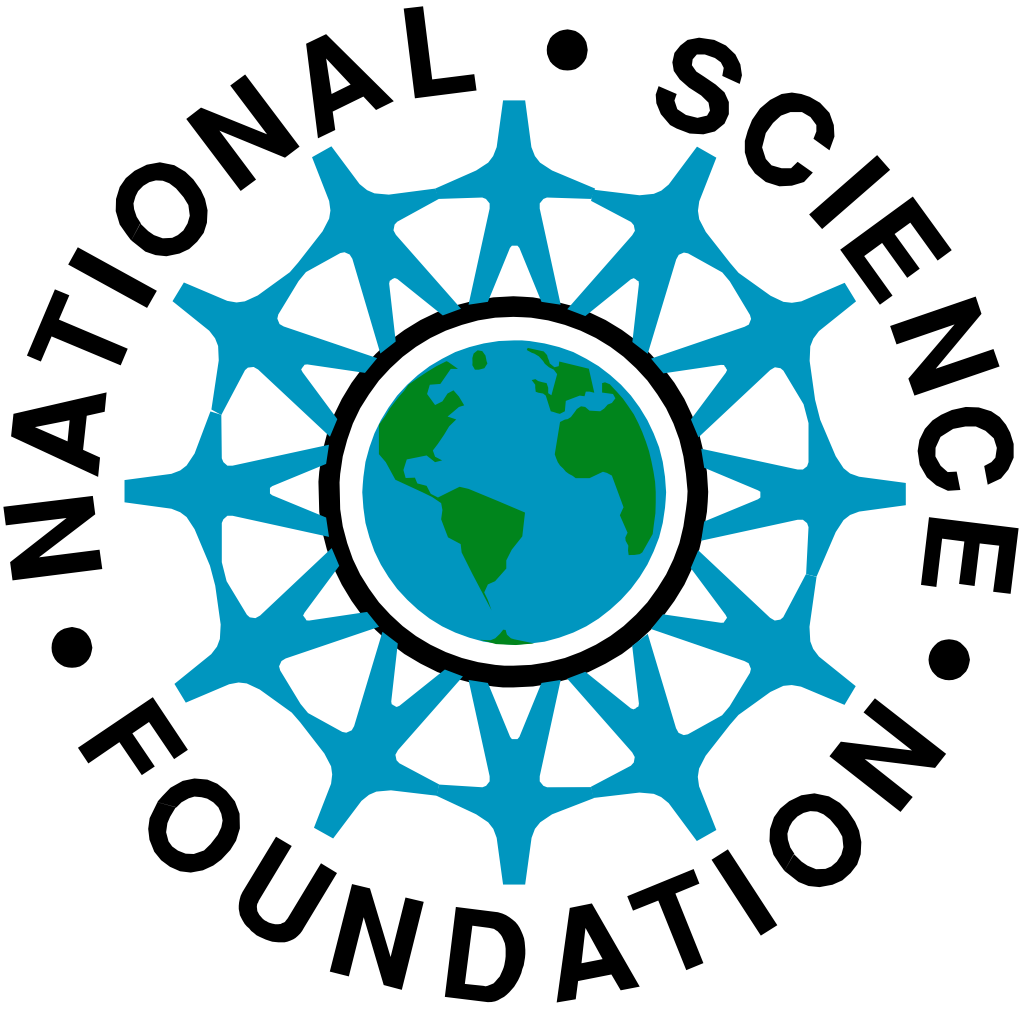

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EXECUTIVE SUMMARY

This report, prepared pursuant to the Government Performance and Results Act of 1993, covers activities of the National Science Foundation during Fiscal Year 2003.

NSF goals are divided into two broad areas: Strategic Outcome Goals and Management Goals.

Strategic Outcome Goals: Our strategic outcome goals focus on PEOPLE, IDEAS, and TOOLS and concern the practical, concrete, long-term results of NSF grants and programs. They represent what we seek to accomplish with the investments we make in science and engineering research and education.

Management Goals: Our management goals relate to the effectiveness and efficiency of our activities. They relate to the procedures we use to make awards, fund and manage capital projects, and otherwise serve our customers.

FY 2003 Results: For FY 2003 we have met 14 (70%) of our 20 goals. Foundation staff verified and validated all NSF performance data. In addition, IBM Business Consulting Services, an independent contractor, was engaged by NSF, to verify and validate performance information and data.

Outcome Goals: We were successful for all (100%) of our four annual performance goals associated with our strategic outcome goals. Our strategic outcome goals are:

- People – Developing "a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens";
- Ideas – Enabling "discovery across the frontier of science and engineering, connected to learning, innovation and service to society"; and,
- Tools – Providing "broadly accessible, state-of-the-art and shared research and education tools."

Examples of accomplishments for each of the outcome goals are provided within the body of the report. They represent only a small fraction of the results identified by external experts.

Management Goals: We were successful for 10 of our 16 goals (63%) in this area: We were able to:

- Allocate at least 85% of basic and applied research funds to projects that undergo merit review (Goal IV-1). We achieved 89%.
- Ensure that at least 70% of reviews with written comments address aspects of both generic review criteria (Goal IV-2). We achieved 90%.
- Ensure that 95% of program announcements are available at least three months prior to proposal submission deadlines (Goal IV-4). We achieved 99%.
- Process 70% of our proposals within six months of receipt (Goal IV-5). Seventy-seven percent of our proposals were processed within six months of receipt.
- Increase our average annualized award size for research projects to $125,000 (Goal IV-6). Our average annualized award size was $135,609.
- Continue to advance "e-business" by receiving through FastLane and processing electronically 90 percent of Principal Investigator award transfers (Goal IV-10). Greater than ninety-nine percent of Principal Investigator award transfers were processed electronically.
- Maintain and enhance the agency-wide security program to ensure adequate protection of NSF's IT infrastructure and critical assets by having a) 95% of major systems with approved security plans on file and b) 95% of major systems with documented certification and accreditation. (Goal IV-12).
- Ensure that diversity considerations are embedded in activities related to agency staffing of scientists and engineers through initiating development of a NSF S&E diversity plan (Goal IV-13).
    - Align or develop competency-based curricula, through the NSF Academy, that provide cross-functional, work-based team learning opportunities through the initiation

of development of new courses or revision of existing courses to address program management, leadership development, and technology and business process training (Goal IV-15).

- Develop competency-based, occupation classification alternatives that support the agency's strategic business processes and capitalize on its technology enabled business systems through identification of workforce competencies for all current NSF job families and initiation of identification of competency-based, classification alternatives (Goal IV-16).

We were not successful for 6 of our 16 management goals. These were:

- Ensuring that NSF Program Officers address both generic review criteria when making award decisions (Goal IV-3). Approximately 53% of Program Officers themselves commented on aspects of both merit review criteria for the particular proposal specified in the review analysis.
- Increasing the average duration of awards for research projects to at least three years (Goal IV-7). Our average duration was 2.9 years. Sufficient resources were not available to achieve both the average annualized award size and the average duration goals. We will continue to focus on increasing both award size and duration.
- For 90 percent of construction, acquisition and upgrade projects, keeping any negative cost and schedule variances to less than 10 percent of the approved project plan (Goal IV-8). Eighty-eight percent of projects kept negative cost and schedule variances to less than 10 percent of the approved project plan.
- For 90 percent of operational facilities, keep scheduled operating time lost to less than 10 percent (Goal IV-9). Eighty-seven percent of facilities kept scheduled operating time lost to less than 10 percent.
- Continuing to advance "e-business" by implementing Phase III of the Electronic Jacket application by implementation of the electronic capability for assigning proposal processing tasks, forwarding proposals to other programs as necessary, and delegating proposal action authority (Goal IV-11). Phase III is expected to be available for NSF staff use in FY 2004.
- Showing an increase over FY 2000 in the total number of appointments to NSF science and engineering positions from underrepresented groups (Goal IV-14).

SOME NSF ACHIEVEMENTS

PEOPLE

Indicator P1. Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future.

Advanced Training Institutes in Social Psychology
Advanced Training Institutes in Social Psychology[1] provide quality training in new methodologies, statistical procedures, and other tools to support and enhance social psychological research. NSF funding helps to establish training institutes where researchers can spend time acquiring basic skills and knowledge.

One institute provides training in the use and development of immersive virtual environment technology (IVET). Another institute focuses on the use of Internet technology to conduct social and behavioral science research. A third institute offers instruction in newly developed statistical methods for understanding social relations.

It is difficult both for those who are early in their careers and for senior investigators to obtain quality training in new areas. Advanced Training Institutes in Social Psychology provide one way in which such training can be obtained. These training institutes focus on the people of social psychological science, and they emphasize the integration of methods and technology from other disciplines. The training received by researchers can then be put to use in their own programs of scientific research and they can teach these new methods to their own students.

Digital Libraries for Children: Computation Tools that Support Children as Researchers
This project[2] was devoted to developing a children's digital library environment containing rich multimedia resources.

