied Science
The George Washington University
Washington, District of Columbia

NSF Strategic Plan, FY 2003 – 2008
Strategic Outcome Goals

PEOPLE GOAL

A DIVERSE, COMPETITIVE, AND GLOBALLY-ENGAGED U.S. WORKFORCE OF SCIENTISTS, ENGINEERS, TECHNOLOGISTS AND WELL-PREPARED CITIZENS

Goal Indicators

P1: Promote greater diversity in the science and engineering workforce through increased participation of underrepresented groups and institutions in all NSF programs and activities.

P2: Support programs that attract and prepare U.S. students to be highly qualified members of the global S&E workforce, including providing opportunities for international study, collaborations and partnerships.

P3: Develop the Nation's capability to provide K-12 and higher education faculty with opportunities for continuous learning and career development in science, technology, engineering and mathematics.

P4: Promote public understanding and appreciation of science, technology, engineering, and mathematics, and build bridges between formal and informal science education.

P5: Support innovative research on learning, teaching and mentoring that provides a scientific basis for improving science, technology, engineering and mathematics education at all levels.

IDEAS GOAL

DISCOVERY ACROSS THE FRONTIER OF SCIENCE AND ENGINEERING, CONNECTED TO LEARNING, INNOVATION, AND SERVICE TO SOCIETY

Goal Indicators

I1: Enable people who work at the forefront of discovery to make important and significant contributions to science and engineering knowledge.

I2: Encourage collaborative research and education efforts – across organizations, disciplines, sectors and international boundaries.

I3: Foster connections between discoveries and their use in the service of society.

I4: Increase opportunities for underrepresented individuals and institutions to conduct high quality, competitive research and education activities.

I5: Provide leadership in identifying and developing new research and education opportunities within and across S&E fields.

I6: Accelerate progress in selected S&E areas of high priority by creating new integrative and cross-disciplinary knowledge and tools, and by providing people with new skills and perspectives.

TOOLS GOAL

BROADLY ACCESSIBLE, STATE-OF-THE-ART S&E FACILITIES, TOOLS AND OTHER INFRASTRUCTURE THAT ENABLE DISCOVERY, LEARNING AND INNOVATION

Goal Indicators

T1: Expand opportunities for U.S. researchers, educators, and students at all levels to access state-of-the-art S&E facilities, tools, databases, and other infrastructure.

T2: Provide leadership in the development, construction, and operation of major, next-generation facilities and other large research and education platforms.

T3: Develop and deploy an advanced cyberinfrastructure to enable all fields of science and engineering to fully utilize state-of-the-art computation.

T4: Provide for the collection and analysis of the scientific and technical resources of the U.S. and other nations to inform policy formulation and resource allocation.

T5: Support research that advances instrument technology and leads to the development of next-generation research and education tools.

ORGANIZATIONAL EXCELLENCE GOAL

AN AGILE, INNOVATIVE ORGANIZATION THAT FULFILLS ITS MISSION THROUGH LEADERSHIP IN STATE-OF-THE-ART BUSINESS PRACTICES

Excellence in managing NSF's activities is an objective on par with the Foundation's mission-oriented outcome goals. It is critical to achievement of all NSF goals. In addition, this goal addresses the President's Management Agenda and focuses on management challenges and reforms identified by OMB or the General Accountability Office, in NSF's annual review of financial and administrative systems as required by the Federal Managers' Financial Integrity Act, or by the NSF Office of Inspector General.

Investment Categories: *The following long-term investment categories directly link to NSF programs and budget resources.*

- **Human Capital:** Investments that produce a diverse, agile, results-oriented cadre of NSF knowledge workers committed to enabling the agency's mission and to constantly expanding their abilities to shape the agency's future.

- **Business Processes**: Investments that produce effective, efficient, strategically aligned business processes that integrate and capitalize on the agency's human capital and technology resources.

- **Technologies and Tools**: Investments that produce flexible, reliable, state-of-the-art business tools and technologies designed to support the agency's mission, business processes, and customers.

Objectives: Excellence in managing the agency's activities underpins all of NSF's goals. The following objectives are especially critical to NSF's goal achievement.

- **Operate a credible, efficient merit review system.** NSF's merit review process is the keystone for award selection, through which NSF achieves its goals. All proposals for research and education projects are evaluated using two criteria: the intellectual merit of the proposed activity and its broader impacts. Specifically addressed in these criteria are the creativity and originality of the idea, the development of human resources, and the potential impact on the research and education infrastructure. Ensuring a credible, efficient system requires constant attention and openness to change.

- **Utilize and sustain broad access to new and emerging technologies for business application.** NSF has moved aggressively to adopt new technologies in our business processes. NSF must sustain and further develop exemplary mechanisms to streamline business interactions, enhance organizational productivity, ensure accessibility to a broadened group of participants, and maintain financial integrity and internal controls.

- **Develop a diverse, capable, motivated staff that operates with efficiency and integrity.** NSF is dependent on the capability and integrity of its staff. Innovative methods of recruitment, development, and retention and employee recognition are needed to meet future challenges.

- **Develop and use performance assessment tools and measures to provide an environment of continuous improvement in NSF's intellectual investments as well as its management effectiveness.** An organization that is dependent on public funds must be accountable to the public. The development and use of effective indicators of agency performance -- measuring NSF's ability to meet mission-oriented goals, its competent use of resources in the investment process, and its efficiency and effectiveness as a reliable partner to others -- are needed to better explain the agency's role to the public.

OVERALL SUMMARY AND CONCLUSIONS

The Advisory Committee for GPRA Performance Assessment (AC/GPA) met on June 16-17, 2005 at the National Science Foundation (NSF) in Arlington, Virginia, to consider the activities and achievements of NSF relative to its Government Performance and Results Act (GPRA) performance goals for FY 2005. The charge to the Committee asked that it provide:

- An assessment of results for indicators associated with the strategic outcome goals of People, Ideas, Tools, and with the merit review indicator for the Organizational Excellence goal. (The other three indicators for this goal were assessed by the Advisory Committee on Business and Operations – see below under Approach and Methodologies Used by the AC/GPA).
- Comments on the quality and relevance of award portfolios.
- Comments on transformative/bold/innovative-high risk research and education.

The Committee reviewed voluminous materials from NSF's award portfolio both prior to and during the meeting. In addition, the Committee had electronic access to supporting documentation for all indicators including a large database of accomplishments (which NSF terms "nuggets"), annual and final project reports and an extensive set of reports from various Committees of Visitors (COVs). The Committee also received input on the Organizational Excellence (OE) goal from the Advisory Committee for Business and Operations (AC/B&O). The AC/GPA reviewed materials supporting an assessment of the merit review indicator of the OE goal. The group conducted extensive discussions on the indicators for NSF's four strategic outcome goals. <u>***It was the unanimous judgment of the Committee that NSF has demonstrated significant achievement for all indicators in the Ideas and Tools goals and also for the merit review indicator of the Organizational Excellence outcome goal. The Committee concluded that NSF demonstrated significant achievement for indicators P1-P4 of the People goal, but has not done so with respect to P5. The Advisory Committee on Business and Operations concluded that NSF demonstrated significant achievement for the other indicators of the Organizational Excellence goal.***</u>

The Committee reiterates that all of the strategic outcome goals are mutually reinforcing and synergistic. They represent an integrated framework that combines research and education and also provides the organizational structure to advance the national scientific, technological, engineering, and mathematics enterprise. The extensive documentation that the Committee reviewed also underscores this interdependence. The Committee also notes that there is great vitality at the junction of disciplines (often multiple disciplines) and that these junctions offer great opportunities for pushing the frontiers of knowledge. However, these advances are inevitably built on a base of disciplinary strength, funded through the "core" of discipline-based NSF programs -- even though, over time, the discoveries at the intersections redefine what a "discipline" is. This is the natural evolution of science and engineering research. Moreover, breakthrough discoveries are only possible when enabled by talented people and capable tools – all supported by innovative, fair and effective business processes to make funding decisions. These decisions must then periodically be assessed for their quality and relevance. Thus, the four goals should always be considered as an integrated whole when assessing NSF's overall performance.

NSF's portfolio of accomplishments for the PEOPLE outcome goal encompasses a wide variety of activities that are intellectually strong and encompass multiple approaches, paradigms and methods. The portfolio contains important examples of programs that are designed to enable students, educators and researchers from a variety of backgrounds and experiences to explore the challenges of science, technology, engineering, and mathematics (STEM) related fields. NSF accomplishments in the IDEAS outcome goal have both advanced the frontiers of discovery and nurtured productive collaborations across disciplines, each of which hold great promise for addressing important current and future societal concerns. NSF accomplishments in the TOOLS outcome goal have expanded access to and availability of data and materials, and have enabled the capacity for discovery by scientists, engineers and educators. NSF's accomplishments in the ORGANIZATIONAL EXCELLENCE goal demonstrate innovation in business processes; in methods of recruitment, development, retention, and recognition of its staff; attention to continuous improvement in management effectiveness; and a strong commitment to continued improvements in its merit review process. Taken together, the strategic outcome goals demonstrate excellence, relevance and leadership. The nation can be both proud and confident of its investment in these activities.

This report is organized as follows:

- A Foundation level summary of FY 2005 investments, including comment on the R&D investment criteria of quality and relevance, and comments on NSF's portfolio of transformative/bold/innovative-high risk research awards.
- Information on the approach and methodologies used by the Committee.
- Detailed assessment of the People outcome goal.
- Detailed assessment of the Ideas outcome goal.
- Detailed assessment of the Tools outcome goal.
- Detailed assessment of the Merit Review Indicator of the Organizational Excellence outcome goal with a meta-assessment of the other three OE indicators.
- Comments on the ACGPA process and the Committee's work.

The Committee would like to extend its deep gratitude to the NSF GPRA staff, particularly Marilyn Suiter, Craig Robinson, Patricia Tsuchitani, Eve Barak, Blane Dahl, Connie Della-Piana, Michael Sieverts, Jennie Moehlmann and Kelli Savia (student intern) for their excellent support. Our work (and this report) would simply not have been possible without their dedication and careful attention to both the "big picture" and the smallest details and their grace under pressure. We want to especially thank Peggy Gartner and Teresa Rinehart, Betty Wong, and Tyler Higgins for developing, refining, and improving the outstanding database for accomplishments and the website. We would also like to thank Joan Miller for her cheerful and competent administrative support before and during the meeting. Lastly, we thank the NSF program staff for their thoughtful reporting of accomplishments of their program portfolios, and NSF's senior leadership for their commitment to this effort.

APPROACH AND METHODOLOGIES USED BY THE AC/GPA

The Advisory Committee for GPRA Performance Assessment (AC/GPA) is comprised of 25 members representing the nation's scientific and engineering research and education communities in the public and private sectors. About half the AC/GPA membership is drawn from existing directorate or office advisory committees and about half are "at-large" members. The membership reflects a broad cross section of talent, expertise, and experience. Its purpose is to provide expert advice and recommendations to NSF regarding the Foundation's performance under the Government Performance and Results Act (GPRA) of 1993. The findings and recommendations of the Committee will provide valuable input to NSF's annual GPRA Performance and Accountability Report.

The focus of the AC/GPA is on the activities and results associated with the indicators and emphasis areas of NSF's four strategic outcome goals: PEOPLE, IDEAS, TOOLS, and ORGANIZATIONAL EXCELLENCE (OE). The principal work of the Committee was conducted as a "committee of the whole." Three subgroups (PEOPLE, IDEAS, and TOOLS) composed of AC/GPA members provided the detailed analysis of the results associated with each indicator. A fourth subgroup for OE was comprised of the AC/GPA Vice Chairman and two other committee members, one of whom chaired this subgroup. All of the subgroups reported their analyses, findings and conclusions to the full AC/GPA for its discussion. Within the subgroups, each AC/GPA member was assigned specific indicators to review on the basis of a large volume of accomplishments provided by the NSF staff. It should be noted that these accomplishments and examples were provided in a "bottoms up" fashion by the Directorates and were not subject to any selective process by NSF GPRA staff prior to the Committee's review. Thus, although illustrative of the range of NSF's activities, these accomplishments/examples did not constitute a strictly statistically "representative" sample (i.e., every program did not necessarily provide accomplishments/examples and the total numbers were not weighted in any way). The Committee has made recommendations to NSF in previous reports on this issue and NSF has endeavored to assure that the largest 30 programs were represented in the nugget database.

Materials were available to Committee members via a secure web site where information was accessible and much of it was electronically linked to the source documentation three months before the annual meeting. Thus, the Committee members were able to do virtually all of the indicator analysis well ahead of the meeting. This provided the opportunity to enrich and enlarge the discussion at the meeting and to focus on the evaluation of the entire portfolio. The subgroups (and the full Committee) had a large amount of material available for its work, including:

- A large database (nearly 900) of accomplishments (also known as "nuggets").
- Committee of Visitors reports.
- A database containing the universe of annual and final project reports.
- NSF's Strategic Plan.
- NSF's Budget Requests to Congress.
- Relevant National Science Board reports.
- Special analyses conducted by NSF staff in response to specific questions raised previously (e.g., fate of resubmitted proposals).

The subgroups consolidated their respective preliminary analyses, indicator-by-indicator, into a draft report for discussion of and consideration by the full AC/GPA committee. Similarly, overall portfolio assessments from each subgroup were shared with the entire AC/GPA for discussion. Comments and amendments from any member of the full Committee were then included in these outcome goal “chapters” and subsequently in the final draft report. The final draft was then distributed electronically to each committee member for review and concurrence.

Assessment of the Organizational Excellence (OE) Strategic Outcome Goal

Organizational Excellence (OE) is a specific NSF strategic outcome goal. We appreciate that NSF has included this goal at the urging of the Advisory Committee for Business and Operations (AC/B&O) since it is an important enabling goal for the outcome goals of People, Ideas, and Tools.

The AC/GPA recommended in its FY2003 report that NSF should consider an approach that involved a significant component of “self study.” We envisioned that this would involve a greater number of NSF staff, would be based on NSF’s strategic goals and indicators, would be data driven and would provide key information at multiple levels of detail. NSF adopted this approach for the Organizational Excellence goal. Early on, it was determined that the AC/B&O would provide an assessment of three of the indicators for the OE goal, Human Capital, Technology-Enabled Business Processes, and Performance Assessment. The AC/GPA would conduct an assessment of the Merit Review indicator.

Following a discussion with the AC/B&O in late March, an assessment of the three indicators was prepared by NSF staff and shared with the AC/B&O for review and comment. Subsequently, the AC/B&O held a conference call to discuss the draft assessment, the draft was revised based on AC/B&O comments, and a letter was transmitted to NSF with the results of the AC/B&O deliberations. The AC/B&O supported NSF’s determination that the agency had demonstrated significant achievement for the three indicators it considered. The AC/B&O also made a number of comments to improve the approach, methodology and analysis for the assessment of performance in subsequent years. The letter and the revised assessment are found in an appendix to this report (see Appendix 1). The OE subgroup of the AC/GPA reviewed the letter and the assessment and performed its own review of the merit review indicator. The results of this analysis were presented to the full AC/GPA for its consideration.

FOUNDATION-LEVEL SUMMARY OF NSF FY 2005 INVESTMENTS

The Committee was asked to provide Foundation-level comments on:

- **The R&D criteria of quality and relevance of the award portfolio as reflected by the accomplishments reported in FY 2005.**
- **Transformative/bold/innovative-high risk research and education in NSF's portfolio of accomplishments reported in FY 2005.**

As noted previously, the Committee relied on numerous and varied sources of information to do its work. In addition, because members of the Committee, both individually and collectively, possess deep familiarity with various aspects of NSF's portfolio, the Committee could complement these data sources with its own expertise and experience in crafting this independent assessment.

Quality and Relevance

The Committee concluded that the quality of the NSF portfolio was high in the three outcome goals of People, Ideas, and Tools and that the Organizational Excellence goal demonstrated quality and innovativeness in its activities. The diversity of projects in the research portfolio is remarkable, representing a spectrum of approaches, methods, ideas, and award types. This diversity enables NSF to support a wide variety of performers including individuals, teams of all sizes, and large centers as well as facilities and other infrastructure (defined broadly).

NSF continues to make important contributions toward the achievement of key national goals. It also provides important service to its constituents in the scientific community as well as serving the broader needs of science, engineering and education as human endeavors. In addition, NSF is recognized as a high-performing organization. Its focus on organizational excellence as a strategic outcome goal is a necessary complement to the other goals and will enable NSF to continue to use the nation's investments wisely and efficiently in support of science, engineering, mathematics, and education.

The Committee wants to reiterate again that the synergy of the four outcome goals is a major source of their power. Discoveries at the frontiers of knowledge are both supportive of and dependent on progress in effectively linking education and research, the development of new instrumentation, facilities, and other tools, and the education and training of a highly qualified cadre of individuals motivated and excited by science, engineering, and mathematics. Organizational excellence in people, processes, and assessment enables all three. The Committee felt that it was important to continue to make this point, as it has done previously.

The Committee concluded that the high quality, relevance, and performance of the NSF portfolio are principally due to NSF's use of a rigorous process of competitive merit review in making awards. NSF has continued to make progress in implementing its two principal review criteria – intellectual merit and broader impacts with over 90 percent of all reviews now addressing both criteria. NSF also continues to provide a heightened focus on the use of both criteria by proposers, reviewers, and program officers. The Committee notes that this will continue to be a "work in progress," that is, an ongoing effort that will require constant vigilance by the NSF program staff and further education for the proposing and reviewing community as to the importance of addressing both criteria adequately. Competitive merit review is a key process for ensuring the quality and relevance of research and in maintaining US leadership in many areas of science and technology. NSF and its external stakeholders, both within and outside the Federal government, should work together to resist the corrosive influence of forces that are inimical to merit review. The National Science Board should use its influence to advocate for expanded competitive merit review across the Federal government's research portfolio.

Transformative/Bold/Innovative-High Risk Research and Education

With regard to transformative/bold/innovative-high risk research and education, the Committee saw evidence of accomplishment. NSF itself has sought to clarify the definition of such research using an "operational" approach. NSF asked its program staff to identify projects they believed reflected transformative/bold/innovative-high risk research and education. The agency then attempted to organize the 150 nuggets so identified into a definitive framework with guidance or rubric. The Committee compared this rubric against the proposals and also reviewed comments in the Committees of Visitors reports on this topic. Based on that analysis, the Committee concluded that there is still work to be done in defining what constitutes transformative research. A complete discussion of this issue is found in the Organizational Excellence section of this report. The Committee appreciates the work of the National Science Board on this issue over the past year and looks forward to its efforts to initiate a dialogue with the research and education community.

No matter how much time is spent to carefully and thoughtfully craft a rubric to define transformative research, there is still no empirical way to determine what fraction of the portfolio should be the farthest out on the frontier. This difficulty is complicated by the fact that researchers (particularly academic researchers) don't typically think of their research in terms of its "riskiness" in the sense we are using that word here.