Over the three years of the project, the team developed visual interfaces that support young children (ages 7-9 years) in querying, browsing, and organizing multimedia information. In doing so, the team worked with children and teachers as "design partners" to develop new digital library technologies that support the learning challenges of young children. This demonstration project focused on multimedia resources of animal information donated by the Discovery Channel and the Patuxent Wildlife Research Center. The outcomes of the project to date include:

- The development of a digital library prototype (SearchKids) where children can search for animals using a zoomable visual querying interface. Multiple children can use this tool at the same time thanks to a special interface that enables multiple mice to be used simultaneously on one computer. This tool is linked to a zoomable presentation tool (KidPad), which enables children to use their animal resources to tell stories.

- The evaluation of the software with 120 second- and third-grade children. These studies have shown that young children not normally capable of complex Boolean searches can do so more efficiently and accurately given a visual interface. In addition, collaboratively navigating information necessitates various interface technologies that encourage cooperation and peer learning.

- Generalization of the interface has begun on two fronts. The team has begun generalizing

[1] Advanced Training Institutes in Social Psychology

[2] http://www.cs.umd.edu/hcil/kiddesign/searchkids.shtml

the technology infrastructure to work with other databases. They have begun generalization efforts by working with the University of Michigan's *Bio Diversity* animal database. In addition, the team has initiated a new research project with the Library of Congress and the Internet Archive to develop the largest international children's book digital library in the world. The project has just been notified that it will receive another $3 million from NSF's ITR initiative over the next five years to complete this research.

Media Coverage of this activity can be found at Online Library Project Plans a Cultural Trove for Children, (The New York Times Online, December 5, 2002) and Library for Kids Goes Online (National Public Radio, November 18, 2002).

Increasing U.S. Citizens and Women in Mathematical Sciences Graduate Programs
The VIGRE (Vertical Integration of Graduate Research and Education) program whose main purpose is to increase the number of U.S. citizens and permanent residents who have completed a Ph.D. in the mathematical sciences is succeeding in that objective. Of the sites reviewed in their third year this year, all but one increased the number of their graduate students from before VIGRE to their third year of operation. The numerical increases are between 3 and 59 with percentage increases ranging as high as 71%. The number of U.S. citizens and permanent residents went up at all but one with increases ranging between 1 and 26 (including a percentage increase of 55%). For example, the University of California, Los Angeles (UCLA) increased the number of U.S. citizens in its entering class from 12 in 1998 to 55 in the Fall of 2002. The number of third-year women graduate students increased at VIGRE sites by 31.7% between the start of VIGRE and this year. At the University of Chicago, for example, the collegial atmosphere helps to attract a large number of female students to the Department of Mathematics. The success in and satisfaction with the department on the part of the current students works as a magnet for incoming prospective female students, even though there are no tenured faculty who are women. The principal investigators (PIs) and graduate students credit the structure of the graduate program for the large percentage of women graduate students, as it works to ensure a collegial atmosphere, without harsh competition among graduate students and without the intimidation of qualifying exams. The number of women increased by nearly 50% from the time the grant started. The substantive increase in the number and percentage of U.S. Citizens and Permanent Residents in graduate school in a priority area is impressive.

NCAR Undergraduate Leadership Workshop
In June 2002, the National Center for Atmospheric Research (NCAR) hosted the first annual NCAR Undergraduate Leadership Workshop[3]. Its purpose was to inform students about the potential for exciting research and career opportunities in the atmospheric and related sciences. The five-day workshop established informal dialogues between students and research scientists as they explored laboratories, instrumentation, and computing facilities that support studies on weather, climate change, solar dynamics, the Sun-Earth system, and the impacts of severe weather and climate change on societies around the world. Science faculty nominated student leaders in junior standing to apply for the workshop, from which 16 students were selected as participants. Applicants were assessed on the basis of their demonstrated interest in atmospheric and related sciences, academic excellence, aptitude for research, and potential to gain from the experience. Students benefited from this experience by gaining insight into the breadth of research topics in the atmospheric and related sciences, while they also learned about NCAR's collaborative role in university research that positively impacts society. They became better informed about opportunities for graduate and post-doctoral studies in the University Corporation for Atmospheric Research (UCAR) community of member and affiliate universities and colleges. The workshop also encouraged them to consider the many ways scientists serve in leadership roles and how they might

[3] http://www.ncar.ucar.edu/eo/

themselves act as leaders by communicating their workshop experiences to other students at their sponsoring university. The sponsoring academic institutions benefited by demonstrating the links between undergraduate studies and NCAR's examples of research and careers in the sciences. Students participating in the program were also expected to become more interested in continuing their studies in the sciences through graduate school. The provision of hands-on information and contact time for undergraduate students who typically have limited experience with geoscientists and their work is a key step in ensuring future graduate student interest in these disciplines.

Indicator P2. Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities (Includes women, underrepresented minorities, or persons with disabilities.)

Using Inquiry-Based Science to Help English Learners Increase Achievement

The Valle Imperial Project in Science (VIPS) is a collaborative effort of the Imperial County Office of Education and the San Diego State University. It was implemented to strengthen K-6 science education in 16 school districts through district-wide professional development of teachers. Located on the California-Mexico border, the Imperial Valley region experiences geographic isolation and poverty. The student body is 82% Latino and 47% limited language proficient, and has historically had limited access to science education training.

An important component of the VIPS project has been the study of effective ways to increase student achievement through kit-based science programs, while strengthening the acquisition of language skills for students with limited English proficiency. The research study, *Helping English Learners Increase Achievement Through Inquiry-Based Science Instruction*, published in the Bilingual Research Journal, summarizes results of a four-year study of K-6 students in the El Centro Elementary School District. Data measuring student achievement in science, writing, reading, and mathematics were analyzed relative to the number of years that students participated in kit- and inquiry-based science instruction that included the use of student science journals. Results indicated that the achievement of English learners increased in relation to the number of years they participated in the project. The longer they were in the program, the higher their scores were in science, writing, reading, and mathematics[4].

The push for accountability demonstrated by student achievement is unparalleled; performance on state mandated tests is required of all students, even those with limited English proficiency. To meet expectations, many districts focus on "the basics," often at the expense of other subjects (*e.g.*, science). Relating science learning to gains in achievement in tested subjects ensures its place in school curricula. This also shows strategy for bringing quality science and mathematics education to students from under-represented populations.

A Workshop to Develop Minority Faculty Leaders in Chemical Engineering

The purpose of the workshop was to provide a forum for aspiring minority faculty currently in Ph.D. programs to network with established minority faculty. More than 60 participants were also able to meet program managers in their relevant disciplines from the major funding agencies such as NSF and the National Institutes of Health (NIH). This targeted mentoring was geared towards increasing the number and success of Minority Faculty in Chemical Engineering. Mid-career minority faculty currently in academic positions in chemical engineering were able to initiate collaborative research (and identify available post-doctoral fellows) among the aspiring minority faculty, with each other, and with the relevant funding agencies. The workshop also provided information focused on career options (*e.g.*, administration, national leadership, *etc*.) for "mid-career" faculty.

Highlights of the program included: (1) Panel discussions with engineering deans, with senior faculty, and with college administrators; (2) Research presentations by participants and poster sessions by aspiring faculty; (3) Meetings with NSF program officers with overview presentations of research-funding opportunities; and (4) Structured opportunities for mentoring and collaboration. A Survey Analysis Method was designed in Spring 2001 by Professor Grant and Saundra Williams (North Carolina State University Adult and Community College Education) to evaluate the impact of the workshop on the participants. The survey was analyzed using the statistical analysis package Statistical Program for Social Sciences (SPSS), the results of which are available to design future mentoring activities. A website was also

[4] The paper is available on-line at http://brj.asu.edu/content/vol26_no2/pdf/ART2.PDF

developed to facilitate the application/selection process for job placements; this provided the foundation for the current website for the Minority Affairs Committee (MAC) of the American Institute of Chemical Engineers (AIChE).

This workshop, aimed at minority chemical engineering faculty at various stages of their career, provided information on how to enhance their careers. It also provided access to various NSF program officers for networking purposes.

Arctic Research Community Coordination and Outreach

The complex interactions of disciplinary and interdisciplinary research in the Arctic region require a great deal of communication to maintain a high degree of efficiency, to propel research initiatives and to facilitate discoveries involving research across disciplines. Outreach by the arctic research community makes research results available to the public and encourages students to pursue arctic science. The Arctic Research Consortium of the U.S. (ARCUS) continues to enable a high level of communication among the arctic research community through their email listserv ArcticInfo with over 5000 subscribers, their web site that includes a searchable directory of arctic researchers (over 3500 entries), a calendar of events, downloadable publications, and the Arctic Logistics Information and Support (ALIAS) web site. ARCUS hosts an annual interdisciplinary arctic research conference, the *Arctic Forum,* in Washington D.C. Each year a competition is held for the best graduate or undergraduate student research paper and the awards in 4 categories are conferred after the students present their work at the Arctic Forum. ARCUS publishes the abstract proceeding from the meeting, reports from ad hoc meetings they facilitate and a bi-annual newsletter, *Witness the Arctic,* which chronicles current developments and opportunities in the NSF arctic research program. ARCUS organizes an Arctic Visiting Speakers' program that provides the opportunity for researchers to travel to a host town to give talks and work with local people, schools, universities and community groups on arctic research topics.

Understanding the arctic region is an inherently interdisciplinary undertaking requiring communication and planning among researchers from a wide variety of fields including the natural, physical and social sciences. ARCUS has done an exceptional job of facilitating communication through email, the World Wide Web, meetings, and publications. Furthermore they have undertaken several outreach efforts to include young scientists and arctic communities in arctic research. The workforce at ARCUS is approximately 50% female–including the executive director and other high-level positions–and 11% minority.

Catalysis for Alternate Fuels

Catalytic Fischer-Tropsch Synthesis (FTS) provides a route for producing gasoline, diesel fuels, oils, and chemicals from smaller organic molecules. However, selectivity limitations for existing FTS catalysts impose significant economic penalties due to costly product separation and the need for further upgrading of lower-grade product fractions. These problems remain unresolved due in part to the lack of understanding of the fundamental reaction mechanisms. Research being conducted at Hampton University is examining a novel catalyst system previously discovered by researchers at the University of Virginia for ammonia synthesis. A broad range of experimental conditions, involving variations in the temperature, pressure, and reactor flow rates, are being systematically examined for the first time. New insights into the reaction pathways have been developed, and the new catalysts have been confirmed to exhibit significantly enhanced selectivity.

This research involves a partnership between chemical engineering departments at Hampton University, a historically black university with no graduate program, and the University of Virginia. Catalysts prepared at Virginia under an established NSF graduate-research project are investigated by a select group of undergraduate students at Hampton. These students receive

their first exposure to a post-graduate educational experience by using advanced microreactor apparatus and state-of-the-art analytical tools. They also learn to make detailed literature surveys on specific subjects and to analyze the acquired data. The principal investigators and collaborators at Virginia mentor their academic progress closely, and an exchange of graduate and undergraduate students is also involved. The Hampton students and principal investigators have co-authored research publications with the Virginia researchers and have presented results at regional conferences. A poster paper was be presented at the 18th North American Catalysis Society meeting in June, 2003.

The collaborative research program introduces underrepresented minorities to leading-edge research conducted at both Hampton University and the University of Virginia. Students are exposed to a catalysis-research area highly relevant to national priorities related to the development of alternate fuels.

Center Aims to Bring More Women and Minorities into Engineering

Women and minorities have always been underrepresented in engineering fields, although their numbers have been increasing recently. The Center for Wireless Integrated MicroSystems (WIMS), an Engineering Research Center (ERC) headquartered at the University of Michigan, has expanded its work in secondary schools with four summer programs that use microsystems to excite students about using engineering to tackle important societal problems. The courses are designed to improve precollege students' skills in science, math, computer science, and communications. More than half of those enrolled were females, and one program targeted students from underrepresented groups (mainly African-Americans from urban schools). "*Legos to WIMS*" is a 5-day commuter program open to fifth through seventh grade students. The "*Detroit Area Pre-College Engineering Program (DAPCEP)/ WIMS Short Course*" is a three-week residential program for students entering 11th and 12th grades, which has been offered through the Diversity Programs Office at WIMS partner institution Michigan State University since Summer 2000. "*WIMS for Women*" was introduced as a 6-day/5-night residential summer program in Summer 2002, and will be expanded to a two-week program in Summer 2003. "*WIMS for Teens*" was offered as a 7-day/6-night residential summer program for the first time in Summer 2002. The program was conducted on the University of Michigan campus but was managed by WIMS staff from Michigan State University. In each of these summer programs the students have a curriculum focusing on math integrated with science, Lego Mindstorm challenge activities, communication skills, and pre-engineering motivational activities.

By working with underrepresented groups at the pre-college level and working to spark their interest in engineering at a young age, the WIMS programs are likely to broaden the future base of the engineering profession.

Change and Its Impact on Culture, Economy and Identity in Three North Bering Straits Alaskan Inupiat Societies: Little Diomede Island, King Island, and Wales

Anthropologist Carol Jolles of the University of Washington has been working with three subsistence-oriented Alaska Native communities in northwest Alaska researching sociocultural and economic change and its association to globalization processes from the 1930's to the present. A crucial aspect to this research is the collaboration between the scientists and the Alaska Native communities. Dr. Jolles has included local people in the research design and fieldwork. These activities, particularly the training of local research assistants, contribute to developing a "diverse workforce" among Alaska Native people.

Dr. Jolles research includes education for minority and Alaska Native students and will help to provide a more diverse workforce for the future.

COACh: Committee on the Advancement of Women Chemists

The Committee on the Advancement of Women Chemists (COACh) was founded by a group of

individuals that wanted to enhance the rate of progress of attaining gender equity in the chemical sciences. Two major goals of COACh are to provide women chemists with the professional skills necessary for advancement in academe, and to increase the overall number, rank and visibility of women faculty in the field. To this end, COACh provides training programs in the development of communication, negotiation, and leadership skills. The programs comprise a series of one-day workshops held prior to National American Chemical Society (ACS) and American Institute of Chemical Engineers (AIChE) meetings. Anyone interested in assisting in the promotion of women chemists is eligible to join COACh. Their web site, http://www.coach.uoregon.edu/, contains information about the workshops and COACh membership as well as other information, such as lists of women academic chemists, job listings, funding opportunities, the results of COACh research efforts on academic climate issues, and a conversation room to discuss current topics of interest to members. Over 100 women faculty have participated thus far in the COACh workshops, with 30 more to participate at the Spring, 2003 ACS national meeting. COACh has received a number of requests to assist in setting up similar training workshops at other professional meetings and at various types of institutions. Following the precedent set by COACh, other professional organizations such as the American Physical Society have started COACh-style workshops at their professional meetings.

The COACh project represents a national effort to enhance opportunities for women in academic positions in chemistry and chemical engineering departments. Through focused workshops and mentor networks, the PIs are promoting gender equity and strengthening the workforce in academic institutions. Assessment of the effort is a component of the project.

Cooperative Agreement with the Alaska Native Science Commission
The Alaska Native Science Commission (ANSC) is made up of Alaska Native scholars and scientists that facilitate the connections between rural communities and NSF supported research. Working with the Arctic Section of the Office of Polar Programs the ANSC, through workshops, personal contacts and meetings, has assisted scientists in making contact with Native Alaskan communities and facilitated Native peoples voices in Arctic science. In this way, scientific research can better meet the needs of Alaskan rural communities. The ANSC also has an internship program for Alaska Native students that helps increase the exposure of students to the many disciplines of science and engineering. In addition, the ANSC publishes a quarterly newsletter to inform Alaskan communities about NSF science projects in their regions. The ANSC is a critical link between science, education, and local community concerns and needs and represents the future of cooperation in scientific research.

The ANSC provides opportunity for the participation of Alaska Native people in NSF activities.

Dispersed REU Site
Research Experiences for Undergraduates (REU) are arguably some of the most important experiences students will have while in college. The REU experience has been enhanced by mechanisms that enable students to share research ideas, experimental designs, and interpretations of data with a group of professors from other campuses and their REU students. Such an REU consortium, the first in the Chemistry Division, has implemented this strategy by engaging 6 research groups with common interests in organic synthesis located at Juniata College (PA), Trinity University (TX), Trinity College (CT), St. Michael's College (VT), Northern Kentucky University (KY), and Macalester College (MN). The entire faculty in this consortium teaches at schools where undergraduate students are the principal, and sometimes only, collaborators. The entire faculty has track records of successfully synthesizing previously unknown chemical compounds with their undergraduate students. They have joined together in a consortium with a common interest in "Synthesis of Theoretically Interesting Molecules." The group works together in spite

of the distance between research sites by making use of electronic communication and face-to-face meetings at each other's campuses and at an annual national meeting. At the end of the summer they converge for a symposium in which the students present their results. The students also prepare a poster of their summer's work to be displayed at their home institution and on the consortium web site. Each campus group has noted the value added to their work through the effective intellectual exchanges that take place via consortium interactions.

This innovative, distributed REU program links the faculty and students at six sites from Texas to Vermont. Using a shared set of research problems in the general area of organic chemistry, participants have an opportunity for professional development as individuals and as part of a scientific community.