Clearly, the nation benefits and the research enterprise advances when transformative research is part of the equation. However, when COVs were asked to comment on this issue, their responses raised the very issues that we know to be the toughest to address, namely, how do you know this research when you see It?; how much should be funded in a constrained environment?; and, how should the very necessary flexibility of NSF program staff be balanced against what might appear to be a rather conservative merit review process in making investment decisions in favor of such research?

This AC/GPA process looks retrospectively at a year, or two or three, of research progress (as evidenced through the accomplishments). The determination about whether an investment in a proposal has yielded results that could fundamentally transform our understanding of the physical or natural world may take decades. All of NSF's stakeholders, internal and external, would do well to keep that in mind.

Lastly, the Committee notes that NSF will shortly begin the revision of its Strategic Plan. This is the continuation of an evolutionary process that began in the mid-1990's following the enactment of GPRA. As NSF reflects on its progress toward its current strategic outcome goals and whether these (and their associated indicators) merit revision, we urge NSF to give some considerable thought to the concept of "significant achievement." As a committee, we have been charged to make determinations of whether NSF has met this threshold of accomplishment. But "significant achievement" has been, and continues to be, very much in the eye of the beholders – even though NSF has endeavored to provide a wealth of data and information to inform our collective assessment. Over time, and with more and more project accomplishments in the database, the gradation between significant achievement and the lack of it will likely become not only tougher, but also more nuanced. We have no answer today to the question of whether there might be an objective standard (or standards) by which "significant" in the context of achievement might be measured. However, we also know that NSF supports some of the best and most creative individuals working in the area of research assessment and the agency should enlist these people and the broader scientific community in thinking through this issue before the next Strategic Plan is finalized.

PEOPLE Strategic Outcome Goal

The Committee found significant achievement for PEOPLE indicators 1, 2, 3 and 4. However, based on evidence provided, the Committee did not find significant achievement for indicator P5.

Quality and relevance: Based on the review of COV reports and project accomplishments (nuggets), the overall quality of projects was determined to be high and relevant to the People strategic outcome goal. Delivery methods and application of research findings were also found to contribute to the high quality of projects reviewed. Many of the projects reviewed have high relevance to the development of a strong workforce and public understanding of science.

Transformative/Bold/High risk-Innovative projects: Projects contributing to the People goal were found across NSF as evidenced by the breadth of nuggets selected to illustrate significant achievement. Overall, the Committee found ambitious projects that we would consider “bold." One general observation was that high risk or bold projects seemed to be less likely to be funded under the PEOPLE strategic goal.

Other Comments:

Reduced funding: The Committee members reviewing this strategic goal expressed serious concern about the significant decrease in funding for programs that focus on the People Goal. Funding levels for this goal have declined from $1,146,880,000 in 2004 to the FY 2006 Request of $978,770,000. In addition, the number of people involved in or impacted by NSF activities has declined from an estimated 215,350 in 2004 to 168,280 in 2006. This trend should be monitored carefully by the AC/GPA because it could have an adverse impact on NSF’s ability to demonstrate significant achievement in the future. The principal organizational unit within NSF for meeting the PEOPLE outcome goal is the Education and Human Resources (EHR) directorate. This directorate has borne the brunt of the funding reductions noted above. This may have long-term implications for meeting the objectives in the People goal. The Committee recognizes that other directorates within NSF are making major contributions to this goal. However, delegating yet more responsibility for meeting these objectives to other parts of NSF because of budgetary realignments may result in lack of experience and expertise in K-12 education, particularly in programs that sustain high-quality, high-commitment engagement of scientists and mathematicians with students and teachers in classroom settings.

Data Collection and Assessment: Effective assessment should be, at its heart, data-driven. Thus, it is very important to develop simple but effective metrics and to provide data that enable both qualitative and quantitative analyses of progress toward the People goal. This will be critical to establishing a context for future evaluations by this Committee or others of NSF’s level of achievement. The Committee on Equal Opportunity in Science and Engineering (CEOSE) recommended in its 2004 report, *"Broadening Participation in America's Science and Engineering Workforce*,” that NSF should expand its systematic and objective evaluation efforts by continuing to “obtain, refine and disaggregate data and factors related to the participation and advancement of persons from underrepresented groups in STEM education and careers” (Executive Summary, p. 7-8; CEOSE 04-02). We support that recommendation and urge NSF to increase its focus on this issue and to strive to identify those data elements (particularly those collected over a long period) that are the most critical to assessing program impact.

Broadening Participation: It is important for NSF to emphasize that "broadening the participation of underrepresented groups" is not an issue of simple demographics, but of increasing the diversity of *paradigms, ideas, methods, and perceptions* brought to the Foundation's programs. In particular, NSF must develop strategies to ensure that activities aimed at broadening participation are carried out with rigor and attention to high-quality research.

P5 Designation: P5, "Support innovative research on learning, teaching and mentoring that provides a scientific basis for improving science, technology, engineering and mathematics education on all levels," is a research goal that contributes to building a workforce. NSF is encouraged to review whether or not it would be more appropriate under the "Ideas" goal.

PEOPLE GOAL -- Indicator P1: Promote greater diversity in the science and engineering workforce through increased participation of underrepresented groups and institutions in all NSF programs and activities.

Based on the accomplishments provided, NSF devotes a substantial amount of resources to fund projects that contribute to the attainment of the PEOPLE strategic outcome goal as articulated under Indicator P1. Collectively, the projects demonstrate significant achievement toward producing a workforce with strong representation of under-represented groups and women in science and engineering. Within EHR, there are numerous programs that are relevant and contribute directly toward this indicator. In total, the estimation was that 134,050, 113,890, and 86,050 individuals were or will be involved in each of FY2004, 2005, and 2006 respectively. In addition, there are programs distributed across all directorates that support this indicator. Examples include selected projects in the Research Experiences for Undergraduates (REU) (0244221) and CAREER programs. The portfolio of the funded activities is broad. Projects such as the "Valle Imperial Project" and the "University of California Alliance for Graduate Education" range from professional development of K-6 teachers in one of the poorest counties in the country (9731274) to graduating more minority doctoral recipients in STEM fields (0450366), and from increasing ethnic minority student participation at the college level through projects in the REU and Model Institutions for Excellence (MIE) programs ("Research Experiences for Undergraduates in Environmental Sciences at Northern Arizona University," 0244221 and "University of Texas at El Paso's MIE-Supported Academic Center for Engineers and Scientists," 9550502) to reaching out to young women in middle and high schools through the Research on Gender in Science and Engineering program (0080386). Due to adverse funding trends in most of the EHR programs, the level of achievement is expected to decline unless funding in other programs is increase sufficiently to compensate for the EHR reduction.

Some of the ongoing projects address the "pipeline" issue by focusing on K-12 students. Consider the Valle Imperial Project in Science (9731274) conducted by the El Centro School District located in the Imperial County in southeast California. It involves 14 other school districts in the county and the Imperial Valley Campus of San Diego State University. Most of the K-12 students are underrepresented minorities and from low-income families. The project has increased the number of students taking college prep STEM classes and led to tripling the percentage of graduates eligible for enrollment in the University of California system. The Techbridge project conducted by a collaborative partnership based at the Chabot Space and Science Center (0080386), focuses entirely on encouraging more women to pursue science and engineering in a girls-only environment. The approach taken involves exposing the students to experiences and opportunities that are otherwise not available to them. The curriculum developed has been found to produce positive results and is available online (http://www.chabotspace.org/visit/programs/techbridge.asp).

At the college level, there are many projects that aim to increase participation of ethnic minorities in science and engineering. Examples include the "REU: Environmental Science Summer Program at Northern Arizona University" (0244221) and the "University of Texas at El Paso's MIE-Supported Academic Center for Engineers and Scientists" (ACES) (9550502). Due to its location, Northern Arizona University is able to attract a significant number of American Indians to participate in the program. In 2003 and 2004, there were 8 and 10 students, respectively, that attended the program: among the 18 were 14 Native American and 2 Hispanic students. Likewise, the University of Texas at El Paso serves an area with a large Hispanic population. Two-thirds of the STEM students at the university are participating in the MIE-ACES program, which has contributed to a 9 percent increase in undergraduate STEM degrees.

Targeted at the post-baccalaureate level, the "University of California Alliance for Graduate Education and the Professoriate (AGEP) Phase II" (0450366) was initiated in 2004. It involves all 10 UC campuses. Impressive results were achieved in Phase I of this project. There was an average of 131 new minority graduate students enrolled in STEM during 1997-1999. By 2003, the number had increased to 237, yielding an 80 percent increase. Phase II of this AGEP will build upon prior success and has the potential to pose a new model for recruiting, retaining, and graduating STEM minority doctoral degree recipients and assisting with postdoctoral placements.

PEOPLE GOAL -- Indicator P2: Support programs that attract and prepare U.S. students to be highly qualified members of the global S&E workforce, including providing opportunities for international study, collaborations and partnerships.

The success of NSF in meeting the P2 indicator is largely due to the activities of one foundation-wide program, OISE (Office of International Science and Engineering, and its earlier incarnation INT). Of the 46 nuggets listed under "primary indicator" for P2, only 13 -- less than 30percent -- met both the stated criteria for selection, namely that the program attract and prepare US students to science **and** that part of preparing them to be highly qualified members of the global workforce include providing opportunities for international collaboration. Six of those were produced by OISE, with a range of other divisions represented. Exemplary activities recruited and trained students in science and offered them significant opportunities for international collaborative learning. The collaborative elements of these opportunities superseded standard international field practices of the past, in which researchers collected specimens or data abroad, brought them to the U.S., and published without consulting, conferring with, or including colleagues from the host nations.

The Boulder School for Condensed Matter and Materials Physics (0437903) brings together large numbers of graduate students (60 this year) from around the world for summer coursework and lectures. Not only is the student body international, so is the team of presenters brought to the campus. This program meets students at a high level to forge new partnerships, understandings, and research agendas at the frontier juncture of optic, atomic, and condensed matter physics. Another highly interdisciplinary program, PRIME (Preparing

Undergraduates for the Global Workforce in Cyberinfrastructure) of University of California, San Diego (UCSD) (0407508), brings together a smaller number of students at an earlier career stage and across a broader level of engagement. Nine students, 3 of them from the US, studied and worked together on research while immersed in the international environment generated by UCSD partners in the Cybermedia Center of Osaka University (Japan), the National Center for High-Performance Computing in Hsinchu (Taiwan), and the Department of Computer Science at Monash University (Australia). Admission to both these programs is competitive, and PRIME requires participants to return to UCSD in the fall for at least one quarter in order to continue their project work and share their experiences with potential new PRIME students.

Graduate students in the University of Alaska, Fairbanks IGERT program, "Regional Resilience and Adaptation: Planning for Change," (0114423) have done research and helped develop related international policy and legislation with scientific bodies of other governments, namely the Swedish Royal Academy of Agriculture and Forestry and the Alaska Native Science Commission. Graduate students in another University of Alaska, Fairbanks, program have participated in a U.S.-Russia International Volcanological Field School at sites in Alaska and Kamchatka, developing professional relationships with each another as they study the relationships between the two major areas of volcanic activity (0429155). And in yet another variant of this indicator theme (0096097), graduate students at the University of Kentucky and MIT have been able to carry out research in the Japanese university system known worldwide for its leadership in carbon science, as part of a U.S.-Japan collaborative research project that's paid off in numerous publications, conferences, and advancements in carbon science.

The 2002 COV report for OISE (still designated as INT at that time) stated: "INT clearly enjoys a level of impact that goes far beyond its very modest budget. It is exciting to imagine how much greater the impact could be if INT had resources more commensurate with its level of responsibility, particularly for project funding and travel for INT personnel." Given the importance of the P2 indicator in achieving the NSF's strategic People goals, we note with approval that OISE has been given a role as a crosscutting “agent of change” within NSF. OISE’s new organizational position should enhance its success in stimulating international activities across the Foundation.

PEOPLE GOAL -- Indicator P3: Develop the Nation’s capability to provide K-12 and higher education faculty with opportunities for continuous learning and career development in science, technology, engineering and mathematics.

NSF invests in developing the Nation’s capability to provide K-12 and higher education faculty with opportunities for continuous learning and career development in science, technology, engineering and mathematics. Development opportunities are funded over a wide range of programs, and evidence from outcomes reported by projects funded in FY 2005 demonstrate significant achievement in taking a variety of approaches to engage teachers and faculty in quality development experiences across STEM disciplines. Research Experiences for Teachers (RET), the CAREER awards, and the Teacher Preparation Continuum (TPC) are examples at the program level that help achieve NSF's goals.

Some projects connect K-12 teachers with university STEM faculty members through active research collaborations. For example, ”The Alaska Lake Ice and Snow Observatory Network

(ALISON): A Statewide K-12 and University Science Education and Research Partnership" (0326631) at the University of Alaska, Fairbanks Campus, provides teachers at 17 schools around the state with a professional development experience and with researcher mentors, as well as connecting them with other teachers throughout the state of Alaska. This experience with science and professional networks can help alleviate the feelings of isolation common to teachers in rural Alaska, where teacher turnover is high and student populations are largely Alaska Native. Another approach that gives teachers opportunities to do STEM research is seen in "RET Site: Research Experience for Teachers in Areas of Innovative and Novel Technologies in Philadelphia" (RETAIN Technologies in Philadelphia) (0227700) at Drexel University. Providing K-12 teachers with hands-on research and education experiences demonstrated the power of experiential learning in science and engineering. The project also helped participants bridge the gap between technology and curriculum by providing workshops and resources to support curriculum development. Finally, the project has led to a number of other related projects throughout Philadelphia schools.

Other projects are providing a foundation for professional development opportunities. The National Science Teachers Association (NSTA) has a conference grant (0442722) sponsored by the Teacher Professional Continuum program, that is testing a strategy that assembles experts supported by NSF to disseminate their findings that address important questions in K-12 science and mathematics education. The first prototype conference, "Linking Science and Literacy in the Classroom," was offered at the NSTA Regional Meeting in Seattle in November 2004. A total of 375 teachers, administrators and professional development providers participated. Presenters included leading scholars, researchers, and practitioners who described NSF-funded work on the multiple aspects of literacy in K-8 science classrooms. The 30 presenters were Principal Investigators (PIs) or participants in TPC, Local Systemic Change, Teacher Enhancement, Instructional Materials Development, or other related NSF programs that have been researching this high profile topic. Another approach is the Lesley/TERC Science Education Master project (9911770), a national, on-line Master's program for K-8 STEM educators that merges the expertise of scientists and educators, and is carrying out research on the effectiveness of on-line learning. Its enrichment curricula should be flexible to accommodate busy schedules and geographical challenges and must be relevant to the classroom. A total of 380 teachers from 33 states and three countries have participated in one or more courses since the program's inception in Summer 2000. The first graduates were in Spring 2003; 47 teachers have graduated from the program, and currently there are 114 M.Ed. candidates. Leadership is the focus of a third example, the Fulcrum Institute for Education in Science (0412456) at Tufts University, where teachers prepare for roles as school-based intellectual leaders in their fields and catalysts for reforming the mathematics and science programs in their schools. Their schools and districts commit to providing the time and resources commensurate with the positions of increased responsibility that the emerging teacher-leaders are expected to assume upon completion of an Institute program that deepens and updates their content knowledge, instructional strategies and leadership skills.

The Southeast Center for Networking and Information Technology Education, (0071047) located at the Daytona Beach Community College, is an example of faculty development in higher education. The center established a framework for community colleges to collaborate in the delivery of advanced technology faculty development workshops that helps colleges offer courses in the key high demand IT curriculum areas. Based on data from the Florida Community College System, the project's 105 faculty development workshops supported instruction across 557 different course titles within the system since the fall of 2000, benefiting 914 community college faculty members, who in turn teach over 20,000 students annually in the region.

PEOPLE GOAL -- Indicator P4: Promote public understanding and appreciation of science, technology, engineering, and mathematics, and build bridges between formal and informal science education.

The range of accomplishments reported under Indicator P4 show that NSF is investing in effective informal science education materials and incorporating public outreach and dialog into many programs and projects. The accomplishments indicate that NSF-supported activities are reaching large numbers of people of all ages with insights from many fields, including biology, the earth and atmospheric sciences, engineering mathematics, and psychology. The portfolio of work shows a willingness to push the envelope, and is highly multidisciplinary. NSF has reached a level of significant achievement in this area.

One set of channels for informal science education is popular media: television, radio, movies, and the Web. An example of using these routes effectively is the "Magic School Bus," the most successful children's science series in history, with more than 54 million books in print and 52 television episodes (9153967). NSF supported the original development of the series, and more recently funded development of associated bilingual traveling exhibits for children aged 5 to 12 (9627162). The traveling exhibit, which has visited 36 cities in a six-year tour, allows students to explore the dynamics of weather. Other examples of the broad outreach of informal science education include the "Pulse of the Planet" series (heard over 309 broadcast outlets worldwide) (0337143), TV411, for adult math education (0104712), *Under Antarctic Ice*, a program in the PBS Nature series (0000373), "Peep and the Big Wide World," a television series for 3 to 5 year olds that was rated second in viewing audience in its time slot (0104700); and web access to news from Antarctica (0000373). NSF is supporting evaluation of the effectiveness of its informal science education work. For example, visitor impact evaluation of learning outcomes from the Magic School Bus tour indicates that 80 percent of the children who tour the exhibit gain new knowledge about weather dynamics or learn a new weather concept. Follow-up telephone interviews indicated that the children stay interested in the weather several months after their visit. Likewise, evaluation has shown that children who watch *Peep* are much more likely to ask questions and solve problems than those who do not.

Museums also provide an opportunity to engage the public. For example, Martin Luther King Day at the Cleveland Museum of Natural History (0133164) was advertised broadly to 54 municipal schools, plus youth groups, church groups, and recreation facilities. NSF-supported polymer researchers, with their graduate students, put together mini-lectures, displays, demonstrations, and hands-on experiments for the more than 4,000 visitors. Attendance was up 50% from the previous year. Other examples of informal science education through museums include "Go Figure," an exhibit at the Minnesota Children's Museum to engage parents and children in mathematics learning, particularly in underserved communities (9725857); the CAREER program's courses involving undergraduate students in independent historical research at science museums (0134482); engaging the public in botanical gardens through studies of the vanilla orchid (0108100); and an exhibit on "Strange Matter," produced by materials scientists and visited by tens of thousands at New Jersey's Liberty Science Center (0213706).