Educational Renewal in Rural Alaska
Rural schools in Alaska are redefining their roles. Stimulating this reconstruction is the Alaska Rural Systemic Initiative (AKRSI-Phase II), now completing its seventh year of rural school reform initiatives. AKRSI focuses on increasing the connections between what students experience in school and what they experience outside of school by utilizing the Alaska Standards for Culturally Responsive Schools. This approach is reaping benefits. Historically showing the lowest student achievement levels in Alaska and the nation, the 20 AKRSI school districts are now making gains in student achievement. For example, AKRSI schools have shown:

- *An increase in student achievement scores*. The indicators of the effects of the first phase of implementation of the school reform initiatives in the 20 AKRSI school districts (which historically had the lowest student achievement levels in the Alaska and the nation) pointed to a differential gain between AKRSI partner schools and non-AKRSI rural schools of 5.9 percentage points in the percentage of students who were in the top quartile on the 8th grade standardized achievement test in mathematics. The 8th grade AKRSI students showed significant progress in closing the achievement gap with their non-AKRSI counterparts from 20 to 15 percentage points (standards-based Benchmark tests – Mathematics).

- *A decrease in the dropout rate*. For example, the dropout rate for grades 7-12 in AKRSI partner schools has declined from a mean of 4.4 to 3.6 over a five year period, whereas the dropout rate decreased from 2.7 to 2.4 in non-AKRSI rural schools in the same time period.

- *An increase in the number of rural students attending college*. Enrollment of first-time freshmen students at the University of Alaska from AKRSI schools had a net gain of 26% compared to the net gain of 8% for freshmen students from Non-AKRSI schools over a seven-year period.

- *An increase in the number of Native students choosing to pursue studies in fields of science, math and engineering*. Of the 12 major fields available at the University of Alaska Fairbanks (UAF), the percent of Alaska Natives student enrollment has increased significantly in most fields over the past seven years. Enrollments of Alaska Native students increased in math, science and engineering fields from 36 in 1994 to 84 in 2000. Enrollment of Alaska Native students in the life/biological science fields (especially biology, fisheries and wildlife biology) have also increased, which is consistent with the interests shown by younger students as they select topics for developing a project to enter the AKRSI-sponsored science fair.

- The consistent improvement in student performance and participation shows that the Alaska Standards for Culturally Responsive Schools have had a significant impact on expanding the opportunities for Alaskan students.

The work of the AKRSI is addressing the mathematics and science perceptions,

performance, and participation of Alaska Natives. A significant contribution is capitalizing on cultural knowledge and values to guide and enhance systemic practices and outcomes.

Louis Stokes Alliances for Minority Participation Program

In 2002, more than 21,429 underrepresented minority students received science, technology, engineering and mathematics (STEM) baccalaureate degrees via the Louis Stokes Alliances for Minority Participation (LSAMP)[5] program. Collectively, the reach of the LSAMP program extends north to Alaska, Washington, Montana and New York; south to Texas, Florida and Puerto Rico; east to Massachusetts, Rhode Island, Pennsylvania and the Carolinas; through Middle America, including Illinois, Missouri, Oklahoma, Tennessee, Colorado and New Mexico; and West to Arizona, California and Hawaii. The program now includes 30 alliances representing over 400 individual institutions. In 2003, the number of STEM students impacted directly by the LSAMP program reached an all-time high of 206,893.

For the National Science Foundation, the outcomes of the Louis Stokes Alliance for Minority Participation indicate progress toward addressing the long-term goal of increasing the production and diversity of Ph.D.s in STEM fields with an emphasis on entry into faculty and research positions.

North Carolina LSAMP

The North Carolina LSAMP[6] was granted a Phase III award in FY 2003 to increase the number of STEM degrees for minority students and prepare and increase student interest in transitioning into graduate school. Significant highlights of the North Carolina LSAMP include:

- 841 Bachelor of Science degrees awarded to minority STEM students in 2002.
- Minority STEM enrollment increased 17.8%, from 4,744 in Fall 1997 to 5,588 in Fall 2001.
- Faculty and students throughout the Alliance participated in 50 STEM-related local, state, and national conferences and professional meetings. Many students made both oral and poster presentations at several of these events.
- During summer 2002, a North Carolina-LSAMP biology faculty mentor and three North Carolina-LSAMP biology students from North Carolina A&T participated in the Faculty and Student Team (FaST) Research Program. The ten-week program at Argonne National Laboratory provided a research experience for the participants with national laboratory scientists.

NC LSAMP is in the capstone phase of their efforts to increase the number of minority students in STEM. Now in its twelfth year, the Alliance has attracted, retained and graduated significant numbers of students who are prepared to move to the next steps in training for STEM careers.

REU -- Spanish Language Retention among Mexican Americans

Why do some Mexican Americans retain Spanish while others lose their native language? In a study conducted as part of the Research Experience for Undergraduates Program funded by the National Science Foundation, Geneva Villarreal, a student from West Texas A&M University, sought to identify factors that are associated with Spanish language retention among Mexican Americans. Using data from the 1990 Public Use Microdata Sample (PUMS), she found that Mexican Americans who are more likely to speak Spanish are persons 35 and older, those with lower levels of education, those who are born in the United States, those whose parents are not intermarried, those living in areas with larger Mexican-origin populations, and those residing in the southwestern region of the country. Ms. Villarreal presented her paper titled "*Correlates of Spanish Language Maintenance: The Case of Mexican Americans*" at the annual meeting of the Southwestern Social Science

[5] http://www.ehr.nsf.gov/hrd/amp.asp
[6] http://www.ncat.edu

Association. Ms. Villlarreal was one of 10 students who participated in this REU Site, an NSF program that contributes to the Foundation's continuing efforts to attract talented students into careers in science through active undergraduate research experiences.

This REU recruits predominantly from underrepresented minority student populations. These undergraduates then spend the summer working with a faculty mentor on an independent research project.

REU Site at Santa Clara University - Ethics Component A Case Study: *Noah's Dilemma*
Under pressure to complete the project, to get the data "right", and to publish the findings, what does Noah do? In the highly acclaimed ethics component of the REU program at Santa Clara University, the summer research students in the Departments of Chemistry and Biology consider case studies dealing with ethical issues related to plagiarism, data manipulation, intellectual property, authorship, deviations from proper research protocol, and the use of human subjects.

Case studies produced by the American Association for the Advancement of Science (AAAS) are first presented to the students as video vignettes. After watching the videos, the students and their faculty mentors break into small groups led by a faculty member to begin discussions. The analysis is typically undertaken within a framework developed by Dr. Margaret McLean, Director of Biotechnology and Health Care Ethics at Santa Clara University's Markkula Center for Applied Ethics. The students later reconvene as a large group to share the more important insights arising from the small-group discussions. In addition to the ethical issues that the videos raise, they open the door for discussions on the everyday process of science, including, for example, the administrative structure of the laboratory, how funding and publication processes work, and the importance of keeping accurate notebooks. This leads to informal discussion in the lab and other venues outside of the ethics meetings.

A response from a student to an evaluation question of the ethics component was: "The ethical issues that actually come up on a daily basis in a real world work field was surprising to me. Confronting these issues and dealing with the problems of integrity is not an easy task and may not have an obvious solution." This Ethics in Science program is underscoring to both students and faculty that workplace ethical dilemmas are not restricted to human cloning or genetic engineering. They arise in everyday issues such as maintaining laboratory notebooks and acknowledging the contributions of others.

This REU program teaches technical skills and scientific methodology, as well as provides an ethical framework for scientific conduct. It directs students on a path of technical and character development that will enhance their effectiveness in the workforce of tomorrow.

The Consortium for Undergraduate Research Experience (CURE)
The CURE consortium consists of the California School Leadership Academy (CSLA), Pasadena City College, Los Angeles City College, Los Angeles Southwest College, East Los Angeles College, and the Jet Propulsion Laboratory (JPL). The goal of the program is to recruit, train, and retain under-represented minorities in science and engineering. Ten students from the consortium schools are recruited annually. Participating students work on research projects with mentors from CSLA and JPL; most of the students observe at JPL's Table Mountain Observatory. Julie Rivera, a recent alumna of the CURE program, finished her B.A. at Pomona College after starting at CSLA. In June, 2002 she was hired as an observatory assistant at Hawaii's Keck Observatory, home of the world's largest telescopes.

This program has been successful in recruiting and training under-represented minorities.

University of Puerto Rico, Mayaguez Undergraduate Creates Nano-filter for Bio-medical Lab-on-a-Chip
Nancy Guillen, an undergraduate at the University of Puerto Rico, Mayaguez, and a participant in the NSF's Research Experience

for Undergraduates (REU) program, spent last summer with a Cornell University research team manufacturing and testing a collagen membrane that could one day be used as a miniaturized lab-on-a-chip for rapid screening of blood samples. Guillen's membrane has nanometer-sized pores small enough to sift biomolecules by size alone. The membrane blocked hemoglobin while allowing DNA molecules to pass through. Guillen's presentation on her project won first place in the Chemical Sciences competition at the 2002 Annual Biomedical Research Conference for Minority Students, held last November in New Orleans[7]. The Cornell team also presented the work in a paper at the Materials Research Society Fall Meeting in December 2002. Guillen worked under the guidance of Lori Lepak, a graduate student in the research group of electrical engineering professor Michael Spencer. She conducted her research at Cornell's Nanobiotechnology Center, an NSF Science and Technology Center, and manufactured her filter on a chip at the Cornell Nanofabrication Facility, a node of the NSF-supported National Nanofabrication Users Network.