Science education goes two ways, especially when it moves into communities with special knowledge of the environment. An example is the project "Fire-Mediated Changes in the Arctic

System: Inter … and Human Activities" (0328282). The community of Huslia, Alaska, has been teaching university researchers about how fire affects their community and researchers share what they know about future changes in climate and fire regime. The mutual learning workshops are turned into teaching materials, which are shared with local schools after approval by the Huslia Tribal Council. The elders view the project as one of few opportunities they have to talk to students about traditional knowledge. Other community-based mutual learning projects include the Community Collaborative Rain, Hail, and Show Network on the Great Plains (0229723); *Math in the Garden*, a set of activities that teach math to children and adults in relation to gardening topics (9909764); and a project on well water quality on the Navajo Reservation [0348873].

NSF programs also move into the classroom to spread interest and confidence in science, and move students from classrooms into the laboratory. An example is Project SERVE (Science Enrichment using Retired Volunteer Educators) (0412101), which links senior citizens with young students. A Discovery Corps Senior Fellowship supported the investigator to train senior citizens in age- and pedagogically-appropriate general chemical principles. The senior citizens then volunteer in elementary and middle school classrooms as teacher's aides, tutors, mentors, and resource persons for under-performing students. Other classroom enrichment projects include EdGCM, a global climate model that is run on inexpensive desktop computers (0231400); glassblowing demonstrations for K-12 students at the University of Iowa (9972466); nanoscience made simple for junior-high school students in southeastern Ohio (0304314; femtosecond laser systems at Michigan State for middle school students (0135581); safe racer competitions in Baltimore that involve elementary students in engineering design (9731748); and demonstrations on nanostructured materials and interfaces for K-12 students in Wisconsin (0079983). NSF's outreach in informal science education is even becoming international. The Fab Lab project (0122419) goes into the field to allow participants to fabricate objects at micron size and microsecond speed. This gives participants a hands-on experience with manufacturing components for information technologies, not just with using the technologies themselves. The exhibit has reached many under-served communities, including in rural India, northern Norway, Boston, and Costa Rica. In the past year, it has engaged the public in Ghana, and is working on a collaborative exhibit in South Africa. The worldwide public is also able to participate in LIGO, the Laser Interferometer Gravitational wave Observatory, searching LIGO data through Project Einstein@home (0200852) and web access to real-time Mars exploration (0104589).

PEOPLE GOAL -- Indicator P5: Support innovative research on learning, teaching and mentoring that provides a scientific basis for improving science, technology, engineering and mathematics education on all levels.

As the following five projects show, activity in this indicator area is found within current NSF-sponsored programs. However, these projects were the only ones found within the set of nuggets proposed to satisfy this indicator (56 in the Primary set, 88 in the Secondary). Thus, we conclude that this does not constitute a body of work sufficient to determine that NSF has met the "significant achievement" threshold with respect to this important indicator. Though one relevant COV report (ROLE) from 2002 suggested significant achievement in this area, the paucity of current nuggets seems to contradict this. This lack of relevant nuggets may be due to confusion on the part of program directors as to what exactly this indicator means. The following programs, significant in their own right in terms of quality, relevance, and multidisciplinarity, are involved in the study of individual learning, group/collaborative learning, the assessment of learning, the dissemination of the results of learning research, and the mentoring of STEM faculty.

The work of Robert Sternberg of Yale University (9979843) is focused on the methods or "modalities" of individual learning through triarchic instruction and assessment. Sternberg's work suggests that individuals learn through a combination of three approaches: creative, analytic, and practical thinking. By training elementary school teachers in this "Triarchic" theory, Sternberg is helping them to recognize the learning patterns of their students and to tailor their lessons to the individual student' needs. Work is also being carried out to better understand how STEM students learn in groups. Gerry Stahl of Drexel University (0325447) is studying how math students utilize the Internet to work together to solve problems. By collecting and analyzing records of student problem-solving chat groups, Stahl hopes to develop a theory for how students best learn in such situations and to disseminate this information to mathematics teachers world wide.

A fundamental problem in pedagogical research is that of assessment. It is crucial to the scientific study of learning that new and innovative teaching techniques be assessed. One NSF-funded project aims to improve upon current assessment techniques. Tiffany Koszalka of Syracuse University (0335644) is leading an attempt to understand and assess how practitioners of a field move from novice toward expert-level problem solving abilities. By discerning the thinking and decision making methodologies followed by experienced practitioners, the "Enhanced Evaluation of Learning in Complex Domains" (DEEP) project hopes to improve the methods of assessing the learning of novice and intermediate-level practitioners. However, individual results from pedagogy research can only be useful to the teaching community at large if they are efficiently disseminated. This is the goal of the project, "Program Evaluation for the Math and Science Partnership" (0456995). This partnership of related programs, known as the MSP Learning Network, is developing a community of connected researchers, allowing them to quickly and easily share their results. Through the building of electronic communities and digital databases, the results of learning and pedagogy research are being made available to K-12 teachers, college faculty, and the technical/scientific community at large.

Lastly, it is important to the success of new pedagogical initiatives that those involved in the teaching be actively mentored. The project, "SOMAS: Support of Mentors and their Students in the Neurosciences," led by Julio Ramirez of Davidson College (0426266) has received funding to both allow junior STEM faculty to involve undergraduate students in their research activities and to bring these students together with mentors to help the mentors make the most of their pedagogical opportunities. The SOMAS project aims to assist junior faculty in integrating students into their scholarly activities thereby improving the students' oral, written, and cognitive skills and making them much more likely to succeed in their programs.

IDEAS Strategic Outcome Goal

The Committee concluded that there has been significant achievement in all indicators of the IDEAS strategic outcome goal, which is to foster "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society." The Committee concluded that NSF had met the goal for each indicator in making investments in discovery, collaborative research and education, connections between discoveries and their use in society, increased opportunities for underrepresented individuals and institutions, developing new research and education opportunities, and creating new integrative and cross-disciplinary knowledge and tools. It is worth noting that our determination of "significant achievement" is, in large part, a reflection of the fact that the ideas embodied in the projects in this portfolio are themselves significant – that is, of high quality and relevance.

Whether we consider engineering, life sciences, physical sciences, social sciences, or information technology, it is apparent that NSF-sponsored research is having a significant impact on our nation and world today and shows every indication of continuing this into the future. The challenge for the Committee in this strategic outcome goal was in selecting a relatively few nuggets from the vast array of very fine projects from which to choose. For each of the six indicators, the accomplishments were chosen to illustrate the breadth and depth of NSF's portfolio with special emphasis placed on the important objective of broadening participation.

IDEAS in themselves are the essence of the research and education mission of NSF. Themes emerged in the arena of IDEAS many of which involve enhanced interaction between scientists and engineers, especially across broad areas within the life sciences. For example, the potential of nanotechnology coupled with the biological sciences is generating research projects that hold significant potential for understanding and improving the human condition. Applications of engineering principles and practices to the environment are now yielding new ways in which we can temper the effects of natural forces such as earthquakes. These themes illustrate the power that multidisciplinary research can have on approaches to answer questions that could not previously be addressed.

Perhaps one of the most powerful illustrations of the potency and efficacy of NSF sponsorship comes from an analysis of funding for Nobel Prize winners. In 2004, Kydland and Prescott won the Nobel Prize in Economics. Both were beneficiaries of NSF support throughout their careers, such as "Studies in Aggregate Analyses" (0422539), and winning a Nobel Prize is further validation of the quality and relevance of NSF-sponsored research. Remarkably, within economics, the NSF has sponsored research for 32 winners of Nobel Prizes.

To broaden participation, the Foundation has supported international collaborations, often involving cross-cultural and crosscutting experiences for investigators and students in particular. For example, there are large and important societal benefits as well as scientific benefits that have been gained from NSF support to send teams of investigators to Africa to investigate ways to preserve and propagate endangered wild animal species. NSF has also significantly increased opportunities for underrepresented individuals to participate fully in the research enterprise embodied in the IDEAS portfolio. Several themes emerged, including projects to improve the access to STEM by disabled persons; culturally-based learning projects that utilize the student's life experience and culture as jumping-off points for hands-on learning; CAREER awards that provide the groundwork for highly successful careers; and the strong coupling between outstanding science and thoughtful mentorship in NSF projects.

Thus, NSF's portfolio of accomplishments in the IDEAS strategic outcome goal exhibits both exceptional quality and high relevance to important national goals. In addition, the Committee found numerous examples of "transformative/bold/innovative-high risk" research in the IDEAS portfolio. A more in-depth discussion of this topic is found in the section on the Organizational Excellence strategic outcome goal.

IDEAS GOAL -- Indicator I: Enable people who work at the forefront of discovery to make important and significant contributions to science and engineering knowledge.

The NSF was established as the "patron of pure science." Therefore, researchers who work at the forefront of discovery are the best candidates for NSF support and are the most likely to receive it. We find that NSF support has been critical to enabling researchers be in the vanguard of those at the frontier. There are numerous examples of major results and below we summarize a few examples that give a sense of the wide breadth and significance of NSF support.

The "Biomechanics and Hydrodynamics of Fish Locomotion" research focuses on the analysis of the motion of fish fins and the resulting propulsion and positioning accuracy using techniques from fluid engineering (0316675). One goal of this research is to apply this knowledge to man made vehicles that at present have several limitations. Recent findings show that 1) fish can extract energy from high-speed turbulent flows and thus maintain position using minimal muscular energy; and 2) fish use several fins simultaneously to generate discrete vortex rings allowing them to achieve fine positional control.

After devastating earthquakes in Turkey and Taiwan, the NSF funded several reconnaissance missions including the project, "Ground Improvement Techniques Shown to Mitigate Earthquake Damage" (0085281). This work investigated the performance of sites that had been improved prior to construction to reduce the liquefaction potential of these sites. The study demonstrated that ground improvement was effective in mitigating earthquake-caused damage and in particular was the first to verify that closely spaced jet-grout columns worked well. Although these techniques have been widely used, this work is first to give evidence of the effectiveness in an actual earthquake. This work has immediate application to the design and implementation of these techniques in the U.S. and worldwide.

"How Does the Brain Overcome Obstacles to Successful Memory Performance? Insights from Studies of Prefrontal Cortex and Interference Resolution" has helped to increase our insight on neuroimaging of cognitive and mnemonic control (0401641). When we try to remember a particular piece of information – like the location of our parked car – there can be interference in the brain due to the recalling of memories having been associated with previous parking situations. This work performed several studies using functional magnetic resonance imaging that established a correlation with activity in the left ventrolateral prefrontal cortex and the interference of memory. This research is important in trying to further understand and hopefully improve memory performance.

There has been a long standing mystery in understanding the seismic data that have been collected from the layer between the outer liquid core of the Earth and the inner mantle at a distance of about 2,700 kilometers below Earth's surface. This boundary is called the D'' layer. The "Inner Earth Revealed" team supported by the NSF analyzed x-ray images of perovskite taken at the high pressure and temperature expected in the D'' layer and found a new type of structure that will explain the previous data (0135533, 0215587, and 0230319). This discovery will allow better understanding of the of Earth's interior.

Researchers on "Nanotube Membrane Mimics the Functions of the Biological Cell Wall" created a working synthetic membrane made of 8 to 12 nanometer gold nanotubes deposited on a polycarbonate template (9987646). They verified that this membrane did function like cell membranes in recognizing and allowing certain DNA segments to pass more easily than others. This multidisciplinary project uses a chemical model to mimic a biological cell membrane. Such membranes could be useful for DNA separation and/or genomic research.

IDEAS GOAL -- Indicator I2: Encourage collaborative research and education efforts across organizations, disciplines, sectors and international boundaries.

There were many examples of projects that met many (or even all) of these goals simultaneously. The project accomplishments that were chosen represent the range of goals captured in this indicator. Additionally, projects were chosen to represent a range of subjects and societal needs.

One outstanding example is the project, "A Sex Pheromone Elicits Distinct Behavior in Male African Elephants," which is multidisciplinary in nature, involving the collaboration of Principal Investigators with different training from three universities across the US (0216862 and 0217062). In terms of education, this project serves not only the graduate students who are about to become professionals in their fields but also creates excellent opportunities for the succeeding group of students, the undergraduates. The project is international in nature, involving the cooperation of international organizations and governments and could not be successful without it. Additionally, this research has the potential for preservation of the African elephant, an endangered species, and therefore maintaining current levels of biodiversity.

Another excellent example is a project, "U.S./Africa Materials Institute" (0231418), in which chemists, materials scientists and biomedical researchers from US universities and organizations join with their counterparts from several African countries to conduct research on improving early cancer detection. Successful treatment of cancer depends in part on its size at detection. Current imaging techniques can resolve tumors a few millimeters in size. So far, the team of scientists working on this project is able to detect tumors that are a fraction of a millimeter. This has untold benefit for the treatment of cancer. The multidisciplinary, collaborative and international nature of the project is clear. One of the interesting (unusual) aspects of this project is that the education is not occurring at the university student level but at the level of the research scientists. And it involves a transfer of information from the African scientists to the US scientists and vice versa. More often the transfer of information is from the US to the lesser-developed region. This research provides opportunities that would be otherwise difficult for the African scientists to access and has beneficial effects on the field of health and medicine in the US and Africa (and potentially the world).

The project, “Beetles and Their Yeast Endosymbionts From Basidiocarp Habitats,” is multidisciplinary and collaborative at the U.S. university level but not at the international level (0072741). Although its scientific basis is sound and interesting, it was chosen as an example of a project that has a very strong undergraduate student component, a commitment to entraining minority students, and outreach to elementary and secondary students. Undergraduate students participated in science at field sites, where they identify, collect and preserve biological specimens -- an invaluable experience. The involvement of undergraduates, minority students and students at earlier stages of their education has important long-term benefits for the students in particular and science in general.
Note: the tenses need rationalizing here – they should all be in the past (‘participated’) or in the present (‘identify, collect, preserve’_). I would choose the past since we were looking at accomplishments.

The “Puerto Rico Collaborative for Excellence in Teacher Preparation” (PR-CETP) project is different from the mainstream. It does not focus directly on scientific research; rather, it focuses on the training of the teachers who deliver the scientific information to pre-university students (0331998). It involves the cooperation of university and K-12 teachers. This effort is notable because of its focus on improving education at the earlier stages of the learning process. Teachers are better prepared which means that students entering university would be better prepared. This bodes well for the ultimate advancement of science.

The “Children’s Research Initiative” (CRI) researches routine tools used by wild Capuchin Monkeys (0125486). It meets each of the goals outlined above. It stands out from the rest of the group because it is an excellent example of research led by a female Principal Investigator and it has the potential for understanding further the links between humans and other primates. This research examines the use of tools by the wild capuchin monkeys and is an opportunity to study the development of this behavior, which was once thought to be peculiar to humans.

IDEAS GOAL -- Indicator I3: Foster connections between discoveries and their use in the service of society.

One of the goals of the NSF is to build and foster connections between research that leads to new discoveries and the societal benefits of these discoveries. What is truly impressive about the breadth of research sponsored by the NSF in this regard is that it is both broad and deep, from large-scale studies that examine carbon cycling in our oceans to improvement of cities at risk for massive earthquake damage.

The project accomplishments selected to illustrate the impacts of NSF-sponsored research in this area include:

1. A Long-Term Ecological Research (LTER) grant, “Plum Island Sound Comparative Ecosystem Study (Pisces) Effects of Changing land Cover, Climate and Sea Level on Estuarine Trophic Dynamics,” that involves an investigation of the contribution of dissolved organic matter from living organisms to the overall carbon cycling within deep oceans (9726921);

2. “Intrusion Detection Techniques for Mobile Ad Hoc Networks,” a project involving student participation at many levels, has led to advancements in wireless security technology that have the potential to be developed for use at very low cost (0311024);

3. The project, “Earthquake Engineering Research Center” had direct applications in improving the ability of the critical infrastructure of the city of San Francisco to withstand significant earthquake activity (8607591);

4. “Organic Materials of Intermediate Dimensions for Optoelectronic Technologies” is a project that has led to the discovery of new optoelectric capabilities for building sensors for the detection of individual viruses or bacteria, a technology that may prove critical in the area of homeland security (0097611); and

5. The project, “Dynamic Employer-Household Data and the Social Data Infrastructure,” is a sociological and economic analysis of means whereby low-income women, the employment rates of whom have reached all-time highs, can be encouraged by policymakers to pursue strategic job ladders that move them out of poverty (9978093).

Each of these projects has a direct impact on an area or areas that have in recent years been identified as a national and/or regional priority. Indeed, several of these illustrate the global nature and potential effects that research in the areas of critical technologies or sociological imperatives can have.

There is relevance and high risk in each of the examples cited above. The impact of the large, multidisciplinary initiatives such as LTERs and ERCs is unquestionably enhanced well beyond the individual sum of the parts involved. The marriage of life sciences with engineering expertise provides a particularly potent approach to formerly intractable problems and is yielding promising results. Moreover, in the case of the fifth example cited above, the potential impact on society at large of the novel approach of focusing on employer strategies and practices rather than on employee characteristics has the potential to transform how we craft future social policies and manage workforce and workplace issues.

IDEAS GOAL -- Indicator I4: Increase opportunities for underrepresented individuals and institutions to conduct high quality, competitive research and education activities.

NSF programs such as the Louis Stokes Alliances for Minority Participation (LSAMP), Centers of Research Excellence in Science and Technology (CREST), Alliances For Graduate Education and the Professoriate (AGEP), the Minority Postdoctoral Fellowship Program, and Research Experiences for Undergraduates have historically provided a stimulus and increased opportunities for women and underrepresented minorities to participate in all stages of the research process. These programs have been successful, and now NSF’s portfolio contains a number of examples of projects that involve the full participation of underrepresented individuals and institutions in the generation of ideas. Several overarching themes emerge, including: a) improved access to STEM (science, technology, engineering, and math) by disabled persons; b) culturally-based learning projects; c) CAREER awards that have provided the groundwork for highly successful careers of underrepresented minorities; and d) the coupling of outstanding science and strong mentorship.

A number of projects involved the improved access to STEM by visually and hearing-impaired persons, with a cluster of projects addressing the needs of blind persons. Involving a totally blind graduate student researcher, the project “Automated Tactilization of Graphical Images: Full Access to Math, Science, and Engineering for Blind Students” aims to automatically create tactile versions of maps, charts, graphs, diagrams, and other images that are found in math, science, and engineering textbooks (0415273). This is an important problem, as the creation of tactile representations of data is very time and labor intensive. Another project, “Exploring New Geometry by Touching, Seeing, and Feeling,” explores new geometry by touching, seeing, and feeling has similar goals (0430730): it combines computer graphics with 3D computer haptics (which imitates the 3D sense of touch) to enable blind persons to perceive geometric shapes including self-intersecting surfaces. Finally, working under the mentorship of the PIs of the “Engineering Research Center for Biomimetic Microelectronic Systems” at the University of Southern California (0310723), a high-school student won the top prize at the 2004 Orange County Science and Engineering Fair for her project, “Intraocular Camera for Retinal Prostheses: Restoring Vision to the Blind.”

Culturally based learning projects are providing a novel approach to the inclusion of underrepresented minorities in competitive research and education activities. A new paradigm is emerging, one that involves the student in STEM by using the student’s life experience and culture as a starting point. Examples include a project, “Agricultural Science Summer Undergraduate Research Education and Development Project” (ASSURED) (0244179), in which the children of migrant workers, who have spent their youth harvesting onions and chili peppers in the field, are now studying these plants in a laboratory. They are looking at ways to improve yield and to understand fundamental characteristics of the plants at the genomic level. Developed in cooperation with Yup’ik Eskimo elders, another project, **“**Improving Alaska Native Elementary Students’ Math Performance” (0138920 and 9618099), produced a culturally based mathematics curriculum for elementary school students. As an example, students learned the mathematical properties of shapes that they made as bookmarks. Students participating in this curriculum had significantly higher test scores than those students in the standard curriculum.

Similarly, there is another project, “Sustainability and Stewardship in Alaska,” that addresses Alaskan Natives and is organized along lines parallel to NSF's Integrative Graduate Education and Research Traineeship (IGERT) program but is focused on undergraduate education and research (0331261). This undergraduate to graduate pipeline approach invigorates the students by infusing them with real-world research concepts. They participate in hands-on research involving the integration of natural and social sciences for natural resource conservation. The focus is on sustainability and stewardship of the land.

Women and underrepresented minorities who have received NSF CAREER awards are making significant contributions to STEM and are becoming outstanding mentors, as well. For example, Janice A. Hudgings developed a 2-D thermoreflectance microscopy technique that enables thermal measurement of optoelectronic devices on the nanoscale in the project, “High Performance Thermal Profiling of Photonic Integrated Circuits” (0321449 and 0134228). She established the first engineering and physics research lab at Mount Holyoke College, an ideal context in which to encourage a diverse group of women undergraduates to participate in science and engineering. To date, 19 women have performed independent research in her lab, nine of which are underrepresented minorities.

Kathleen Pickering is using the Pine Ridge Lakota Indian Reservation as a starting point to study how pre-industrial indigenous societies organized economic production on a "subsistence" level, based on the family and different from that of market-based industrial capitalism in “CAREER: Cash and the Social Economy of the Pine Ridge Indian Reservation: Labor Allocations, Consumption, and Economic Development on the Periphery” (0092527). Her research advances theoretical understandings of the subsistence-market distinction, trains students in research design and methods and encourages local Lakota students to consider advanced studies at the university.

CAREER awardee Kim Venn, in collaboration with researchers at University of Texas at Austin and University of Texas, El Paso, has analyzed the chemical composition of stars in a sample of local dwarf galaxies and compared them to published datasets for stars in the Milky Way in the projects, “The First Stellar Abundances in Local Group Galaxies” and “Collaborative Research: Chemical Evolution Beyond the Milky Way” (0306884, 0307534, and 9984073). They find distinctive differences; their results challenge basic ideas about the formation of galaxies.

Finally, CAREER awardee Kristi Anseth of the University of Colorado, Boulder, received the 2004 Waterman Award, which is the highest prize the NSF offers to scientists from all fields who are not more than 35 years old and seven years since their doctorate. In her pioneering work in the field of tissue engineering, “CAREER: Photocrosslinkable Polymers for Fracture Fixation” (9734236), she created polymeric scaffolds that serve as specific templates for the attachment, growth, and proliferation of cells, and has also developed novel polymeric materials for the fixation of fractured bones.

A number of projects illustrate that strong mentorship, especially by and of women and underrepresented minorities, is a very positive by-product of outstanding STEM accomplishments. For example, Casonya Johnson is a female African-American who, after graduate and post-doctoral work at the Johns Hopkins University, returned to her alma mater, Morgan State University, where she serves as an important role model for her students. Her research involves functional characterization of a novel class of genes, discovered through analysis of the *C. elegans* genome sequence. Her project, “Genetic and Molecular Characterization of Dual HLH Domain Proteins in *C. elegans*” (0212336), supports the integration of quality research and education at a historically black university.

Two of the graduate student researchers in Frank Bates’ (winner of the prestigious Turnbull Award of the Materials Research Society) laboratory at the University of Minnesota who contributed to the discovery of a totally new phase in soft matter were African Americans. The project team for “Phase Behavior and Network Morphologies in ABC Triblock Copolymers“ (0220460) synthesized tri-block copolymers, in which the three molecular components segregate themselves into continuous nanoscale pathways that are intertwined in a regularly structured way. In this manner they may find unique applications as membranes, templates, or composites. These students now have outstanding careers in industry and academia.

Using nanoparticle-mediated assembly of crystals, Jennifer Lewis at the University of Illinois at Urbana-Champaign has reported, for the first time, a new directed-assembly route that allows for the creation of crack-free, single region (or domain) colloidal crystals of high quality. Her research, “Novel Colloidal Routes to Photonic Band Gap Materials” (0071645), may lead to new optical devices for chemical/biological sensing, optoelectronics, optical computing, and telecommunication networks.

IDEAS GOAL – Indicator I5: Provide leadership in identifying and developing new research and education opportunities within and across S&E fields.

NSF supports a broad array of research projects that promote the identification and development of new research and educational opportunities in science and engineering fields. Many of the projects demonstrate leadership and novelty and represent new and ingenious ways of approaching research. Much of the work in this indicator is interdisciplinary, requiring input by a number of researchers from different areas. Further, many of the studies involved a combination of fundamental and applied research with high potential for practical outcome.

For example, NSF funded, "Renewable and Resource Efficient Composite Materials for Affordable Housing" (0229731), the research of Professor Chandrashekhara at the University of Missouri, Rolla, and his team of mostly undergraduate students to develop new fiberglass-epoxy composite materials from soy products. These materials are suitable for structural use in floors, roofs, and walls and in the form of a foam for use in insulation panels. This project delineates an innovative approach to utilizing a waste product to form low cost and environmentally friendly construction materials. This creative research involves a multidisciplinary team with backgrounds in polymer chemistry, composite manufacturing, structural mechanics and environmental engineering.

Another project, "Multiscale Virtual Reality of Diffusion-Induced Deformation Processes" (0313346), an Information Technology Research (ITR) project, shows leadership in developing a novel approach to educating today's students for tomorrow's jobs by supporting the development of joint doctoral programs between San Diego State University and the University of California, San Diego (in applied mechanics and materials science) and between San Diego State University and Claremont Graduate University (in computational materials science). These joint doctoral programs provide a link between research universities with those more oriented toward teaching and community service-based education. These programs will produce students who are well versed in the technological challenges of today while being equipped with an extensive background in the fundamental sciences. Both joint programs enhance the flow of innovative ideas that will provide San Diego's booming technology economy with a more creative and inventive workforce.

A project led by Kenneth Beard at the Carnegie Institute, "Investigating the Origin and Early Evolution of Primates in Asia" (0309800), challenges earlier interpretations whereby most or even all of the major events in primate and human evolution were thought to have occurred in Africa. The team has uncovered evidence for a broad range of early primates in Asia, including the oldest and most primitive primates and anthropoids yet to be discovered. This project has attracted a substantial amount of attention from popular media and has fostered international collaborations among American, Chinese, French, Thai, and Burmese scientists. This research demonstrates leadership because it challenges the long-held hypothesis that primate and human evolution took place only in Africa. This work has the potential to change the way we think about where the evolution of humans began.

Research by Caroline Ross and colleagues at Massachusetts Institute of Technology on controlled self-assembly of nanostructures, "Nanostructured Surfaces with Long-Range Order for Controlled Self-Assembly" (0210321), a Nanoscale Interdisciplinary Research Teams (NIRT) project, is hoped to generate a set of methods and processes to impose precise long-range order nanostructure arrays over large areas. These methods are designed to be scaleable and compatible with low-cost, high-volume manufacturing. The educational goals of this work are to contribute to the public understanding of nanotechnology and to the training of skilled researchers.

Another project that demonstrates significant leadership is one that engages diverse students in developing nuclear physics tools for unraveling the mysteries of subatomic particles, **"**Precision Measurements with Pions **"** (0354808, 0245407, and 0114343). This work is a collaboration involving three interactive projects: Research in Intermediate Energy Physics, Study of Electromagnetic Structure of Light Pseudoscalar Mesons via the Primakoff Effect, and Center for the Study of the Origin and Structure of Matter. This collaboration includes several Historically Black Colleges and Universities (North Carolina A&T and Hampton University), as well as scientists from China, Russia, Ukraine, Armenia and Brazil. Undergraduate and graduate students from five different universities have been involved in the project. This effort brings nuclear physics to students often underrepresented in this challenging area.

A team led by S. J. Yoo at UC Davis is working on a project, “Protocol Agile Optical Networking for the Next Generation Internet” (9986665), that explores new research opportunities in high-speed optical networking by creating new switching technologies. This project contributes to knowledge in the area of networking architectures by developing and demonstrating a new optical networking approach. This new networking technology can be integrated with campus networks to form the basis for future cyberinfrastructure. This research group is committed to integrating research and education and has directly trained 14 graduate students and educated 150 graduate and 250 undergraduate students.

IDEAS GOAL – Indicator I6: Accelerate progress in selected S&E areas of high priority by creating new integrative and cross-disciplinary knowledge and tools, and by providing people with new skills and perspectives

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The NSF supports a wide variety of projects that create new integrative and cross-disciplinary knowledge while providing researchers with new skills and multi-disciplinary perspectives.

One extremely innovative project fosters cross-disciplinary knowledge by developing a new graduate program in astrochemistry at the University of Hawaii, “Untangling the Energetics and Dynamics of Atom-Radical and Radical-Radical Reactions” (0234461). This project is the first of its kind in the United States and has been spearheaded by Ralf Kaiser, an assistant professor and CAREER awardee. This program features a curriculum that relates chemical dynamics to astrochemistry, planetary sciences, laboratory astrophysics, astrobiology, and combustion chemistry in reaction dynamics and astrochemistry. Participating units include the Department of Chemistry, the Department of Physics & Astronomy, the Institute for Astronomy (IfA), the Hawai'ian Institute of Geophysics and Planetology (HIGP), and the Astrobiology Institute (NAI).

In the interest of fostering highly integrative knowledge exchange, NSF supported a project that utilized a series of workshops aimed at unifying the cross-disciplinary knowledge of complex networks in order to generate a text describing that nascent field, **"**First Crossdisciplinary Text on Optimal Adaptive Management of Complex Systems,” (0223696 and 0224592). These workshops, organized by Jennie Si at Arizona State University, brought together experts in neural networks, control theory, operations research, artificial intelligence, electric power and fuzzy logic. The new text focuses on adaptive systems that learn to optimize performance with foresight to manage complex systems prone to unexpected disturbances like power grids, critical infrastructure and financial systems.

William Kaiser from UCLA is building a networked infomechanical systems (NIMS) robotic sensor system to operate continuously in the forest at the James San Jacinto Mountain Reserve that will provide accurate environmental (0331481). NIMS systems have generated the first three-dimensional characterization of solar radiation on the space and time scale of forests, waterways and wetlands. These new robotic sensing systems are suspended on cable infrastructure and may move, sense, draw water samples from a stream, or collect images high in the forest canopy while responding suddenly to events by moving immediately to acquire detailed imaging of compact objects at centimeter ranges. NIMS research is a convergence between the computer science and engineering fields of networked sensing and robotics along with the science application fields of biology and public health that enables fundamental investigations of ecosystem energy, water and carbon budgets critical to global change. The NIMS project includes a summer REU program involving students from universities throughout the U.S.

The Particle Engineering Research Center (PERC) at the University of Florida is developing a major new alternative drug transport technology (9402989). This involves collaboration between chemical engineers, materials scientists, and pharmaceutical researchers. This technology is designed to deliver drugs specifically to diseased cells, thereby greatly reducing doses needed by patients while providing a more effective treatment. Potential applications include drugs used to treat life-threatening human maladies such as cancer, heart disease, and AIDS. This significant new application of nanotechnology is the result of a multi-disciplinary team working in an Engineering Research Center.

NSF is taking the lead on supporting a collaborative research platform of geographically distributed infrastructure that will be connected via information technology to address pressing environmental questions on regional to continental scales. The National Ecological Observatory Network (NEON) will be a large-scale multi-disciplinary effort led by the American Institute of Biological Sciences that involves biologists, engineers, computer scientists, social scientists and educators in a collaborative effort. NEON will generate knowledge of complex environmental processes by applying emerging sensor, analytical, communication and information technologies to investigate the structure and dynamics of ecosystems and to forecast biological change, such as in the project, “Infrastructure for Biology at Regional to Continental Scales” (0229195). Example environmental questions that will be addressed include evaluating the ecological effects resulting from climate-driven changes on global water and carbon cycles and the emergence of infectious diseases and invasive species resulting from anthropogenic activities.

TOOLS Strategic Outcome Goal

The Committee concluded that there has been significant achievement in all indicators of the TOOLS strategic outcome goal. The Committee also concluded that the projects contained in the TOOLS portfolio exhibit both high quality and high relevance to important national goals.

Innovative/High-Risk /Bold Research: A more thorough discussion of this issue is found elsewhere in this report. However, the Tools subgroup endorses the definitional efforts of the Organizational Excellence Subgroup on this topic. Additionally, we offer three observations:

- First, it may be useful to look at NIST's ATP (Advanced Technology Program) risk rating system, which has been developed over years of experience.

- Second, one of the mechanisms used by NSF to encourage "bold" research, Small Grants for Exploratory Research (SGERs) is not, in our view, effectively addressing the innovative research issue. Although program officers have considerable latitude to employ SGER grants to foster innovative research to counter what might be unwarranted caution in review panels, in fact SGERs are used relatively rarely. Foundation-wide, divisions may use up to 5 percent of their budget on SGER grants, but in reality only 0.4 percent of these budgets are used in this way. In our view, SGER grants are not a significant fraction of the overall portfolio therefore, they may not be playing a significant role in increasing the amount of highly innovative research. The reason(s) for this is (are) unclear. We encourage NSF to re-examine the purpose and use of SGER grants.

- Third, it does not appear that clear data exist which demonstrate that NSF either does or does not fund enough innovative research. With respect to the TOOLS portfolio, we found that many of our nuggets indeed reflected bold/innovative research efforts. On the other hand, some directorates that use a number of different mechanisms may not be making such awards with a full understanding of the implications for the entire portfolio, or, conversely, may not be using the full suite of mechanisms available to them to encourage and fund innovative research efforts. The bottom line is that it is important to have a clear definition in hand as the necessary precursor to collecting reliable data to form a more accurate picture of the portfolio mix with respect to innovative or transformative research.

Multidisciplinary Research Projects: More and more, forefront science sits between traditional disciplines, and some of the more innovative ideas involve investigators from very different fields collaborating on "terra incognita." NSF has a structure that, for the most part, has been established to fund single principal investigators. While many of the new, targeted solicitations and priority areas encourage or require multidisciplinary activities, these are often short-lived programs (e.g., Information Technology Research, Nanoscale Science and Engineering, and Biocomplexity in the Environment). We encourage NSF to develop ways to encourage and fund multi- and/or inter-disciplinary activities through its ongoing programs. .

We point out the difficulty of parsing projects to fit into a single indicator "box". Many of the large, NSF-funded centers and networks impact many indicators not only in the TOOLS strategic goal, but sometimes including indicators from the IDEAS and PEOPLE strategic goals. The Network for Earthquake Engineering Simulation (NEES) is an example. Since we will refer to it several times, to minimize repetition in the text, we describe it here, before we turn to the individual indicators.

From the Pacific coast to our nation's interior, more than 75 million Americans in 39 states live in towns and cities at risk for earthquake devastation. While scientists are digging into the origins of seismic waves, engineers are pushing the boundaries of design to create structures that remain safe when an earthquake ultimately occurs. The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) (0126366, 0117853, and 0402490) integrates 15 experimental facilities located at academic institutions across the United States, including shake tables, geotechnical centrifuges, a tsunami wave basin, large strong floor and reaction wall facilities with unique testing equipment, and mobile and permanently installed field equipment.

NEES is a major state-of-the-art facility and important for the discipline (Indicator T1). Indeed, it goes beyond the state of the art in developing the prototype of next-generation ways of doing science (Indicator T2). It is a distributed "virtual instrument" for earthquake engineering research (www.nees.org). It has enabled a large community of earthquake engineers, computer scientists, and other disciplinary specialties to share resources in a unique way. It provides the necessary tools for remote data acquisition, for sharing data through metadata management software, for remote simulations, virtual laboratories, even for telepresence. The interface is friendly enough to support K-12 teachers and be usable by the general public. This effort is serving as a model for other distributed scientific instrumentation. As such, it demonstrates the potential for cyberinfrastructure (Indicator T3) to transform the way that researchers do research and that teachers teach.

Other Important Issues

Expanding the NSF community beyond research-focused institutions: In the past, research-focused institutions have stood out as being the primary recipients of NSF funds. In order to meet the future needs of the nation for scientists, engineers, and technically trained people, NSF must redouble its efforts to expand its constituency to include predominantly undergraduate institutions (typically teaching-intensive) and minority-serving institutions as well as research-focused institutions. NSF has made significant progress on building infrastructure capacity at many of these other types of institutions. However, it is clear that a primary barrier to making continuing progress towards enhancing the research capacity at institutions educating a large percentage of underrepresented groups is the high teaching workload of faculty at these institutions. The NSF should examine the relative balance of its investments in aimed at enhancing infrastructure, encouraging student pursuit of STEM fields, and supporting the professional development of faculty in the community colleges, predominantly undergraduate, and minority-serving institutions.

Sustainability: We continue to be concerned about the sustainability of a number of the tools developed with NSF funding. This issue was also raised by several COV reports that we reviewed. For example, databases whose collection, organization and initial presentation, often on web sites, must be maintained after the duration of the grant or upon departure of a PI, graduate student or other technical staff from the institution that hosts that database. Another example would be facilities that are funded and built to provide access to a user community, but then the funding is reduced or eliminated either due to termination of the program (for example, large projects funded by Information Technology Research) or funding cycle. The accomplishment descriptions of the various projects mentioned in our report do not provide any indication about what the institution will do when the NSF funding runs out. We suggest that merit review panels should, where appropriate, consider the quality of the proposer's plan for the long-term sustainability of the site or facility.

TOOLS GOAL -- Indicator T1: Expand opportunities for U.S. researchers, educators, and students at all levels to access state-of-the-art S&E facilities, tools, databases, and other infrastructure.