Guillen's efforts broke new ground on several fronts. She used collagen monomers as raw material, which are up to 50 times thinner than the collagen fibrils used in commercially produced collagen membranes, and prepared them by the spin-deposition technique, which is also one of the easiest and cheapest ways to make the 100-nanometer-thick membrane. The successful use of collagen, the main connective tissue protein in the human body, offers the major advantage for the filter of biocompatibility –meaning that implantable devices using *Guillen's membrane would be free from immune reactions*. For example, a coating for transplanted pancreatic islet tissues would let glucose and insulin pass through freely, but block the larger immune system molecules that lead to rejection. Biomedical devices using collagen membranes may thus someday free organ-transplant recipients from lifetime regimens of powerful immunosuppressant drugs.

The first uses of the filter will likely be to prepare DNA chips for quick medical analysis or newborn screening tests. Such a filter may also be used one day as part of implantable devices such as an artificial liver.

[7] http://www.abrcms.org/2002Winners.asp

Indicator P3. ***Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal. (For example, broad-based, program-wide results that demonstrate success related to improved math and science performance for preK-12 students, or professional development of the STEM instructional workforce, or enhancement of undergraduate curricular/laboratory/instructional infrastructure, or highly synergistic education and research activities, or international collaborations, or communication with the public regarding science and engineering.)***

Award Winning *DragonflyTV* Brings Science Investigations to 25,000,000 Children and Parents in its First Season

DragonflyTV[8] has broken new ground in presenting science to children, ages 9-12, via television, the Web and publications. The program exclusively features real children engaged in their own science investigations, and these investigations are crafted and presented—in collaboration between the show producers and the featured children—to model complete inquiry experiences. *DragonflyTV* young investigators explore every kind of science, from the mysteries of the human body to the power of a tornado. More than 50% of young investigators are girls and more than 50% are children of color. Nearly 70% of the show segments feature uses of technology, the application of which is of growing importance to the workplace and society.

The program and its supplementary products are impacting millions of children and adults. Program evaluations have demonstrated that children who watch *DragonflyTV* increase their interest in doing science investigations and have a better appreciation of experimental techniques. As a result of viewing the show, 80% of kids tested wanted to try their own science projects.

In 2002, the first season of *DragonflyTV* aired on 250 PBS stations, with the potential for reaching 87 percent of U.S. households. It was carried in both large and small markets, and has become a featured part of the video curriculum on state educational networks (*e.g.*, Georgia, Iowa, South Dakota). According to Nielsen Research for February 2002, 1,600,000 viewers tuned in each week; and total viewers for 2002 exceeded 25,000,000. Nearly 25% of the audience was composed of children, ages 6-11; 33% was adults, suggesting that many families watch the show together. Season Two and Three are in production with plans to expand the outreach and web activities.

NSF funding has helped leverage major corporate underwriting from Best Buy, which has recently committed $1.1 million to the continuation of the series.

DragonflyTV has already been recognized through national awards for its innovative approach to science and commitment to excellence. It won the CINE Golden Eagle Award, the World Silver Award from the New York Festivals, and the Chris Award from the Columbus International Film and Video Festival. The *DragonflyTV* Web site has won the Broadcast Design Association Bronze Award.

This importance of this project is that it has provided quality broadcast programming to increase student interest in science and mathematics; increased access to science for children from underrepresented groups; and increased parental involvement in science and mathematics education.

An Environmentally-benign ('Green') Organic Chemistry Curriculum

The University of Oregon is:

(1) Developing new organic chemistry laboratory experiments that teach the fundamental concepts and skills of organic chemistry in a safer manner, while teaching the tools and strategies of "green" chemistry;
(2) Disseminating these materials through workshops, a laboratory textbook and a searchable web-based database; and
(3) Promoting the participation of a broad spectrum of educators in higher education.

[8] http://www.dragonflytv.org/

In all, 25 new laboratory experiments have been developed and classroom tested with support from the Course, Curriculum, and Laboratory Improvement (CCLI) Program. The new experiments teach the core concepts and techniques typically associated with organic chemistry lab courses while teaching students a process with which to evaluate and redesign chemical products and processes to make them "greener." The new experiments are safer, reduce waste and inspire students to use chemistry to solve environmental problems.

More than 40 educators have participated in the project's annual weeklong Green Chemistry in Education Workshops. Nearly all of these educators are now introducing green chemistry into their courses. Articles describing selected experiments have been published in Green Chemistry and Journal of Chemical Education[9] The textbook "*Green Organic Chemistry: Strategies, Tools and Laboratory Experiments*" is being published by Brooks/Cole. Five of the project's experiments have also been published in an American Chemical Society (ACS) publication "*Greener Approaches to Undergraduate Chemistry Experiments*." To assist educators in choosing between the growing numbers of educational materials, the PI has established an electronic database on the web[10].

New organic chemistry laboratory experiments are being developed that are safer, reduce waste and inspire students to use chemistry to solve environmental problems.

An Integrated Undergraduate Program in Bioinformatics

Modern molecular biology has come to depend more and more upon the analysis of large amounts of data to identify trends and patterns in the complex workings of natural systems. The sequencing of the human genome has paved the way for new methods based on a coupling of high-throughput methods in biology with state-of-the-art computational analysis. The pharmaceutical and bioinformatics industries are demanding scientists and professionals that are trained in both computational analysis and biological experimentation to perform this research. Unfortunately, the entrance requirements for graduate programs in computational molecular biology and bioinformatics are often prohibitively extensive.

The content of Wright State University's introductory-level, interdisciplinary bioinformatics course has been developed into the first undergraduate textbook in bioinformatics, "*Fundamental Concepts of Bioinformatics*," published by Benjamin Cummings in the Fall of 2003. In addition, PocketMol, the first molecular graphics tool for the PocketPC platform, was developed by undergraduate students involved in the research arm of the bioinformatics program at Wright State. PocketMol allows biological macromolecules, such as proteins, to be viewed, rotated in 3D, colored and modeled on a palm-sized PocketPC computing device.

The undergraduate bioinformatics program at Wright State University is designed to serve as a national model for undergraduate bioinformatics education, allowing universities to prepare students for careers and graduate education in bioinformatics with a minimum overhead in terms of new courses and faculty. An associated undergraduate research program has been established to provide unique research opportunities to undergraduate students pursuing their degree in bioinformatics.

Culturally Situated Design Tools

Rensselaer Polytechnic Institute (RPI) is developing and evaluating Culturally Situated Design Tools (CSDTs). These software applications use ethnomathematics–the mathematical practices embedded in artifacts such as cornrow hairstyles, native American beadwork, rhythm patterns in music, *etc*.–to teach students how their cultural background can become a bridge, rather than a barrier, to information technology careers. An example of a graphic provides a specific illustration of the learning potential of CSDTs. The graphic was

[9] Green Chemistry 2001, 267-270; J. Chem. Ed. 1999, 77,1627-1629, J. Chem. Ed., in press

[10] http://www.uoregon.edu/~greenlab

created by an 8th grade African American student in RPI's after-school ethnomathematics course that was carried out in a public housing project in Troy NY, using the cornrow software. The student wrote the following description of his design process:

"I made this braid when I was fooling around with the program. What I did was start with one braid, and then copied all the numbers from the first braid, and then mirrored the braid, then I was done."

Quantitative analysis of attitude surveys of students who had taken the course using this tool showed a statistically significant increase in interest in IT careers.

MLIAM: NESPOLE! - Negotiating Through Spoken Language in E-commerce

This research in the area of multi-lingual speech translation and communication has produced a prototype system that enables native users to connect with a "commercial" service provider that speaks a different language and receive detailed information via a live video-conferencing channel, in which speech-to-speech translation is seamlessly embedded. A simple and easy to use "whiteboard" application that allows the two parties to simultaneously view shared WebPages, maps, images and annotated gestures complements the speech communication channel, significantly enhancing the effectiveness of communication. The speech-to-speech translation is accomplished via a unique server architecture, which is distributed over the Internet. Very minimal software is physically required on the standard personal computers (PCs) of the end users. This technology opens the door to new global e-commerce applications for common users that transcend the language barriers of today. The project uses an "*interlingua*" so that it can support multiple language pairs, and has managed to achieve successful speech recognition of relatively low quality speech taken from video conferencing equipment.