NSF supports and provides a wide variety of accessible, state-of-the-art science and education facilities, tools and infrastructure, and in most cases is the only support for such instrumentation in academia. These tools provide opportunities for researchers, educators, students, citizens and policymakers. NSF supports large state of the art facilities, and nearly all of the US's land based astronomical facilities, and tools that push the forefront of science and engineering. It supports databases and acquisition/analysis software that present and synthesize large amounts of data collection by numerous researchers around the US and the world. Through a variety of funding mechanisms on different scales, NSF addresses both the needs of researchers to have and develop facilities and infrastructure that enables scientific discovery and educators to develop innovative means of disseminating science to students and the public. NSF has made a significant achievement with respect to indicator T1. A selection of examples follows:

Through FabLab, which is an educational outreach component (0122419), the Center for Bits and Atoms provides outreach facilities to bring the ideas of fabrication and micro-manipulation to the US public and includes modules in Kenya and South Africa. The tools of this large center are made available to the public through these activities and the Fab Lab serves as a model for Centers that are more than the total of all the science that occurs there because the science is disseminated and brought to the public in meaningful, hands-on methods. CBA's laboratory research on technologies for personal fabrication is complemented by the field "Fab Lab" program. The FabLab brings prototype capabilities to under-served communities that have not had access to the reach of conventional and modern technology development and deployment.

“Expanding National Library of Virtual Manipulatives (NLVM) Reaches U.S. and International Audiences of K-8 Math Learners” (0352570) and “National Library of Interactive Web-based Virtual Manipulatives for K-8 Mathematics” (9819107), are projects that enhance the mathematics education in grades K-8 in both the US and abroad. This project provides on-line, web based tools and databases that have more than 1 million hits a day as students access the information on the web. Not only does the program provide state-of the art educational tools for students, but it also provides pre-service teacher training in a field where innovation on a K-8 level that is solid and rigorous is hard to come by. Accessibility will be increased as well as the team is working on creating a version in Spanish. The outreach of this activity is expanding, has free access and can help to increase mathematics literacy by providing manipulatives via the internet that are formal curriculum tools as well as informal learning environments.

Materials Science as a field has developed to the point where scientists are beginning to predict macroscopic properties from atomic or microscopic structure. However, in order to have this capability, the tools of cyberscience—algorithms and computational expertise—are needed. Researchers at the University of Illinois at Urbana Champaign have begun to address this important cyberinfrastructure need by developing software and education cyberinfrastructure

(0325939). From a small group award, the seeds of this idea grew to a larger proposal in FY03 awarded through the Information Technology Research solicitation and is funded through the Division of Materials Research with co-funding from the Chemistry Division and the Division of Computing and Communications Foundations in the Computer and Information Sciences and Engineering Directorate. This program has provided software dissemination openly, developed new software tools, and hosted a workshop to promote the exchange of ideas and new advances in algorithms for computational materials research and a computational summer school to help train the next generation of computational materials researchers in state of the art computational methods. This project is an example of the cyberscience tools being developed through the NSF that will enable the forefront science of the next generation.

The Protein Data Bank (0312718) promotes international cooperation and is the authoritative, international repository for 3D structural information for biological macromolecules. Indeed, anyone in the US or abroad looking for the structure and classification of a protein can access all published information on the web. This database not only provides information, but is coupled with tools for visualizing the protein structure as well. In addition, storage of this data, archiving and backup is pushing the frontiers of international collaboration as well as the issues of permanent or long term storage and ownership/responsibility for long term maintenance. Suzanne Richman from Rutgers University writes about her work in Japan on this project "Despite our differing cultures and languages, working at PDBj felt like home. We are all working on the same project, half a world apart, but with the same thoughts and feelings about it, and in an annotation room that can be just as eerily quiet, as we all work and concentrate hard." Science can bring people together and break down barriers of language, culture, and geography. The Protein Data Bank provides an excellent example of the unifying force of science.

The Cyber Defense Technology Experimental Research (DETER) Network (0335298) is a facility funded by NSF. The DETER network and test-bed serves as a center for interchange and collaboration among security researchers, and as a shared laboratory in which researchers, developers, and operators from government, industry, and academia experiment with cyber security technologies under realistic conditions. It provides an infrastructure that would not otherwise exist to both aid in the development of tools for protecting cyberinfrastructure and for training students and the next generation of cyberinfrastructure researchers. This is a unique facility with broad outreach to a diverse community involved in network security evaluation.

Microsystems Packaging is a key component of all consumer electronics, and yet as a field has not yet been developed. This innovative program has developed textbooks, innovative curricula and develop and important field (9402723). Students from the program at Georgia Tech have been highly sought by industry. Two of the largest professional societies, IEEE and IMAPS have helped develop 15 new courses for the Internet that are accessible internationally. This access as well as the adoption of the textbook at 47 universities shows the importance of MSP and the need for the tools and curricular databases provided by this program.

Through a joint collaboration between U.S. and Indian astronomers, a spectroscopic fingerprinting of over 1200 stars has been funded and will be provided openly to the scientific community (0114536). This is a huge undertaking as the current largest star mapping is about 200 stars. This library will include spectral data over the largest wavelength range available as well. The star library is a unique data resource for our international scientific collaborations, as for the whole astronomical community. The scientific potential of the library is that certain spectra can be used as building blocks for analyzing the evolution of galaxies. As a database, this library will be unparalleled in the astronomical community.

TOOLS GOAL -- Indicator T2: Provide leadership in the development, construction, and operation of major, next-generation facilities and other large research and education platforms.

The development, construction, and operation of major, next-generation research facilitates many essential discoveries that advance fundamental knowledge and enhance the American economy. Innovative facilities and research tools often open unique opportunities for collaborative research across institutions, nations, and disciplines. Facilities and other large research and education platforms provide the long-term infrastructure for creating new knowledge that serves society. The NSF has made significant achievement in providing leadership in the development, construction, and operation of major, next-generation facilities and other large research and education facilities**.**

The Arctic Ocean is a crucial region determining the present and future state of the world's oceans and climate. The extreme conditions of the Arctic environment have limited scientific observations to a relatively few locations and seasons of the year. The design and implementation of an observational array for Arctic oceanographic measurements through "An Observational Array for High Resolution, Year-round Measurements of Volume, Freshwater, and Ice Flux Variability in Davis Strait" (0230381) will provide a highly integrated and interdisciplinary perspective on the role played by the Arctic and sub-Arctic in steering decadal scale climate variability. The observing system to will provide the first year-round measurements of the total water volume, influence of freshwater, and ice fluxes across Davis Strait between Greenland and Canada. The ocean, ice, and atmospheric observations from this facility will be essential for understanding and documenting the influence of future climate variability and change on Arctic environments.

In February 2004, the Global Biodiversity Information Facility (GBIF) (0301149) went online with a prototype data portal (www.gbif.net) that provides digital access to data from the world's natural history collections, herbaria, culture collections, and observational databases. Participation in the GBIF consortium is open to any country or relevant international organization. The consortium currently consists of 72 participating institutions. This revolutionary capability for sharing a treasure of unique data collected from important ecosystems across the entire planet will promote scientific collaboration and dramatically improve fundamental understanding of the state of the world's biodiversity. Science and society stand to gain much from the GBIF data. Data mining will turn up gems of insight and understanding that cannot be predicted but are likely to lead to fruitful new directions for both research and commercial applications of natural substances. Such insights are vital to creating better futures for both people and nature.

From the Pacific coast to our nation's interior, more than 75 million Americans in 39 states live in towns and cities at risk for earthquake devastation. While scientists are digging into the origins of seismic waves, engineers are pushing the boundaries of design to create structures that remain safe when an earthquake ultimately occurs. The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) (0126366, 0117853, and 0402490), integrates 15 experimental facilities, located at academic institutions across the United States, including shake tables, geotechnical centrifuges, a tsunami wave basin, large strong floor and reaction wall facilities with unique testing equipment and mobile and permanently installed field equipment. A NEESgrid connects these experimental facilities via the Internet2 to form the world's first prototype of a distributed "virtual instrument" for earthquake engineering research (www.nees.org). NEES also provides national resources for developing, coordinating, and sharing new educational programs and materials to excite and support future generations of the earthquake engineering workforce.

Scientists and engineers at the University of Texas at Austin, Center for Space Research (CSR), Mid-American Geospatial Information Center (MAGIC) lead the development of cyberinfrastructure that rapidly integrates and distributes crucial environmental, engineering, economic, and social data necessary to disaster mitigation, response, and recovery in their project “Extensible Terascale Facility (ETF): Enhancing the Capabilities, Scope and Impact of the Extensible Terascale Facility” (0338629). This timely and usable information is quickly provided to state and federal agencies, regional and local governments, academic institutions, and the public. This accomplishment is a stunning example of translating fundamental earth science observations and research into operational uses that will reduce the loss of life and property caused by hurricane winds, storm surges, tsunamis, floods and other disasters. This project involved collaborations with the Texas Advanced Computing Center, Oak Ridge National Laboratory, and Purdue University.

The Cyber Defense Technology Experimental Research (DETER) Network (0335298) is a new center for collaboration among information technology networking and security researchers. This facility encourages collaborative research and education efforts - across organizations and disciplines - by involving six universities and four industrial institutions in an effort that spans both networking and security issues. This project provides leadership in the future networks and computational infrastructure that will be necessary to the emerging knowledge society. This project also expands opportunities for U.S. researchers, educators, and students at all levels to access state-of-the-art network security evaluation infrastructure.

TOOLS GOAL – Indicator T3: Develop and deploy an advanced cyber infrastructure to enable all fields of science and engineering to fully utilize state-of-the-art computation.

Cyberinfrastructure constitutes the research environments that make advanced computation, data acquisition, and collaborative services available through high-speed networks. NSF has built up the country's cyberinfrastructure through a variety of programs, notably the PACI (Partnerships for Advanced Computational Infrastructure) supercomputer centers, the Middleware Initiative, the Information Technology Research (ITR) program, and the Teragrid.

There was significant achievement in the cyberinfrastructure goal through the combination of these facilities, indicated by progress in several funded activities, falling roughly under two headings:

- Successful applications of the existing cyberinfrastructure. Several project accomplishments attest to how the recently developed infrastructure is supporting many scientific projects, from access to astronomical surveys (the National Virtual Observatory), to parallelizing existing useful software, like the Harvard CHARMM code for molecular mechanics. Two nuggets are exemplary in this regard: “Computing dark energy” and “Using Grid platforms to better understand neuro-transmission.”

- Development of new tools to extend the reach of the cyberinfrastructure. We highlight two project accomplishments among the several that fall into this category: "Rocks Cluster Management Software" and "Workflow Scheduler for Distributed Computation."

The greatest concern is stable funding and management of these resources in the future.

Successful applications:

The recent conclusion that the expansion of the universe is accelerating likely due to the presence of "dark energy" was initially supported only from supernova data. Now a second line of evidence from the projects "Statistical Data Mining for Cosmology" and "Searching for Correlations in a High Dimensional Space" (0121671 and 0312498) bolsters the same conclusion, based on the so-called Sachs-Wolfe effect. The faster expansion rate of a universe that contains dark energy would leave its mark on photons that gain energy passing by gravitational potentials. This effect has been observed with the help of statistical data mining algorithms developed to search the massive astrophysical surveys.

MCell is a Monte Carlo simulator of cellular microphysiology. It simulates the dynamics of biochemical reactions in 3D microenvironments, and in particular, of neurotransmitters in synapses. Current demands are of the order of 2CPU-months of computation and 35GB of memory. The project, "Virtual Instruments: Scalable Software Instruments for the Grid" (0086092), altered MCell to MCell-K to permit it to run in parallel, distributing the work onto large Grid platforms. Clusters at the San Diego Super Computing Center, the Tokyo Institute of Technology, and the IBM BlueHorizon supercomputer, were all used for large-scale simulations previously unapproachable by serial MCell.

Development of tools:

There is a need to make stable and manageable parallel computing platforms available to a wide range of science and engineering research, as the project "National Partnership for Advanced Computational Infrastructure" (9619020) may demonstrate. An impediment has been the difficulty of setting up a cluster, and then managing it, e.g., ensuring all nodes have a consistent set of software. Rocks addresses this need by making it easy to create, manage, and upgrade a Linux cluster. The basic idea is to make complete OS installation on a node the basic management tool, which is faster and easier than determining the software synchronization of all nodes. Rocks software clusters use a MySQL database for site configuration. The software builds a cluster by installing a Linux suite of software, and provides tools for easy upgrades and extensions. Rocks has quickly developed an extensive worldwide user base, and won several awards at the 2004 Supercomputing Conference.

Scheduling the flow of work in a distributed computation is a critical issue for heterogeneous tasks, which are more challenging than tightly-coupled parallel computations. This new workflow scheduler (0331645) seeks to minimize the "makespan" (overall job completion time). It creates a task graph, and ranks each eligible resource against subtasks, incorporating information (some automatically estimated) about communication and memory costs. Optimization heuristics then choose a mapping of components to nodes. Experiments indicate significant improvement over randomized scheduling.

TOOLS GOAL – Indicator T4: Provide for the collection and analysis of the scientific and technical resources of the U.S. and other nations to inform policy formulation and resource allocation.

Our examination of the nuggets and other background information indicates that the NSF and its grantees contribute to a great extent to the national need for information needed to inform policies and budgets. This information is produced in three basic ways, which we will discuss in turn. First, the NSF's division of Science Resources Statistics (SRS) and its contractors collect and interpret a great deal of information themselves. Second, a variety of programs within the NSF make grants that result in a number of databases that scientists, educators, and citizens can use. Third, some grants made by the NSF either deliberately or accidentally produce policy-related information that is useful for dealing with specific issues. We find that that the NSF program merits the designation of "significant achievement" in the T4 area.

NSF's SRS unit gathers a great deal of data on Research and Development (R&D) which forms the statistical basis for the familiar volume *Science and Engineering Indicators*, published every other year under the imprimatur of the National Science Board. Surveys cover such topics as Industrial R&D, Federal Funds for R&D, Federal science and engineering support to universities, colleges, and nonprofit institutions, academic R&D, and science and engineering research facilities. SRS works with other units of the Federal Government, most particularly the Census Bureau, in developing these data.

A committee, convened in 2002 by the National Academy of Sciences, reviewed the performance of SRS and issued a report in 2005. This report contains 32 separate recommendations that largely deal with ways in which SRS could improve and/or extend the kinds of data, which it does collect (Brown, Plewes, and Gerstein 2005). Given the scope of this group's review and the integrity of the National Academy review process, our subcommittee chose to simply accept the positive review by the National Academy committee at face value and did not make our own independent evaluation of SRS.

The second way that the NSF supports the development of useful policy data is to support projects that include as all or part of their mission the development of websites that either contain some data themselves or have links to websites that contain data. We cite here three examples of such projects that came to the committee's attention as being examples of particularly noteworthy endeavors.

The Math and Science Partnership program (MSP), developed in conjunction with the President's “No Child Left Behind” education initiative, has generated among other things a pooled database of successful practices that will be very useful both to people within the MSP community and beyond it, for example, in the project “Program Evaluation for the Math and Science Partnership” (0456995, 0335334, and 0445398). Exploration of one of the many websites supported by this project (http://hub.mspnet.org/) revealed that already, only a few years after the MSP projects began, there are a considerable number of papers presenting Results which are of interest to practicing science teachers. The links were easy to follow and information on particular areas of interest was easy to find.

Scientists and science instructors occasionally find themselves interested in some very specific areas that suddenly come on to their radar screen. For example, a university scientist who has been asked to visit a school for deaf children would do well to visit the website of the NSF-funded project COMETS (Clearinghouse on Mathematics, Engineering, Technology, and Science). The COMETS website, developed at the National Technical Institute of the Deaf, aims to contain virtually everything ever published that is related to deaf education in STEM fields (0095948). This website (http://www.rit.edu/~comets/pages/featurespages/biblio/bibliopage.html) has information on a great deal of individual investigations, and a complete list of scientists who were deaf or hard of hearing.

Another example deals with a particular environmental niche, the cold regions of our planet. A scientist who had a need for information on the work that had been done in arctic and sub-arctic regions of the planet, and who was not already familiar with the network of literature and investigators in this area, could simply go to http://www.coldregions.org/) . This website, prepared with NSF support (9909727) apparently contains links to almost everything published on these parts of the planet.

A third way that the Foundation supports policy studies is to support basic research projects which not only have significant policy implications but which seem to be influenced by the need to develop data with policy implications. For example, Dr. Robbie Luliucci at Washington & Jefferson College studies the aging of silica-reinforced polymers used in weapons systems (9909727). The materials that age are not the materials that explode, but the plastic and rubber-like materials that are equally important to the integrity of a weapon. Undergraduate students develop skills that can be used in industry, particularly as is related to homeland security. As another example, Marina Alberti of the University of Washington led an interdisciplinary study of urban development, land-cover change, and bird diversity, a study that could certainly be useful to any land-use planner who was interested in the relationship between environmental integrity and the intensity of urban or suburban development in any particular area (0120024).

TOOLS GOAL – Indicator T5: Support research that advances instrument technology and leads to the development of next-generation research and education tools.

An important part of NSF's research strategy is to provide new and advanced tools as a "backbone" that can position our nation to investigate and develop "next-generation" research programs further advancing science and technology. Perhaps of equal significance is the training and development of students and academia to new methods and processes that enable us to do things tomorrow that are just being imagined today thus leading to "development of next generation research and education." We find that the NSF efforts in this area are worth describing as "significant achievements."

In evaluating the various research nuggets for 2005, it is clear that there are many NSF-funded programs producing results for putting in place new instruments that can and will provide opportunities for great advancements in the fields of biology, medicine, materials, and computer technology.

For example, at the Center for Bits and Atoms at MIT, scientists are developing new methods that fundamentally will change the way a computer works integrating both "living" software and hardware that changes to meet the computational needs at hand. This program is innovative in that it seeks to fundamentally revisit the notion of what a computer is, and what a computation is. By taking a more holistic approach and a radically new view of the process, the program seeks to revolutionize the computing process. If successful, this program has the potential of creating a new foundation for much more advanced computing and management of much larger amounts of information at higher speeds than ever before possible. This program expands the narrow "hardware" focus of current computational techniques and methods. The vision is to include in the computational approach "context" information. The goal is to overcome the very real scaling limits of "data crunching only" that creates an obstacle to designing and managing very large-scale data and information systems. The program is high risk, multidisciplinary, and has already achieved some positive results, one of which is a new type of analog to digital converter. Under NSF funding for “Center for Bits and Atoms” (0122419), Neil Gershenfeld and his team have produced an extremely energy-efficient version of the versatile analog-to-digital converter. Conversion of analog readings to digital signals is becoming extremely important, not only in technology advancement, but also in everyday life. This device applies new methods to increase speed of conversion and energy efficiency over previous technology. This instrument has an array of applications in the computer, automotive and communications industries.