The NESPOLE! Project is funded under the MLIAM program with one US partner (Carnegie Mellon) and three European research partners: University of Karlsruhe (Germany), Joseph Fourier University (France), and ITC-irst (Italy). Two European industrial partners are also involved in the project: AETHRA (an Italian telecommunications company), and APT (the Trentino provincial government tourism bureau). NSF funded Carnegie Mellon University's (CMU) participation in the project. The European Community (EC) funded the European participants. The collaboration has been very successful, with the partners working closely on overall system architecture, interlingua design, evaluation, user studies, and Human Language Technology (HLT) component design. The prototype system developed accomplishes the tasks described above.

The project has made technological advances in developing a distributed architecture for machine translation that integrates multimodal communication with speech technology for multiple language pairs. The NESPOLE! Project has established two users groups: an industrial affiliate group of about 10 technology and service provider companies, and a research interest group involving four research institutions external to the project.

New Approaches for Teaching Power Electronics and Electric Drives in the Electrical Engineering Curriculum

An NSF/Office of Naval Research (ONR) sponsored workshop on teaching of power electronics-related curriculum was organized jointly by University of Minnesota and Arizona State University (ASU), and held at ASU, Tempe, January 5 – 7, 2003. More than 120 faculty from U.S. universities engaged in teaching power engineering participated in the workshop. The workshop consisted of presentations and discussions on new developments in teaching undergraduate power electronics and electric drives courses, as well as discussions on the contents of advanced course on power systems applications of power electronics. A very interesting part of the workshop was the demonstration of newly developed laboratories for power electronics and electric drives. Many universities have already expressed a desire to adopt these new laboratories. Tutorials on Pspice and

MATLAB/Simulink for power electronics applications were very well attended and appreciated. Leading experts in academia, industry and federal research agencies conducted panel sessions on identifying challenges and solutions in power electronics education. Twenty faculty exhibited posters on best practices in power electronics education. More information on the workshop and the new approaches can be found at http://www.ece.umn.edu/groups/workshop2003.

As a result of the 2002 workshop in this series, 23 universities adopted the new approach to teaching electric drives and 21 universities submitted Course, Curriculum, and Laboratory Improvement (CCLI) proposals to adopt the new laboratory. The CCLI program[11] seeks to improve the quality of Science, Technology, Engineering, and Mathematics (STEM) education for all students and targets activities affecting learning environments, course content, curricula, and educational practices. At the 2003 workshop, 43 professors have stated that they plan to submit CCLI proposals to adopt the newly developed laboratories.

Supercritical Carbon Dioxide Technologies

The Science and Technology Center for Environmentally Responsible Carbon Dioxide Processes enables researchers from the University of North Carolina-Chapel Hill, North Carolina State University, North Carolina A & T, University of Texas-Austin, Georgia Institute of Technology, Los Alamos National Laboratory, and industry to conduct cutting-edge research on the uses of supercritical carbon dioxide in innovative processes. The basic research fostered at the Center has been adopted by a variety of industries. Use of supercritical carbon dioxide has led to environmentally friendlier processes and reduced pollution. Examples include the manufacture of polymers (Dupont Process G to make Teflon), and dry cleaning. The dry cleaning company Hangers received the "Most Valuable Pollution Prevention Award" from the National Pollution Prevention Roundtable in recognition of the fact that use of supercritical carbon dioxide eliminated the need to use a more toxic chemical that had been traditionally employed in dry cleaning. The Center also recruits outstanding K-12 mathematics and science teachers from North Carolina to develop novel curriculum tools for K-12 education and creates engaging exhibits at the North Carolina Museum of Natural Sciences[12].

This partnership between a research center, K-12 teachers, and a science museum make advances in research accessible to pre-college instructors, their students, and the public. The Center has also been extraordinarily effective at technology transfer: two very different industries, polymer manufacturing and commercial dry cleaning, have made extensive use of the Center's research.

[11] NSF02-095

[12] See: http://www.nsfstc.unc.edu/

IDEAS

Indicator I1. Discoveries that expand the frontiers of science, engineering or technology.

Bose-Einstein Condensation Proved
About 75 years ago a peculiar kind of condensation at low temperatures was predicted to occur in some gases whose atoms were of a special quantum-mechanical type called "bosons." This condensation, called a Bose-Einstein condensation after the inventors, was believed to occur, but was only indirectly verified until a few years ago when convincing experiments could be done in "cold traps."

The open question, from the mathematical point of view, was whether this phenomenon actually follows from Schroedinger's equation of quantum mechanics that is supposed to govern such gases. Lieb and Seiringer, whose paper was published in the Physical Review Letters achieved this proof by a careful analysis of the behavior of the gas at several different, but relevant length scales. This work was followed by a further analysis by Lieb, Yngvason and Seiringer in which superfluidity was proved to occur for the same physical system.

An experimental phenomenon of great importance for both fundamental physics and applications is found to be a rigorous prediction of the Schroedinger equation.

The Computer Science of Biologically Embedded Systems
Illness or injury may impair the ability of humans to sense or act in their environment. Interdisciplinary research at Brown University is exploring new ways to restore lost function by directly connecting brains and computers. These hybrid human-machine systems represent a new form of "biologically embedded" computing. Building such systems requires answers to the following questions:

1) What "signals" can we measure from the brain, from what regions, and with what technology?
2) How is information represented (or encoded) in the brain?
3) What algorithms can we use to infer (or decode) the internal "state" of the brain?
4) How can we build practical interfaces that take advantage of the available technology?

This approach exploits neural signals recorded from the motor cortex using an array of chronically implanted microelectrodes. Various statistical models are used to model the activity of these cells and study how this activity relates to hand and arm motions. Linear, non-linear, and non-parametric probabilistic models have been explored. The group adopted a Bayesian formulation of the decoding problem in which they infer the motion of the hand from the firing rates of a small population of cells (between 20 and 100). The resulting reconstructed motion is sufficiently accurate to permit the neural control of unconstrained 2D cursor movement or simple robotic functions. The work at Brown is advancing basic understanding of neural coding, is providing new methods for decoding neural signals, and is building a foundation for a new class of assistive technologies for the severely disabled.

The focus is on the statistical modeling of populations of motor cortical neurons using probabilistic methods. The project has developed new Bayesian methods for decoding neural activity that provide accurate reconstruction of hand motions.

A New Telescope is Born!
The dream, now more than 40 years old, of constructing a radically different telescope has been realized by the innovative Antarctic Muon and Neutrino Detector Array (AMANDA)-II project. Instead of sensing light, AMANDA responds to a fundamental particle called a neutrino. Neutrino messengers provide a startlingly new view of the Universe. Members of the AMANDA team designed the first practical implementation of the generic ideas formulated many years ago, and re-introduced in late 80's using ice instead of water. Due to the remoteness of the site in Antarctica, the team decided to minimize complexity of the design while recognizing that the simplest devices and system architectures were sufficient to answer the key questions. This concept proved highly

effective. AMANDA is now an international collaboration involving institutions from the U.S., Germany, Sweden, Belgium, and Venezuela.

Black Hole at the Galactic Center
Recent work by Dr. Andrea Ghez of the University of California, Los Angeles has solidified the case for a massive black hole at the center of our Galaxy. Over several years, with NSF support, she has used the orbits of stars near the center of the galaxy to infer the density of the dark mass at the Galactic core. Most recently, using adaptive optics, and with a 7-year baseline, she has been able to follow the detailed orbits of a larger sample of fainter stars. One of these stars passes a mere 60 astronomical units from the central dark mass at a velocity of 9000 km/s. The orbit of this star increases the constraints on the density of the dark mass by four orders of magnitude over her previous estimates, and eliminates several remaining alternatives to a supermassive black hole. Our own galaxy has now become the strongest case for a normal galaxy containing a supermassive black hole.

Characteristics of Extrasolar Planets Emerging
The discovery of planets around stars beyond the Sun is one of the most exciting results of the last decade. Now the international Anglo-Australian Planet Search Team, in part sponsored by the NSF, has found more extrasolar planets in the Southern Hemisphere than any other group. With recent finds, the total number of planets found to date by all groups is about 117. Given this total, astronomers are beginning to see patterns in planet characteristics. The first ones found were close in to their parent stars, but now they are finding more planets farther out and in nearly circular orbits similar to our own solar system.

One of the most recent planets found has a mass of about 1.2 times the mass of Jupiter. The planet is located about the same distance from its star as our asteroid belt is from our Sun (2.5 times the Earth-Sun distance), and its orbit is roughly circular.

Based on the 15-year survey, which Paul Butler of Carnegie Institution of Washington and Geoff Marcy of the University of California, Berkeley have headed (with team members Debra Fisher and Steven Vogt), about 12% of the Sun-like stars in our galaxy have planets that can be detected orbiting their stars within about 5 astronomical units (an astronomical unit is the average distance of the Earth from the Sun, about 93,000,000 miles). As the number of extrasolar planets found grows, more planets are being found farther out from the star they are orbiting. This finding supports the idea that giant planets in solar systems may form at great distances from their stars and later move inward.

This research has depended on special instrumentation and analytical techniques developed by the investigators (and shared with other groups). It is at the core of fundamental problems in astrophysics, and captures the public imagination stimulating interest in science.

Fertility Control in China
Until the 1970s, weaving was an important subsistence activity that rural women in southern China were engaged in. This research in Xiaoshan reveals that women not only used the loom for weaving, but also used it to carry out voluntary abortions before modern birth control facilities had become widely available. The working method–the pregnant woman repeatedly battering the lower abdomen (uterus) with the handle while weaving–may seem brutal, yet it helped women realize the necessity of voluntary fertility control without informing the husband. The discovery of the women's use of the loom for deliberate abortion sheds light on the debate over the roles of rational decision-making on historical demographic transition in China. It reveals that deliberate fertility control was a reality among some subgroups of the poor rural population in Xiaoshan. Women's usage of the loom for abortion also touches on issues of gender. It shows that family fertility was not uniformly regulated by the collective good of the male-headed family. Rather, women themselves

often had great individual power in manipulating and making rational decisions in fertility control.

This research expands the frontier of cultural anthropology research and has great broader impacts.

Gold Discovered in Outer Space
An astronomer at the University of Oklahoma has been making major advances in understanding the formation of the heavy elements in nature by searching for gold. Recently John Cowan and coworkers identified, for the first time, a number of heavy elements, in particular gold, in some of the very oldest stars in our Galaxy. These results also provide new insights into the conditions at the time of formation of our Galaxy. They have also identified radioactive elements such as thorium and uranium in the spectra of some of these stars. They then employed the abundances of these elements and knowledge of how they are likely produced in the interiors of stars to make estimates of the ages of the oldest stars. They find them to be approximately 15 billion years old. Such age estimates provide us with strong constraints on the age of our Galaxy and add further limits on the age determination for our Universe.

Five undergraduate students [including two Research Experiences for Undergraduates (REU) students] participated in this work. In the course of these studies they developed new techniques in stellar spectroscopy, elemental and isotopic abundance determinations, and for theoretical heavy element abundance predictions.

This research promotes understanding of the formation of the elements, the age and formation of our Galaxy, as well as the development of new analysis techniques, and it provides research training for undergraduate students.

How to See Invisible Matter
One of the most stunning scientific findings of the 20th century is that "normal" matter–the atoms, protons, neutrons, and electrons that comprise our material existence–makes up just a tiny fraction of our Universe. Most of the matter in the Universe is known to be some as yet undiscovered particle that neither emits nor blocks light, and passes right through "normal" matter as if it were not there. How do we know that this "dark matter" exists if we cannot see it and don't even know what it's made of? Even dark matter obeys the laws of gravity: the primary evidence for dark matter is that we see normal matter moving in ways that imply it is being pulled by the gravity of some invisible material.

Professor Gary Bernstein, PhD recipient Michael Jarvis, and several collaborators have conducted an inventory of the amount and distribution of this dark matter by measuring its subtle gravitational effects. If we look past a lump of (invisible) dark matter at a normal galaxy in the background, the image of the background galaxy will be distorted because its light rays are bent by the gravity of the dark matter as they pass by. This "weak gravitational lensing" distortion is extremely subtle, so it is impossible to detect on any individual background galaxy. But by comparing the shapes of millions of galaxies, the pattern of dark matter in the foreground can be revealed.

Results by this group and others confirm that the dark matter greatly outweighs all the atoms in the Universe. More interestingly, the pattern of dark matter is seen to be consistent with the theory that all the structures in the Universe are descendents of the tiny fluctuations in the early Universe that are seen by cosmic background radiation measurements such as the Wilkinson Microwave Anisotropy Probe satellite. These tiny "seeds" accumulate matter under the influence of gravity until they become galaxies and clumps of galaxies hundreds of millions of light-years across. So now we can "see" the dark matter, and understand how it fills the Universe and builds galaxies - but we still do not know what it's made of.

Incarceration and Fragile Families
The U.S. Bureau of the Census recently reported that the number of single mothers in the United States has grown nearly 200 percent since 1970 and that in 1998, 9.8 million mothers were unmarried. Coupled to this trend, the male

prison population grew from 200,000 inmates in 1974 to 1.3 million by 2001. Could the growth in the penal population explain some of the rise in single-motherhood, particularly among poor and minority couples, whose men are at greatest risk of incarceration?

Using data from the Fragile Families and Child Wellbeing Study, the researchers conducted a cohort study mainly comprised of children born to unwed parents. Analysis of these data indicates that fathers in the survey are unlikely to be living with the mothers of their children at the child's birth and are very unlikely to get married later. Among men not living with the mother only 4.3% of African Americans, 12% of Hispanics, and 14.5% of whites were married 12 months after their child's birth. Serving time in prison or jail reduces marriage rates even more. A prison or jail record is estimated to reduce the probability of marriage by 47% for African American fathers, 19% for Hispanic fathers, and 43% for white fathers. If these effects are applied to the population as a whole, they imply that the marriage rate among white men would be about 2% higher, and among black men about 12% higher, if the rate of incarceration were zero.

This research is on the cutting-edge of sociology and explores important social issues.

New Cells in Adult Mammalian Brain Can Make Functional Connections

Contrary to dogma, the adult brain exhibits considerable plasticity. New cells that are born in particular brain regions migrate within the forebrain and differentiate into neurons. But do these new cells make functional connections that allow them to be influenced by events in the environment? Using adult male hamsters, Eric L. Bittman and colleagues discovered that newborn brain cells could make functional connections that are activated by exposure to estrous female hamsters. They also found that the survival of these cells for seven weeks required the presence of testosterone in the animal's bloodstream. These discoveries pioneer the exploration of basic mechanisms of cell birth, migration, and death that may prove useful in treatment of damaged or diseased nervous systems.

New cells in the brain of an adult mammal can make functional connections, and their survival depends upon the animal's physiological state. These discoveries expand the frontiers of neuroscience in the exploration of basic mechanisms of cell birth, migration, and death throughout the life span of the organism.

Research across Disciplines -- Earthquakes and Supershear

Jean Carlson is a condensed matter theorist and a former Packard Fellow. She is actively involved in giving public lectures and in the local Physics Circus Outreach Program for K-12. Her research interests build on her background in condensed matter and statistical physics. Her present research group is comprised of students and postdocs from physics, geophysics, geography, systems biology, engineering and materials science. This vibrant group is addressing problems such as models of earthquake rupture dynamics, models of friction and granular materials, merging concepts from statistical physics and control theory, networks in ecology and finance, systems biology and forest fires.

Carlson's work on earthquake rupture dynamics has recently appeared in Science magazine, where Carlson and collaborators report "a new phenomenon unique to three-dimensional cracks: Locally stronger fault sections, rather than slowing ruptures, drive them forward at velocities exceeding the shear wave speed." This work helps us to understand not only the damage mechanism of earthquakes but also the failure of engineering materials. Motivated in part by the study of earthquakes, Carlson and collaborators have been performing computer simulations of models for the rupture process that occurs during an earthquake. Rupture is initiated by stresses that push material above a fault plane in one direction while pulling material below the plane in the opposite direction. If the resulting stress is high enough, the cohesiveness of the material is lost resulting in the formation of a crack and the materials on either side of the fault plane sliding

over each other behind the crack front. An analysis of ground motion reveals that such a crack follows a complicated path due to variations in stresses or the presence of nonuniform geophysical materials that have different strengths.

Carlson has been investigating the different roles of these heterogeneities in determining the way these shear cracks move. The limiting rupture velocity of most earthquakes seems to be the Rayleigh speed, the speed of surface waves, but there have been several reports of shear crack fronts moving faster than the shear wave velocity (most notably in the 1999 earthquakes in Turkey). In the course of investigating heterogeneities on the fault, she discovered an interesting new mechanism to excite this supershear transition.

This is an example of theoretical research that has yielded a possible explanation of earthquake phenomena observed in the 1999 Turkey and 1984 Morgan Hill earthquakes and possibly others and at the same time provides insight into the shear fracture failure of materials. This cross disciplinarity and high impact are signature of Professor Carlson's wide-ranging work that also includes granular materials and networks.

***Indicator I2.* - Connections between discoveries and their use in service to society.**

African Ice Cores Reveal Prolonged Tropical Droughts

Ohio State University professors Lonnie Thompson and Ellen Mosley-Thompson led an international team of researchers to the summit of Mt. Kilimanjaro in 2000 to collect ice cores from glaciers at the summit in order to study tropical climate and the African monsoon system. What they discovered was completely astonishing. Through careful analyses, the team of researchers recreated an unprecedented and highly detailed record of three catastrophic droughts that plagued the region 8,300, 5,200 and 4,000 years ago. Glaciers at the top of Mt. Kilimanjaro in Tanzania began forming 11,700 years ago. Data from Kilimanjaro's ice cores reveal a wetter landscape in the region some 9,500 years ago than compared to today. Lake Chad, now the fourth largest body of water on the African continent with an area of 17,000 square kilometers, covered 350,000 square kilometers – an area larger than the modern day Caspian Sea. But beginning around 8,300 years ago, the ice cores reveal a climate of recurring and prolonged droughts, some lasting 300 years. While the causes of such climatic events are under active study by the Thompsons and colleagues, their recurrence is of major concern because seventy percent of the world's population now lives in the tropics and social systems can be dramatically stressed by climate events of the magnitude recorded in the ice.