As another example, NSF has taken a leadership role in developing nanotechnology and instrumentation. In the project “Nanotechnology Moves into Production at IBM” (0213618 and 0213695), Curtis Frank of Stanford University and Thomas Russell of University of Massachusetts Amherst have developed a new tool for high-density lithography. Collaboration with IBM scientists has led to the application of this technology to increasing the lifetime of flash memory over 100-fold, compared to previous technology. As with the analog-to-digital converter, this application of nanotechnology is important in technological research as well as improving everyday life.

Carl Wieman and Thomas Perkins, at the University of Colorado at Boulder, in their project “Watching Proteins Bend DNA with Subnanometer Resolution” (0404286 and 0096822), have created another breakthrough nano-scale instrumentation as a tool, which allows biologists to follow the motion of a single molecule. Until this advancement, scientists needed to rely on the average of a set of measurements on a group of molecules in order to study molecular behavior. Now, molecular motion can be measured with ten-fold greater resolution at times on the millisecond level. This project opens up the opportunity to measure the motion of enzymes replicating.

Another new tool in the field of biology and medicine allows for early detection of esophageal cancer. Adam Wax of Duke University in the research project, “Low Coherence Light Scattering for Biophotonics” (0348204), developed a method, which has been proven successful in experiments with rats, using the scattering of light to detect an enlarged nucleus, one of the earliest signs of pre-cancerous cells. Measurements of light scattering can be taken in 40 milliseconds, making diagnosis possible in less than a second (compared to the many minutes it takes using current methods). Time is of the essence in cancer diagnosis, so shorter diagnosis times combined with earlier detection capabilities are great strides in instrument technology for cancer treatment. Not only is this a valuable platform tool, but also extension from rats to humans, if successful, could save many lives.

At Carnegie-Mellon University, "Synchronized Transatlantic Synchrotron Research" (0079996) has yielded a new tool that can increase our ability to predict and control the properties of ceramic and metallic materials. The instrument developed in this program uses x-rays that can penetrate through centimeters of solid samples, allowing scientists to measure the shapes and orientations of grains in the material and how they change with time. An increased understanding of material structures and properties can lead to improvements in fabrication of products from bridges to microscopes to prosthetics.

The Materials Research and Science Engineering Center (0079996), as well as the previous four projects described, advances in instrument technology are creating opportunities to better understand and improve products and processes in the fields of biology, medicine, materials, and computer technology. Thus, through achieving success in Indicator T5, NSF-funded programs are enabling "discovery, learning and innovation," one of the National Science Foundation's five main goals.

Reference

Brown, L.D., Plewes, T.J., and Gerstein, M.A. (eds.). 2005. Measuring Research and Development Expenditures in the U.S. Economy. Washington, D.C.: National Academies Press.

ORGANIZATIONAL EXCELLENCE (OE) Strategic Outcome Goal

An agile, innovative organization that fulfills its mission through state-of-the-art business practices. NSF is successful when significant achievement is demonstrated for the following performance indicators:

- ***Human Capital Management:*** *Develop a diverse, capable, motivated staff that operates with efficiency and integrity.*
- ***Technology-Enabled Business Processes:*** *Utilize and sustain broad access to new and emerging technologies for business application.*
- ***Performance Assessment:*** *Develop and use performance assessment tools and measures to provide an environment of continuous improvement in NSF's intellectual investments as well as its management effectiveness.*
- ***Merit Review:*** *Operate a credible, efficient merit review system*

Introduction

The OE strategic outcome goal was added to the NSF Strategic Plan for FY2003-2008. This was a major step forward in recognizing the linkages between excellence in advancing science and excellence in organizational development. Within the OE goal, the indicators "mirror" the people, ideas, and tools structure of the other strategic outcome goals. The Human Capital indicator is the "people" dimension of OE, the Technology-Enabled Business Processes is the "ideas" dimension, and the Performance Assessment and Merit Review indicators together are the "tools" dimension.

At the time the OE goal was added, it was determined that the Advisory Committee for Business and Operations (AC/B&O) would provide an assessment of the first three OE indicators (Human Capital, Technology-Enabled Business Processes, and Performance Assessment) and the AC/GPA would conduct an assessment of the Merit Review indicator. As part of its OE analysis, the AC/GPA reviewed data and information from:

1. ***Report to the National Science Board on the National Science Foundation's Merit Review Process -- Fiscal Year 2004 (NSB 05-12).*** This is a report on the statistics and processes related to the proposal and award activity for the fiscal year 2004 and the merit review process (number of proposals received, numbers of reviewers, etc).

2. ***Committee of Visitor (COV) Reports.*** NSF convenes panels of relevant community experts to maintain high standards of program management and to provide advice for continuous improvement of NSF performance, in part through their assessment of how NSF programs evaluate and process proposals (i.e., merit review). Each NSF program undergoes a COV review approximately every 3-5 years. These COVs are also asked to comment on organizational excellence and multidisciplinary and high-risk proposals. Table 1 shows which NSF areas had COVs in 2004 (shown in bold type). Directorates decide what level to do these COV reviews (e.g., program, division, directorate, etc). The schedule for all COV program evaluations and COV report template and questions can be found in the 2004 NSB Merit Review report in Appendices 12 and 13.

3. ***The NSF Advisory Committee on Business and Operations 2005 Assessment of Organizational Excellence.*** This report looks at the non-merit review elements of organizational excellence (human capital, business processes, and performance).

2005 AC/B&O Assessment

The 2005 AC/B&O assessment supports NSF's conclusion that the agency has demonstrated significant achievement for the three indicators it considered (human capital, business processes, and performance assessment). The AC/GPA agrees with this conclusion. The AC/B&O also made a number of comments to improve the approach, methodology and analysis for the assessment of performance in subsequent years. The AC/B&O report can be found in an Appendix to this report. For our part, we conclude that the MRP is effective in the processing and reviewing of a large and increasing volume of proposals and in the engagement of a broad and diverse segment of talent in the NSF's science and engineering enterprises. While the MRP will always, in our view, require vigilance and a commitment to continuous improvement, when taken as a whole and when one looks at the results as illustrated in the People, Ideas, and Tools portfolios, clearly, the process remains a major positive force in advancing the frontiers of science, mathematics, and engineering. From this review, we concluded that NSF has demonstrated significant achievement for this OE indicator.

2004 Committee of Visitors OE Assessment

The 2004 COVs listed in Appendix 2 were asked to comment specifically on NSF's ability to provide "an agile, innovative organization that fulfills its mission through leadership in state-of-the-art business practices" (i.e., organizational excellence). The COVs were also asked to comment on the merit review process (MRP), which will be discussed in the next section. While less than half of the COVs actually provided OE comments (something NSF needs to work on), those COVs that did answer concluded that the respective programs were meeting the OE challenge. Some comments and issues of note include:

- **COV Process.** The COV process itself was cited by COVs as an innovative practice that ensures the quality of NSF's grants and awards.

- **Crosscutting Programs.** Crosscutting programs involve NSF staff distributed in diverse directorates, divisions, and programs (e.g., Biocomplexity in the Environment involves seven directorates and two offices). The COVs found the crosscutting management structure, while not excellent, is "good enough". NSF staff has learned to use the current crosscutting structure even though it is cumbersome. NSF should examine how its internal processes could be improved for this kind of matrixed management. Such an analysis should include staffing requirements, fund management, decision-making, time use efficiency, preparation and review of program announcements, and outcome assessments. Most NSF staff involved in these crosscutting programs does so in addition to their normal disciplinary program responsibilities. Streamlining processes and providing program assistance would help reduce or manage this often overwhelming workload.

- **Benchmarking.** One COV suggested that NSF should consider periodic benchmarking with other government agencies, academic, and private sector organization to maintain state-of-the-art business practices.

- **Impact on External Organizations.** A few COVs mentioned the impact that NSF's financial management requirements have on other organizations (e.g., universities, school districts, etc.) and encouraged NSF where possible to provide these organizations with much simpler and more "user-friendly" financial management guidelines to avoid additional administrative costs.

- **Review Process.** A few COVs noted that the increased reliance on panel reviews over *ad hoc* mail reviews has enhanced the timeliness of reviews. COVs also noted that the reliance of the review process on leading scholars, the rotation of Program Officers which leads to the infusion of new ideas, and improvements to Fast Lane have substantially contributed to OE.

- **Program Officers.** Many of the COVs concluded that effective Program Officers (POs) were pivotal in ensuring OE and described POs as dedicated, hard-working, and innovative staff who are agile and as responsive as the Congressional budget process will permit (i.e., lack of needed funds, appropriations late in the year, etc). Several COVs cited POs who have been particularly creative in developing programs to address areas of increasing importance (e.g., in response to 9-11). NSF should recognize these outstanding POs and do as much as possible to provide training and mentoring to new POs.

2004 Multidisciplinary Committee of Visitors Assessment

In its 2004 report, the AC/GPA discussed the effectiveness of the MRP for the review of interdisciplinary or multidisciplinary proposals. At that time, we debated without resolution whether the organizational structure of NSF (relatively autonomous directorates with disciplinary divisions) promotes effective reviews and uniform processes for such proposals. We now suggest that this issue is ripe for additional discussion by NSF's senior leadership with an eye toward creating consistent review practices for these types of proposals across the Foundation. For 2004, the COVs mentioned in Table 1 were asked to comment on whether NSF program portfolios have an appropriate balance of multidisciplinary proposals. Most of the COVs reports on this topic replied either "yes" or "appropriate," or provided few comments. In future years, NSF should work more closely with the COVs to address this topic more fully. Of the comments that were received, two themes emerged:

- **Program Officers.** The ability of a multidisciplinary proposal to be successful is a direct reflection of the willingness of POs to consult with experts outside their range of expertise when collecting reviews and to think broadly about how their programs relate to the broader needs of science and society.

- **Budget Constraints and Review Process.** The budget environment may be acting as a constraint on the amount of multidisciplinary work that can be funded; further the review process does not preclude funding these projects, but it also makes no special effort to single them out.

The AC/GPA believes that neither the budget nor the review process should create barriers to funding high quality multidisciplinary proposals.

2004 Merit Review Process Assessment

In general, the MRP continues to be impressive and effective. Some statistics and issues taken from the NSB merit review report and COVs on merit review (Table 1), include:

- **Proposal and Success Rate.** In 2004, over 96% of NSF's awards were selected through the competitive MRP. NSF took action on 43,851 competitively reviewed proposals (40,075 in 2003, 35,165 in 2002, and 31,942 in 2001) and provided funding to 10,380 of them. While the number of awards funded has not changed much in the past few years, the number of proposals acted upon has risen by 38% since 2001. This resulted in an overall NSF-wide average funding rate of 24 percent (27% in 2003, 30% in 2002, and 31% in 2001). The 2004 funding rate is the lowest rate in 15 years and largely due to the substantial increase in the number of submitted proposals and budget constraints. The funding rate ranges between 16-45% depending on the NSF program. Funding rates for female PIs is one percent above the overall average and one percent below this average for minorities. The funding rate for new PIs is 17% (down from 19% in 2003). Some COVs cited this declining rate as also contributing to larger numbers of proposals being resubmitted and re-reviewed with little gain in quality and further burdening the review process. However, in response to questions raised by the AC/GPA in 2004, NSF analyzed resubmitted proposals and the data show that these proposals are not disadvantaged in the review process – thus, the issue for NSF is one of proposal volume.

- **Sector Distribution.** The distribution of NSF awards among institutions of varying size remains relatively unchanged over the past four years. The top 100 universities still receive the overwhelming majority of all NSF awards (74 percent). The TOOLS subgroup also commented on this issue.

- **Grant Size and Duration.** The average annualized award amount for individual investigator research grants in 2004 was $139,522 (3 percent more than in 2003 and 22 percent more than in 2002). The average award duration for 2004 was 2.96 years. NSF's goal has been 3.0 years.
- **Proposal Reviews.** Proposals are reviewed primarily by three mechanisms: *ad hoc* mail reviews only, panel reviews, and mail-panel combination. The use of the panel and mail-panel combination is increasing while the use of mail reviews only continues to decrease (down to 7% in 2004.) Including all mechanisms of review, the average number of reviews per proposal for 2004 was 6.0, slightly lower than the 2003 level of 6.3.
- **Reviewer Pool.** Selected from the electronic database of about 300,000 reviewers, 58,000 reviewers participated in the MRP, and of those, 13,000 were first time reviewers (up from 8,000 in 2003). In 2004, 7092 or 17% of the distinct 41,263 reviewers returned demographic information. Out of these, 2,449 or 35% indicated they were members of an underrepresented group (i.e., minority or women). Provision of demographic data is voluntary and, given the low response rate, there is not enough information to establish a baseline. Thus, there is no apparent way to judge balance between racial, ethnic, and gender representation among the reviewer population. The AC/GPA is concerned about this situation both for reviewers and for PIs and urge NSF to redouble its efforts to collect this data and engage a diverse pool of reviewers in the MRP. We understand that the PI database and the reviewer database are currently separate, but easy and

comprehensive retrieval of systematic and holistic demographic information about reviewers and PIs remains desirable and necessary. There were also concerns in many of the COVs about the potential for overuse of reviewers (i.e., burnout, low response rate, etc) and the impact on the reviewer pool from the substantial increase in the number of proposals. COVs made a number of suggestions on improving the reviewer pool:

- Include private sector reviewers especially when tool development is a major objective of a proposal to ensure that proposals benefit from private sector expertise and are not duplicating projects already underway in the private sector.

- Create an on-line system to allow potential new reviewers to register, describe their interests, and be certified that they are prepared to be reviewers.

- Promote the benefits of reviewing to prospective reviewers (e.g., there is no better way to learn how to write a good proposal) and develop ways to publicly recognize reviewers (e.g., distinguished service award). This could help change the social norm of reviewing from a burden to something that is valued by one's peers (the same way teaching awards have changed the norm in many universities). A panel provides the opportunity to bring developing scientists into contact with established researchers and help these developing researchers obtain insights about proposal preparation and review standards.

- Seek more flexibility and mechanisms for appointing review panels, such as having six standing members on three-year rotations and two short-term members appointed on the basis of proposals received for each round of solicitations.

- Increase the number of young qualified reviewers and ask panel members to provide lists of review candidates.

- Encourage Program Officers to write journal articles to help increase reviewer return rates.

- **Reviewer Response Rates.** In 2004, 59% of requests for mail review elicited positive responses, up slightly form 58% in 2003. Many COVs mentioned the decline in review return rates and thought that this was attributed to the great number of proposals and fewer available reviewers. Many COVs mentioned the impact of this low reviewer return rate and that it could limit the number of outside reviewers, particularly if those who do respond are only somewhat familiar with the research area. Several COVs postulated that some the lower return rate might be related to a "Fast Lane learning curve" and that Fast Lane has shifted the burden on reviewers to download and print proposals. Some COVs suggested that further testing be done on Fast Lane to help non-technical people use it -- although the AC/GPA has not seen the Fast Lane interface as an impediment. NSF might consider modifications to Fast Lane that would provide a convenient way to automatically monitor responses by prospective reviewers and remind reviewers as deadlines approach.

- **Dwell Time.** The NSF goal of processing 70 percent of all proposals within six months of submission was once again exceeded in 2004 (77 percent, about the same as 2003 and up from 63% in 2001). This achievement is particularly significant given that the number of proposals has increased 38% since 2001.

- **Review Feedback.** COV reports also indicate that more specific feedback to the PIs is desirable, including strengths, weaknesses, and suggestions for improvement. Several of those reports recommended tutorials on review preparation with examples of helpful reviews (for prospective reviewers and panel members). In 2003, the AC/GPA mentioned the need to ensure the panel summaries in the proposal jackets fully capture the rationale for funding decisions and the make up of panel experts (e.g., short bio). This lack of concise summaries was mentioned again repeatedly in the 2004 COV reports. While this is may be a PO workload issue, the AC/GPA believes that it is very important that these rationales be included or the COVs process will be negatively impacted. There were some COV comments that the "Summary" section of the review forms varies considerably. In some reviews, the summary synthesizes all comments, while in others the summary simply reiterates reviewers' comments. The former is more desirable and NSF should make this clear to reviewers. One COV suggested that reviewers should take the perspective -- "if I were the PI on this proposal, what feedback would help me turn this into a successful proposal". Some reviewers organize their reviews according to NSF criteria and others do not. NSF should insist on a consistent format that easily relates to the MR criteria.

- **Merit Review Criteria.** One of NSF's original GPRA goals was to increase reviewer and PO attention to both review criteria (scientific merit and broader impacts). It has been noted in the past three AC/GPA reports that consideration of the broader impact of the proposed research (i.e., Criterion 2) continued to be somewhat inadequate. In 2004, 92 percent of all external reviews addressed aspects of both MR criteria (90% in 2003, 84% in 2002, and 69% in 2001). In 2004, 236 proposals were returned without review due to failure to address both criteria (276 in 2003). There is clear improvement in the statistics on this issue.

  While most COVs mention this improvement, they also all continue to cite the uneven attention of reviewers to Criterion 2 because reviewers, proposers, and POs still don't fully understand and apply these criteria consistently. It was widely held by the COVs that the *broader impact* criterion needs better definition, since its meaning can vary substantially depending on the background and perspective of both proposers and reviewers. For example, how does one judge a proposal impacting 20 students at a small liberal arts college and another proposal impacting 1,700 students at a large university?

  Suggestions offered by COVs to improve the quality of Criterion 2 include: (1) redesign Fast Lane so reviewers must fully address both criteria; (2) provide clear and repeated guidance to review panels to comment on both criteria; (3) better define the criteria; (4) make available models of good and bad reviews; and, (5) insist that program announcements specify what sorts of broader impacts are relevant to a particular program. Ideas for providing examples of broader impacts are presented throughout the COVs reports and the COVs suggested that NSF should consider conducting Panel Review Workshops at national meetings to help train and certify reviewers. The AC/GPA finds that the review of the *broader impacts* criterion remains a challenge for most reviewers and we recommend that NSF intensify its efforts on this issue.

- **Program Officers.** Many of the COVs found the thoughtfulness and thoroughness of the POs' review of proposals and reviews extraordinary. They balance competing priorities, manage the review process, and many other things. The AC/GPA recognizes that POs are a key element in the success of the MRP in that they select the reviewers, compose the panels, and manage the process of review. The typical PO processes 105 proposals each year and spends 55 percent of his/her time on the review process (source: Booz, Allen, Hamilton workload survey of NSF staff).

  Since this survey was the first of its kind ever performed, we have no basis on which to assess whether more than half of an average PO work year on proposal review is too much or too little, but it does seem to us an inordinate amount of time, especially given the other important duties that a PO should be attending to (e.g., program development, award management and oversight, outreach and communication, performance assessment). In the past ten years the budget of NSF has nearly doubled and the number of proposals has increased significantly, yet the number of NSF staff has only increased by four percent.

  The AC/GPA recommends that NSF continue to track the amount of the PO's workload that is devoted to the MRP and consider providing the POs with additional resources (e.g., portfolio assistants). Throughout the COVs there are references to outstanding POs. NSF should analyze why these particular POs are so effective, reward them, and develop training for other POs based on these findings. Some of the attributes of a good PO include: long-term experience in the MRP, well respected in the field, close ties to leading scholars, no perceived personal biases, and ability to run a very effective review process. COVs also mentioned the importance of non-rotator POs that bring "long-term memory" into the process and this should be balanced with the "fresh ideas" that rotators bring to NSF.

- **Efficiency and Effectiveness.** Some COVs mentioned that for very small awards, the peer review process might be excessive and add delay and cost to the process. NSF might want to consider a level under which some proposals can be handled with a less cumbersome procedure. It was also suggested that the number of required reviewers should vary with the amount of requested funding.

- **Lost Capacity.** In 2004, over $2 billion of declined proposals were rated as high as the average rating for an NSF award (4.2 on a 5-point scale). These declined proposals represent a rich portfolio of high quality, yet unfunded research and education opportunities that we hope will not be lost to the nation.

Based on our analysis of NSF's merit review process, we offer these comments and recommendations that we hope will be helpful and that we suggest NSF consider for additional action:

- **Crosscutting Programs.** As crosscutting programs and initiatives increase, NSF must focus on the associated infrastructure and management to assure continued OE (i.e., the structure is balky and should be overhauled or streamlined).

- **COVs.** The COV reports have proved to be extremely valuable in the AC/GPA analysis. However, COVs too often either did not respond at all or responded solely in monosyllables (i.e., yes or no) regarding the review process for the multidisciplinary proposals and OE. As the number of the proposals increases, the importance of effective program review by the COVs grows. Thus, NSF should ensure that all COVs address MRP effectiveness for multidisciplinary proposals and OE topics.

- **Program Officers.** The positive effects of outstanding POs are critical to the success of the MRP. NSF should develop and recognize these POs and use their best practices in the training and mentoring of new POs. Although the numbers of proposals have increased significantly, the staffing managing the MRP has not increased proportionately, causing heavy workloads for POs. NSF is encouraged to continue to track the PO workload and to assign resources based on these results.

- **Budget Constraints.** The AC/GPA noted the COVs' contention that the funding of multidisciplinary proposals is budget constrained or negatively impacted by the MRP itself. The ACGPA encourages NSF to not let the budget and/or review process limit the funding of these proposals.

- **Proposal and Success Rate.** The 2004 funding rate is the lowest rate in 15 years and largely due to the substantial increase in proposals. Many of the declined proposals are rated well above average (~$2 billion) and are costly to develop. Thus, NSF will need to develop strategies on how to take advantage of this important national intellectual capacity and avoid discouraging the pursuit of important research and education efforts.

- **Reviewer Pools.** Demographic data allowing the determination of the balance of racial, ethnic, and gender representation among NSF reviewers remain scarce. The NSF is urged to redouble its efforts to broaden the numbers and diversity of the review pools. Reviewer response rates are roughly flat and there are signs of reviewer overuse and burnout. NSF should consider developing an on-line system to register and certify reviewers and develop a mechanism for Fast Lane to automatically monitor reviewer responses and deadlines. NSF should also promote the benefits of being a reviewer.

- **Review Criterion 2.** An imbalance in the quality and thoroughness of the responses to Criterion 2, the *broader impacts* criterion, persists. We recommend that NSF continue to focus on this issue, including considering conducting Panel Review Workshops at national meetings to help train and certify reviewers.

Assessment of Transformative/Bold/Innovative-High Risk Research and Education Proposals

In its 2004 report, the AC/GPA discussed the issue of whether the MRP may filter out "high risk" and "innovative" proposals. The AC/GPA came to no conclusion about this issue in the brief time they had to consider it and encouraged NSF to study this issue. Over the past year, NSF created a rubric to define this type of research (Appendix 3) based on analyzing a set of 150 accomplishments that POs thought should be considered as "innovative-high risk" (Table 3). The AC/GPA compared the definitions to the 150 proposals and also reviewed COVs comments on the use of the designation of "innovative-high risk" to proposals in their reviews. From this analysis, the AC/GPA concluded the following regarding this topic:

- **Goal of the "Innovation-High Risk" Category.** The Committee considered the type of research that would be captured in this category. Much of this discussion was focused on whether an approach or theory is truly new, might be very difficult to pursue, and might offer a very high reward if successful. These criteria describe much of NSF's portfolio, therefore this category would be the "exception to the rule" --- not just projects that are inherently complicated and that push the intellectual or technical boundaries. In reading the program officer comments for the 150 selected nuggets (see Appendix 4), it was difficult to determine how many of these projects truly met the "exception to the rule" test-- largely because the POs didn't have a uniform set of criteria to consider.

- **Current NSF Draft Definitions and Program Officers' Comments.** We conclude that NSF has made a good start in developing a rubric to define transformative research. However, based on our attempts to apply the draft definitions to the 150 proposals, NSF should consider refining the draft rubric to make it clearer and simpler. For example:

    - Types 1 and 3 might be combined. Out of the 150 PO comments, there were very few proposals that seemed to fit only type 3 and, in our view, type 3 seems to be a subset of type 1.

    - It was very difficult to distinguish between types 1 and 2. These two descriptions appear to mix innovative, risk, and return-on-investment (reward) in unintended ways. For example, the current definitions tie together "novel and untried", "high reward and technical challenge", and "innovative and contrary to current theory". Something could be very high reward and have little technical risk. That is why NSF should consider separating innovation, risk, and reward.

    - It would seem that "risk to society if not successful" should be in nearly all NSF grants, whether they are "high risk" or not. While important, "PI safety" is not in the direct "spirit" of what we are trying to measure, it should be considered part of technical risk. "Risk to society if a result is harmful" is a very important issue and should be tracked -- but it might also be beyond the spirit of what we are trying to measure here. Thus, while types 4 and 5 are important -- they are probably not as relevant to the particular designation of "transformative/bold/innovative-high risk" and NSF should consider eliminating them from this rubric.

- **COVs Comments on Innovative-High Risk Research and Education.** For 2004, the COVs were asked to comment on whether NSF program portfolios have an appropriate balance of transformative/bold/high-risk proposals. Many of the COV reports on this topic either replied "appropriate" or provided few comments. In future years, NSF should work more closely with the COVs to address this topic more fully. It was also difficult to judge or apply this category to many of the 2004 programs reviewed by COVs (e.g., NSF-NATO post-docs, cyber scholarships for service, etc). COVs did note the following:

    High Risk Definition. Many of the COVs mentioned the need to further clarify the concept of "risk" or characteristics of a "risky" proposal so that reviewers can apply the rubric more effectively. Most COVs noted that in many cases funded proposals appear to be the more conservative ones, with some evidence within the proposal jackets of a tendency toward risk-aversion. Some COVs that examined very similar programs said that it was relevant to judge risk while others said it was not possible. A few COVs mentioned that panel reviews could have an inherent bias to seek consensus, which may overlook or deemphasize high-risk, high-potential projects.

Budget Constraints and Competing Priorities. Several COVs said that NSF's ability to fund high-risk proposals was substantially reduced due to budget constraints and the many priorities that POs must balance (e.g., providing grants of sufficient size and duration, funding new and underrepresented investigators, core disciplines, etc). Many "gems" reside in the "could fund" (but not funded) category because the projects are controversial by nature.

Program Officers. COVs noted the importance of the PO's role in funding high-risk proposals. Typically, high-risk proposals had favorable reviews on the basic science ideas, but low ratings due to reviewer skepticism regarding the feasibility of the project or lack of track record of the PI. In many cases, it was the intervention of the PO that provided that type of proposal a chance to succeed.

Based on our analysis, the AC/GPA recommends: (1) a simpler, yet effective "innovative-high risk" definition, (2) more effective guidance and training for POs to apply it, particularly given the critical role POs play in supporting this type of proposals, and (3) clearer guidance to POs that budget constraints should not influence their ability to make reasonable investments in this type of proposal.

The AC/GPA suggests that NSF consider the "innovation- risk-reward" criteria below to develop a revised rubric:

- **Innovation.** Significantly more forefront, novel, and transformative than other proposals in the field.

- **Risk.** The proposal may have significant technical risk (including risk to the PI safety), a high probability of failure, it may be untried, and/or it may be contrary to current theory. If there is significant risk to society that a result might be harmful (e.g., health, environmental, safety, etc), this should be explicitly documented, and flagged for a policy-level decision prior to funding.

- **Reward.** The proposal has significant economic, intellectual, societal, etc. return on investment.

- **Overall Rating.** A proposal would be considered "innovative-high risk" if it is clearly innovative beyond other proposals in the field, might have substantial risk, and offers the potential for outsized returns on investment.

If NSF finds the above idea promising, we urge that it be further studied and tested internally to make sure that users of the revised rating system find it to be an improvement. One challenge in this regard will be to ensure that POs and COVs are able to use the new rubric in a comparable fashion to facilitate comparisons across organizations and time. It would make sense to do some retrospective analysis to look for trends as part of the internal "testing". During our deliberations, it was brought to our attention that the Department of Commerce NIST Advance Technology Program may have developed this type of high-risk rating approach and NSF should examine whether the NIST approach may be applicable for NSF. We also discussed the value of exploring whether the current Small Grants for Exploratory Research definitions and award process needs to be updated. The SGER process was created some time ago and might need to be updated to reflect current research trends.

COMMENTS ON THE PROCESS AND THE COMMITTEE'S WORK

The AC/GPA Committee is pleased with the continued improvements that NSF has made in the process. Not only were we able to do much of our work in advance of the meetings, but NSF also provided periodic updates on the progress of each subgroup in its analyses of indicators. This Committee, with NSF's invaluable assistance, has, we believe, modeled the very organizational excellence behavior that we seek from NSF. We also note that this committee is, perhaps, unique within the Federal government. We commend NSF's past and current leadership for their foresight and their commitment to an assessment process that is both thorough and impactful.

Although the Committee believes the AC/GPA process is working effectively, the Committee has some additional comments that we offer in the spirit of the continuous improvement that distinguishes high-performing organizations:

- Over the course of our two-day meeting, many members of the Committee expressed the view that they would have benefited from a brief overview session on the first day that would have encompassed the philosophy and structure of NSF's Strategic Plan, the relationship of the four strategic outcome goals to the Plan and to each other and the relationship of the individual indicators in each strategic outcome goal to the achievement of that particular goal. We characterize this session as "peeling the onion," with each layer enriching and deepening our understanding of the context in which we are doing our assessments. This contextual information will be especially important in years where NSF has revised its Strategic Plan or where indicators have been modified.

- Continuing in this vein, we again note that we are being asked to determine whether NSF has reached a threshold of "significant achievement" toward its goals. The principal source of evidence for this determination is the extensive and rich database of accomplishments (aqua: nuggets). However, we would like to know more about how these accomplishments relate to the indicators they are supposed to support. In the absence of more contextual information, we are often left wondering how strong the linkage is between the accomplishments and the outcome goals. It might be worth experimenting with a "feedback" loop in which NSF program staff assign project accomplishments to specific indicators, but then allow principal investigators to comment on how they believe their project supports (or doesn't support) the indicator for which it has been identified.

- Some panel members felt it would be beneficial to have access to basic program data in a spreadsheet format that would permit some additional analysis for specific indicators. Additional data to be included in such a spreadsheet might include: division, directorate, program, project title, grant number, hyperlinks to project summary and annual reports, award amount award duration, numbers of direct participants, numbers of beneficiaries (such as students), and PI names and institutions. We recognize that this suggestion might not be workable in this form given the workload already inherent in creating and validating the accomplishments database. However, the Committee makes this suggestion with the hope that, over time, more information, especially about numbers and types of participants and beneficiaries can be added to the existing information about project accomplishments. While simply counting things (outputs) won't in and of itself drive a determination of significant achievement, it is very helpful to understand the breadth and depth of the impact of a program or project – especially in the PEOPLE goal.

- In addition, the Committee believes that it might benefit from access to external, contractor-performed formal evaluations of programs. These are common in some directorates, e.g., Education and Human Resources, but they also exist for other programs, e.g., the Science and Technology Centers. These evaluations could provide important information to the Committee during its review and deliberations. Since these reports are often quite voluminous, it would be helpful if contractors preparing them could be asked to include a summary discussion of how their evaluations relate to NSF's strategic outcome goals. This would increase not only the utility of such evaluations, but would also serve to "close the loop" between program development, execution and assessment.

- The Committee was honored and grateful for the opportunity to discuss our work with Director Bement. However, we suggest that this discussion might be more meaningful and, perhaps, more helpful to the Director if it occurred on the final day of our meeting. By that time, the entire Committee would have had time to synthesize and reflect on our preliminary findings and recommendations and on the strategic issues that we would be highlighting in our report.

- Over the last three years NSF has streamlined and focused the process of reviewing accomplishments in PEOPLE, IDEAS, and TOOLS portfolios. This has expedited completion of the report during the Committee's meeting. Over the next year, we recommend that NSF now consider how to make corresponding improvements to the task of the OE Subgroup. For example, it would be helpful to have:

  (1) more guidance and context for the form and structure of the final OE product, given the variety of issues that must be covered (e.g., merit review, multidisciplinary and transformative research);

  (2) more information on the relative priority of key data sources that need to be analyzed;

  (3) information on any outstanding OE issues that have not been resolved in the previous year; and

  (4) more information on the COV reports that will be used in a given year and whether those particular COVs might contain gaps or biases (i.e., the COVs in a particular year are not broadly representative).

- It might also be helpful for the OE Subgroup chair to attend the meeting of the AC/B&O committee (at which the other three OE indicators are discussed). This meeting occurs about 2 months before the AC/GPA meeting. In that way, the OE chair could have the benefit of that discussion as the subgroup looks at the totality of the OE goal.

Lastly, the Chair and Vice Chair specifically wish to thank all of their committee members and especially the able chairs of each of the subgroups, Harry Shipman, Sally Mason, Gloria Rogers, and Jack Fellows. It is always a pleasure to work with a group of capable, motivated, and hard-working individuals and this Committee typifies those traits. Each person "did their homework" and came to the meeting prepared to discuss, debate and synthesize the collective results of their work. NSF is fortunate to have such people in its “corner” and it has been an honor to serve as their leaders.

Appendix 1: Advisory Committee For Business and Operations Letter

National Science Foundation

Advisory Committee For Business and Operations

May 25, 2005

Mr. Anthony A. Arnolie
Director, Office of Information and
Resource Management

Mr. Thomas N. Cooley
Director, Office of Budget, Finance,
and Award Management

Dear Mr. Arnolie and Mr. Cooley:

The National Science Foundation's (NSF) Advisory Committee on Business and Operations met May 5-6, 2005, to consider ongoing issues at NSF, with special emphasis on the 2005 assessment of Organizational Excellence*.*

The committee offers the following thoughts and perspectives on the items discussed at the meeting.

CIO, IRM, and BFA Updates

The committee again appreciated the updates on CIO, IRM, and BFA activities. A number of important observations came to light through the presentations and ensuing discussions:

- NSF's leadership on major eGov activities, especially Grants.gov and the Grants Management Line of Business, remains vital to the science and engineering community. Because the "customers" for Federal grant programs are as varied as the programs themselves, it is important that NSF and other R&D agencies work to ensure that the emerging systems adequately support competitive, investigator-initiated activities.

- The Knowledge Management Pilot Projects discussed appear to hold great potential for improving both programmatic and operational efficiency at NSF. For example, the work in advanced searching and clustering could greatly benefit key parts of the merit review process, as it could lead to improved methods of assigning reviewers and panelists to proposals.

- An important attribute of IRM's major initiatives is the involvement of a broad cross-section of the NSF workforce – in terms of both staffing level and organization. This emphasis on outreach and communication, as was highlighted in the discussion of the Administrative Functions Study, is vital to the success of these activities.

- The committee looks forward to future discussions on how best to update the Organizational Excellence component of the NSF GPRA Strategic Plan. The BFA Update noted that the planning environment is being shaped by a complex set of internal and external drivers, such as the President's Management Agenda, new guidance related to internal controls, a growing and more detailed set of metrics and scorecards across the government, and the findings from NSF's own Business Analysis, to name but a few. In this light, it would be especially valuable to further explore the "people" and "process" synergies that cross the five major PMA initiatives.

Report of Facilities Subcommittee

Dr. Tom Kirk, the subcommittee chair, reviewed the activities of the facilities subcommittee. He noted that the subcommittee held its first meeting on March 25, 2005. At that meeting, the subcommittee received presentations from NSF staff on issues related to facilities management. Following the meeting, the subcommittee developed a written report, which the full committee agreed should be provided to NSF (following a 2 week period for committee comments, as is noted in the Minutes).

Dr. Kirk noted that a first task for the subcommittee was defining its role, recognizing that the subcommittee's activities are framed by three major policy documents:

- The 2004 National Academies (NA) Report, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation,*

- The October 2004 draft NSF/NSB report, also titled, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation,*

- The July 2003 NSF policy document, *National Science Foundation Facilities Management and Oversight Guide.*

The subcommittee decided to assess the interaction of these three policy documents with the actual functioning processes of the NSF as the Foundation carries out the assessment, approval, funding and oversight of the large initiatives undertaken as "Major Research Equipment and Facilities Construction" (MREFC) projects.

Dr. Kirk described the three main observations that emerged from the subcommittee's review:

1. The implementation of adequate project management methods for MREFC projects during the Development Stage seriously lags the National Academies Report recommendations as well as NSF policy guidance currently provided for MREFC projects; accordingly, the needed 'Baseline Project Definitions' have not been achieved with adequate reliability as projects move towards New Project status and are submitted by NSF to Congress for funding.

2. The failure of NSF to regularly achieve adequate Baseline Project Definitions during the Development Stage is closely tied to the agency's under-investment in professional engineering, cost estimating and project management support for projects during this period; a useful guideline for the necessary level of pre-project engineering/project management investment is between 10% and 25% of the total project cost to provide reliable cost and schedule estimates at this stage.

3. The Deputy for Large Facilities Projects at NSF is a properly conceived role but one that has not been adequately empowered, staffed and supported within the agency to this point in time; a

strengthening of the Deputy position plus significant staff enhancement are needed to realize the purposes recommended in the National Academies Report and accepted by the Foundation.

In addition to agreeing to provide the subcommittee report to NSF, the committee also agreed that the materials presented to the subcommittee by NSF staff at the March 25 meeting should be made publicly available.

NSF 2005 Assessment of Organizational Excellence

The principal focus of the meeting was NSF's 2005 Assessment of Organizational Excellence. This was the second year that NSF developed a self-assessment of activities related to its OE goal, and the committee was again asked for input on three of the four indicators used to determine significant achievement in OE:

- Human Capital,
- Technology-Enabled Business Processes, and
- Performance Assessment.

The fourth OE indicator, Merit Review, will be assessed by the Advisory Committee for GPRA Performance Assessment (AC/GPA).

The committee's discussion focused on two questions:

1. Does the evidence presented support NSF's determination that it has (or has not) "demonstrated significant achievement" for the indicator?

2. Should any changes in approach or methodology be considered for future OE assessments?

Regarding the first question, the committee concluded that the evidence presented does support NSF's determination that it demonstrated significant achievement for the three indicators. The committee in particular commended the BFA and IRM staff for incorporating the observations provided last year on improving the assessment process.

This year's presentations were especially valuable in highlighting 1) the major activities that addressed the three indicators, 2) the mechanisms used to determine success, and 3) the relative level of success (fully successful, partially successful, etc.). The committee appreciated the high quality of the presentations and how they demonstrated clear leadership in the broad and complicated area of Organizational Excellence.

Through its discussion, the committee also provided a number of observations to NSF that address the second question related to potential improvements to the assessment process. One recurring theme in the committee's discussion was the need for NSF to clarify the connection between activities that address the OE goal and NSF's overall mission. A number of the committee's observations directly addressed this point:

- The OE assessment should be vigilant in reminding people about NSF's mission and purpose. The current assessment framework presents NSF's business processes in isolation. This runs the risk of rewarding NSF for the processes themselves and overshadowing the agency's actual mission of promoting progress in science and engineering.

- The OE assessment should also distinguish between “strategic” accomplishments and “tactical” ones. If the assessment focuses disproportionately on achievements at the tactical level, it loses the strategic connection to the agency’s mission and long-term vision. This can lead to NSF’s assessment appearing indistinguishable from those of other agencies, as the underlying processes are somewhat generic. It is important for the assessment to demonstrate NSF’s unique role among Federal agencies.

- A third area that should receive increased attention in future assessments is the impact of NSF’s leadership in government-wide initiatives, especially those in eGovernment. The committee recognized that NSF’s leadership in these areas is often more valuable to the initiatives than to NSF itself, at least in the near term. One possible approach to this issue would be for future assessments to highlight the elements of government-wide activities that benefit NSF and the elements that NSF is pursuing primarily to meet specific requirements.

Finally, the committee noted that NSF’s presentations and the ensuing discussion outlined the key set of issues that will need to be addressed when presenting the OE goal in the next update of the agency’s GPRA Strategic Plan.

The committee understands that NSF will provide these observations to the AC/GPA.

Transforming the NSF Academy

The presentation, *Transforming the NSF Academy,* provided the committee with an excellent overview of the Academy’s goals and major activities. It also underscored NSF’s motivation in establishing the Academy, namely to serve as a catalyst for a continuous learning organization. A number of issues for NSF consideration arose in the discussion following the presentation, such as the importance of involving all parts of the agency in planning the Academy’s activities, how best to highlight the links between the Academy’s activities and the agency’s strategic goals, ensuring that the Academy’s leadership competency models appropriately complement other such models in use at NSF, and the importance of blended learning environments for e-learning activities.

The NSF Business Analysis

The committee found the approach used in the presentation on the NSF Business Analysis – following a single topic (merit review in this case) from baseline analysis through findings and recommendations – to be a productive way to frame the committee’s discussion. NSF is encouraged to continue using this approach in future presentations.

In its discussion, a central issue the committee raised for NSF to consider is whether there may be opportunities for increased integration across the analysis and for putting the analysis in a broader context. The findings seem to reflect discrete lines of analysis, focused on workload, or the merit review process, or the results of the applicant survey, but lacking integration that would answer questions like “what should be done about the rising proposal workload?” “How do workload and staffing issues affect the advancement of science?” For example, could the workload survey clarify what tasks are shared across employee categories, and which tasks are most important to NSF’s core mission?

In terms of context, the business analysis should communicate more explicitly the integral importance of NSF's many external relationships. Unlike most federal agencies, NSF's accomplishing of its core mission depends on extensive and extended interaction with individual scientists and their institutions. Business analysis results should emphasize how NSF's own activities affect and are affected by these relationships. For example, the committee's discussion underscored the importance of NSF program officers taking time to work directly with first-time applicants to NSF. This arose in the context of discussing the possibility of creating a customer service center to answer investigator inquiries currently handled by program managers. The committee noted that educating and guiding investigators, especially young or unsuccessful investigators, is a valuable part of NSF's culture. NSF should therefore continue to approach this kind of proposed activity as one that complements the role of the program officer.

Meeting with Dr. Bement

The committee again appreciated the chance to meet with NSF Director Dr. Arden Bement. Dr. Bement noted that a major challenge for the agency is to address the increasing proposal workload on program managers. He described selected strategies under discussion with senior management to slow the increase in the number of proposals received each year. He added that the most important function of the NSF program officer is to serve as "signal processors" for science and engineering – ensuring that the agency remains focused on the frontiers of research and education.

He also discussed the importance of aligning NSF's staff functions and business systems with the agency's strategic goals, especially in light of the revision of the NSF Strategic Plan scheduled for next year. In addition to asking the committee to help NSF develop the next iteration of its Strategic Plan, he asked it to give attention to the agency's internal controls and their importance in achieving public trust. The committee shared with Dr. Bement the major issues raised previously during the meeting.

In closing the meeting, the committee noted that an appropriate topic for the Fall meeting would be how to foster a deeper integration of the OE strategic goal with the NSF mission, in the context of the upcoming revision of the agency's Strategic Plan.

The committee hopes these observations help to inform and guide the Foundation as it addresses the range of issues discussed at the meeting. We would like to thank the staff that helped make this meeting a successful one. We look forward to reviewing anticipated progress on the various issues discussed at this meeting and to discussing other mission-critical issues at our next meeting.

On behalf of the committee,

Dr. Norine Noonan
Co-Chair

Dr. Peter D. Blair
Co-Chair

May 5-6, 2005 Meeting

Appendix 2: 2004 NSF Committees of Visitors

NSF-Wide

Biocomplexity in the Environment (BE)	February 25-27, 2004
Nanoscale Science and Engineering (NS&E)	May 11-13, 2004

Biological Sciences

Division of Biological Infrastructure (DBI)	June 16-18, 2004
Plant Genome Research Program	August 11-13, 2004

Education and Human Resources

Teacher Preparation (CETP and STEMTP)	October 9-10, 2003
Federal Cyber Scholarships for Service (SFS)	November 19-20, 2003
NSF-NATO Postdoctoral Fellowships in Science and Engineering	August 9-10, 2004
Centers for Learning and Teaching (CLT)	May 3-5, 2004
Tribal Colleges and Universities Program (TCUP)	May 20-21, 2004
Rural Systemic Initiative (RSI)	May 20-21, 2004
Urban Systemic Program (USP)	August 25-27, 2004

Computer and Information Science and Engineering

Civil and Mechanical Systems (CMS)	March 22-24, 2004

Geosciences

Lower Atmosphere Research Section (LARS)	September 14-16, 2004
Earth Sciences Instrumentation and Facilities (EAR/IF)	August 18-20, 2004

Mathematical and Physical Sciences

Division of Chemistry (CHE)	February 3-4, 2004
Division of Mathematical Sciences (DMS)	February 11-13, 2004

Social, Behavioral and Economic Sciences

Economics, Decision and Management Science	March 29- 31, 2004.
Economics	
Decision, Risk, and Management Science Program (DRMS)	
Innovation and Organizational Change (IOC)	
Methods, Cross Directorate, and Science and Society	March 29-31, 2004
Methodology, Measurement and Statistics (MMS)	
Science and Technological Studies (STS)	
Societal Dimensions of Engineering, Science & Technology (SDEST)	
Social and Political Sciences	March 18-20, 2004
Law and Social Science Cluster	
Political Science Cluster	
Sociology Cluster	

Note: All executed and approved COV reports are posted on the COV webpages in the NSF Office of Integrative Activities

Appendix 3: NSF Draft -- Innovative-High Risk Research Definitions

A STARTING POINT FOR THE AC/GPA DISCUSSION ON INNOVATIVE-HIGH RISK RESEARCH – FROM PROGRAM OFFICER COMMENTS IN RESEARCH OUTCOMES (“NUGGETS”)

<= Projects may fit multiple categories =>

1. Forefront, Novel or Transformative but Untried or Untested

- This work is high risk since it explores the actual working of a living organism. We have very little information and knowledge in this area. An understanding will bring revolutionary changes to information processing. On the other hand we do not know the “right approach” until we try out many and it is possible that we will be unable to unlock this mystery that nature holds.
- This is an exploratory research project. It is high-risk because it is based on a novel idea that has not been tried before.
- For the first time it involves both state-of-the-art computational and experimental techniques. It has the potential of a large impact.

2. High Reward but Significant Technical Challenges and/or High Probability of Failure

- The technological hurdles are so immense that the project may never succeed.
- The work is high risk because many unknown factors may complicate or hinder the scale-up of the process by several orders of magnitude.
- This work involves new technology and deployment in high risk environments, so there is a risk of failure and loss.
- The return of data from a hostile alien environment hundreds of millions of miles from Earth is a risky endeavor [how NSF radio telescopes saved the wind data collected during decent on Titan after configuration problems on the remote NASA/ESA Cassini spacecraft]

3. Innovative and Contrary to Current Theory or Conventional Paradigms

- There is always risk when exploring new areas of science, especially if the research may run contrary to current theory.
- This work involves fundamental issues involving computing architectures of the future that may be a radical departure from the way computing machines are designed today.
- This work challenges the common understanding of how water molecules interact. These researchers are using new, cutting-edge tools to re-examine the structure of liquid water.

“High Risk”, but not necessarily Innovative-High Risk

4. Risk from Not Succeeding

- Any study of severe storms (including floods) is high risk (for the P.I.s) and for the speedy results that could save lives. The risk is in the criticality of the research.
- Failure could mean less minority students will enter the scientific workforce.
- The risk is that delays in the research can result in disastrous events that may have been prevented.

5. Risk to Principal Investigators/Others

- To drill 48 boreholes on a glacier can be very dangerous and risky.
- The PI undertook lengthy, dangerous fieldwork in the Golden Triangle area of Southeast Asia.
- With our research ever involving new ideas and technologies as a technical society we must always be vigilant in protecting society. At the moment there are many unknowns surrounding nanotoxicology and still we continue to produce these products. The risk is our lack of knowledge and understanding for the products being produced.

Appendix 4: 150 Innovative, High Risk Projects -- NSF Program Officer Assessments

Title
A Manifold Learning Toolbox For Nanostructure Simulations
A Materials Prediction Map for Tailoring Crystal Chemistry to Bulk Modulus
A New Camera for Extrasolar Planets
A New Paradigm for Cell Biology: Putting Some Muscle Into RNA Transcription
A New Sun-to-Earth Coupled Model
A Search for Dark Matter
A Wireless Stent That Measures Arterial Blood Flow
Adelante!: Focus on Latinas in Math, Science and Engineering
Advanced Optical Instruments for Monitoring Asthma
Air-Sea Exchange Measurements by Eddy Correlation
An Electrically Regenerated Diesel Particulate Filter
An Inexpensive Vertically Profiling Float for Seasonal-High-Resolution Measurements in P-BECS
An Observational Array for Arctic Oceanographic Measurements
Analysis of a Novel Mechanism of Genetic Reversion in Arabidopsis
Automated Housing Construction with Contour Crafting
Baby Cosmos Grows Up
Bioengineers Harness Prehistoric Marine Microorganisms to Produce Nanoscale Semiconductor Composite Materials
Brain Function and Economic Decisions
Brain-Like Learning Can Boost Electricity to Users
Breakthrough in Learning to Save Babies' Lives
Breakthrough Structural Information on Viruses through Combination Techniques and Methods
Bring Statistical machine Translation to the Real World
California State University at Fresno develops Certification Program with NSF Support
Cardiovascular Informatics
Catch a wave from space: Einstein@home
Challenging our Understanding of Water
Collaborative Research: Formal Methods for Behavioral Subclassing and Callbacks
Complex Reaction Networks on a Chip
Computer-Aided Design Algorithms and Tools for Nanotechnologies
Controlling Cell Shape
Cooperative Wireless Communications
Dark Matter in a Lambda CDM Universe
Design for Near-Term Cost Breakthrough in Access to Space
Designing New Materials to Prevent Protein Adsorption Fouling
Devices and Architectures for Neuromorphic Circuits with Nanoelectronic Components
Dynamic Evolution of DNA Supercoils and Loops
Dynamic Scheduling for Parallel Server Systems
EdGCM: A Global Climate Model (GCM) for the Classroom
Education Technology Software Promises to Ease Difficulties in Studying Science
Enhancing High-Speed Machining of Difficult-to-Machine Materials
ET Might Write Not Radiate
Event Driven Software Quality
Examination of Natural Products using X-Ray Crystallography
Exploiting Fading in Wireless Channels to Make Data Services Feasible
Fibers and fabrics that change color when illuminated
First Arctic Ocean Drilling Reveals Subtropical Past
First Crossdisciplinary Text on Optimal Adaptive Management of Complex Systems
First light for the Advanced Modular Incoherent Scatter Radar (AMISR) in Peru
Flames for Nano-Manufacturing
Foundations of Autonomous Biomolecular Computation

Fractures as Main Pathways of Water Flow in Temperate Glaciers
Gaffers Guild gives Glassblowing Demos to Thousands of K-12 Students Annually
Helical Configurations of Large Molecules
High Throughput Manufacturing of Nanoporous Films
IGERT Research Effectively Crosses Fields
Implicit Discrimination: New Insights into the Source of Discriminatory Behavior
Influence of Nano-particle Additives on Boiling in Liquids
Innovative Ocean Wave Energy Extraction Devices
Inside the San Andreas Fault
Internal Cooling of Turbine Blades for High Efficiency Propulsion and Power
ITR/SW: STRATEGIC SOFTWARE DESIGN: Value-Driven Software Definition, Development, Deployment, and Evolution
ITR: A Community Based Partnership for Community-Based Education (COPIRE)
ITR: New Approaches to Human Capital Development through Information Technology Research
ITWF: Culturally Situated Design Tools
Judicial Pioneers: Litigants in the Moscow Theater Hostage Case
Kidney Exchange: A Life-Saving Application of the Theory of Two-Sided Matching
Laser-Controlled Production of Antihydrogen
Lasers Talk with One Single Atom
Learning gains from Triarchic Instruction
Long-term turbulence observations and modeling in the coastal ocean
Loss processes for ozone in forests
Microbial Fuel Cell Generates Power From Waste
Modeling Impacts on Spacecraft
Modulating light on a CMOS chip
Molecular Computation in Ciliates
Molecular Storage by Charge Trapping
Molecule Fluorescence Methods and Myosin V
Multiple-Dye Luminescent Solar Concentrators
Nanoporous Silica Sluries
Nautical Knots and Engineering Design
NEES: George E. Brown, Jr. Network for Earthquake Engineering Simulation
NEESgrid: Cyberinfrastructure for Earthquake Engineering Research
NER: The First Rational Approach to the Preparation of Single Molecule AFM Tips
New Environmental Technology to Treat Sludge
New Evidence for Hope of Breakthrough in Fuel Cells
New Techniques in Cryopreservation Optimize Survival of Cells and Tissues
New Valve Based on Magnetic Coupling
New World Record Magnet at the National High Magnetic Field Laboratory
NGRIP Basal Ice
Novel DNA Nanostructures for Targeted Molecular Scale to Micron Scale Interconnects
NSF Radio Telescopes Save Saturn Moon Data
Observing Cosmic Rays at the Energy Limit
Ocean Drilling Probes the Deep Biosphere
Pipelines to the Stars
Polymer Nanocomposite Foams Produced by Environmentally Benign Carbon
PRAM-On-Chip
Predicting Storm, Tsunamis, and Flood Emergencies
Pretzels, Noodles & Mini-Proteins
Probabilistic and Statistical Methods in Machine Learning
Programmable Nanoscale Self-Assembly on Solid Surfaces
Protein Motors Incorporated
Quantum-mechanical Features of Thousands of Biological Macromolecules
Rapid Response Telescope Array Sees First Light
Reactive Mounting of Heat Sinks

Reactive Nanotechnologies to Enable Lead-Free Soldering
Reliability of Defect Tolerant Architectures using Probabilistic Model Checking
Replicating the Earth's Magnetic Field in the Laboratory
Research Experiences for Undergraduates in Chemistry at California State University Los Angeles
Research Experiences for Undergraduates in Chemistry at James Madison University
Research Experiences for Undergraduates in Environmental Sciences at Northern Arizona University
Researchers Fabricate Nano Test Tubes
Retwistered Twister
Reverse Engineering Cellular Pathways from Human Cells Exposed to Nanomaterials
Ring Arrays for Magnetic Storage Applications
Risky Project Helps Arabidopsis Genome Annotation
Safety Analysis for Critical Product Lines
Scientists Discover Undersea Volcano Off Antarctica
Security of Elliptic Curve Cryptography
Self-Adaptive Software'
Self-assembled polymer nanofibers for nerve repair
Self-Perfecting Genetic Circuits
Semiconductor Devices for Control of Solid-State Laser Dynamics
SGER: “Game Based Software Adaptation”
SGER: Biomimetic Wet Attachment Mechanism for Miniature Climbing Robots in Unstructured Environments
SGER: Development of the MERMAID Float: an Autonomous Vehicle for Recording Regional Earthquakes within the World's Oceans
Single Photon and Single Atom Sources
Smart Nanotubes for Selective Biomolecule Delivery to Living Cells
Solid-State NMR and Plant Structural Biology
Soy-Based Renewable Composite Material for Affordable Housing
Spin-Dependent Processes in Organic Semiconductor Devices
Stress-Induced Nucleation of Nanocrystals
Strong-Coupling Emission from a Quantum-Dot Photonic-Crystal-Slab Nanocavity
Structure of an RNA catalyst in its Entirety
Synchronized Transatlantic Synchrotron Research
Synthesis of new electrooptic polymers for DNA and RNA sensors
Technology-EDA Integration Through Nanometer Interconnect Design Tools
Test of the nuggets submission process -- not for approval
The 2004 NSF Waterman Award
The LIGO Livingston Observatory says “Goodbye” to Noise from Logging
The Long-Term Effects of Technology on Microprocessors
The Opium Trade in the Wa Area of the Golden Triangle
The Self Reorganization of Matter: Beyond the Standard Theory of Phase Transitions
Toward an international network of gravitational wave detectors: LIGO scientist participates in Virgo
Ultraviolet Photonic-Crystal Laser
Undergraduate Research for Freshmen and Sophomores at Xavier University of Louisiana
Uptake of Anthropogenic Carbon Dioxide by the Ocean During the Industrial Age
Using a Moss to Understand Chloroplast Biogenesis
Using Biomolecules to Assemble Building Blocks of Matter
Visualization of Proteins
X-ray Reflectivity of Liquid/Liquid Interfaces