The study of paleoclimates from ice cores is consistently at the cutting edge of new insights and technologies that enable broader understanding of the interaction of climate and society.

Discovering How Some Plants Resist Insects May Lead to Safer Insect Control

When plants are attacked by insects that eat them, they often respond by producing proteins that protect them from being eaten. Drs. Dawn S. Luthe, Peter Ma, and Tibor Pechan, of Mississippi State University, have discovered a unique enzyme in corn that is capable of drastically slowing the growth of caterpillars by damaging their midgut structure. This is a fundamentally new mechanism of plant resistance to insect feeding that could greatly benefit the agricultural industry. It may be possible, in the future, to use this to genetically engineer plants to resist insect feeding. Insect feeding is responsible for 15% of the world's crop losses, a major economic and ecological problem that decreases the supply of food to a growing human population. The availability of effective and environmentally safe insect control is important to everyone.

The discovery of this fundamentally new mechanism of plant resistance could revolutionize the control of insect damage to crops.

International Water Vapor Project

The International H2O Project (IHOP) field experiment, one of the largest weather-related studies in U.S. history, took place from 13 May through 25 June 2002. The project tracked swaths of moisture across the southern U.S. Great Plains. The chief aim of IHOP was to improve characterization of the four-dimensional distribution of water vapor and in turn improve the understanding and prediction of convection.

Over 200 investigators and technical personnel spent a large part of their summer in Oklahoma and Kansas to support this NSF-funded project, which involved important contributions from groups at UCLA (Wakimoto), Penn State (Richardson), Oklahoma (Xue) and was coordinated by NCAR scientists David Parsons and Tammy Weckwerth. Because improved rain and snow forecasts are one of the main goals of the U.S. Weather Research Program (USWRP), the project also received support from the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE).

IHOP 2002 was motivated in part by the significant impact on society of flash floods, which in the U.S. cause billions of dollars in

property damage and the largest number of weather-related fatalities. The full impact of the IHOP 2002 experiment on operational forecast systems and the associated impacts to society from improved prediction of flash floods and other warm season hazardous weather is likely years away due to the time required for careful analysis of the observations and the associated theoretical and numerical work.

Researchers anticipate two of what may be many potential dramatic impacts of the IHOP 2002 efforts. Accurate forecasting of hazardous weather is typically a "nowcasting" problem. For example, the average lead-time for flash flood warnings in this country is approximately one hour.

Early in the project, scientists found an interpretation of data that from a relatively new technique called "radar refractivity" was able to provide additional clues on where storms might form. At times this provided several hours of lead-time on where fine lines might occur. A potential implication of this approach is that forecast times for nowcasting storms may be dramatically extended.

In addition to potentially improving weather prediction, such analysis also allows us to address the long-standing question of whether boundaries between irrigated and non-irrigated croplands are significant from a weather standpoint.

Further details on other IHOP activities can be found at www.atd.ucar.edu/dir_off/projects/2002/IHOP.html

There is a known societal need is to improve the reliability of our forecasts of severe weather and flash floods in order to prevent loss of life and mitigate economic losses. While the acute effects of these storm systems may have impacts at highly localized scales, their clearer description, understanding and prediction requires study across large space and time scales.

Retreat History of the West Antarctic Ice Sheet, Marie Byrd Land

This award supported the reconstruction of a retreat history of the West Antarctic ice sheet along a flowline through the Ford Ranges in Marie Byrd Land, from the last glacial maximum to present. The ice surface elevation history of the region was reconstructed using cosmogenic isotope exposure dating of moraine boulders and ice-abraded bedrock surfaces. As the covering layer of ice thinned and disappeared, the rocks were exposed to bombardment by cosmic rays, altering their isotopic composition. Using a particle accelerator to count the cosmic ray-produced atoms in a rock allows scientists to determine its age and, as a result, the time the glacier disappeared from the rock surface. Previous research has inferred the history of the ice sheet indirectly, from such things as changing beach levels or volcanic debris. In this study, the scientists gathered rocks deposited by glaciers on mountain peaks and dated them using cosmogenic exposure age dating which allowed them to track the thinning of the ice sheet over the last few thousand years.

The most surprising conclusion of the project so far is that deglaciation took place mostly in the late Holocene, and is probably still underway in parts of West Antarctica. These results contribute to our understanding of the history and dynamics of the West Antarctic ice sheet and will help forecast its future stability. They show that:

(i) Deglaciation of the Marie Byrd Land sector of the ice sheet occurred gradually over a period of 7,000 - 10,000 years, not catastrophically:
(ii) West Antarctic melting has contributed to eustatic sea level change since 6000 years B.P., the widely assumed 'end' of late Pleistocene/Holocene deglaciation; and
(iii) Parts of West Antarctica are still undergoing gradual deglaciation, contributing to the present-day background rate of eustatic sea level rise.

This work establishes a background pattern of steady decline in the West Antarctic ice sheet. This project received a lot of media attention at

the time of publication of a paper in Science on January 3, 2003. There were several media stories about these results including an article on CNN.com on Jan. 3, 2003 entitled "*Antarctic ice sheet may melt in 7000 years*." A story featuring the principal investigator, John Stone, and his results also appeared on CBS Sunday morning on January 19, 2003.

Spider Venom may Yield Environmentally Friendly Pesticides

The venom of the Australian funnel-web spider contains a poisonous mixture of potent neurotoxins, and a bite from one of these spiders is usually fatal. Dr. Glenn King at the University of Connecticut Health Center has been studying the molecular structures of several of these toxins that selectively target the nervous systems of insects. Because these toxins do not affect the mammalian nervous system, it may be possible to use these insect-specific toxins as the bases for environmentally friendly insecticides.

Dr. King's work has focused on determining the molecular structures of the toxins, since this is critical to understanding the mechanism of action of the toxins at the cellular level. Dr. King and colleagues determined the three-dimensional structures of one excitatory neurotoxin and two paralytic neurotoxins from the funnel-web spider at the atomic level. Dr. King is also introducing mutations into the toxins to identify the areas of the toxin surfaces that are important for their insecticidal activities. He foresees several ways in which it may be possible to use the insect-specific neurotoxins in agriculture, thus reducing dependence on chemical pesticides.

The genes for the neurotoxins could be inserted directly into the plant genome, or insect-specific viruses could be used as vectors to deliver the toxins to a restricted number of species. Dr. King's work has been done in collaboration with scientists in Australia. Reports of his work have appeared in the press[13] and on national television.

Dr. King's group is the first to study the structures of these insect-specific neurotoxins and to devise creative potential applications for agriculture.

Vocational Education in the Metalworking Industries

The machining and tool and die industries are significant contributors to the American economy in terms of providing jobs and creating value. Like nearly all other industries, the viability and competitiveness of machine shops and tool and die shops depend, in part, on hiring and retaining skilled employees. In this study, anthropologist Garry Chick examined, compared, and evaluated the ways in which machinists and toolmakers are trained in western Pennsylvania, an area with one of the highest concentrations of small- and medium-sized machine and tool and die shops in the world.

Chick was interested in how potential employers saw the effectiveness of high school vocational training in the metalworking trades. The most striking contrasts between potential employers and potential employees were apparent in terms of what individuals in each group felt that machinists and toolmakers must know in order to succeed on the job. Students in high school vocational programs in machine-tool technology did not believe that topics such as trigonometry, algebra, oral communication, critical thinking, problem solving, and computer programming would be particularly important to them in their occupational futures while skills in these areas were precisely what potential employers regarded most highly. On the other hand, students felt that "machine-tool technology," basically learning to run machines, was extremely important while company owners felt that they could teach new employees how to run machines but they could not teach algebra, trigonometry, and problem solving skills.

The fact that students who attend vocational high school programs are often there because they are unsuccessful at or uninterested in academic classes is a major human resource problem in the machining and tooling industries. Similarly, the mismatch between what students think that they need to know in order to be

13 http://www.uchc.edu/ocomm/newsreleases01/april01/funnelwebspider.htm

successful and what employers want them to know is a serious problem in vocational education for the metal working industries.

Reports based on Chick's research have been provided to academic and vocational high schools in western Pennsylvania, the Northwest Pennsylvania and Southwest Pennsylvania branches of the National Tooling and Machining Association, the Northwestern Pennsylvania Tech Prep Consortium, the Western Pennsylvania School-to-Work Tech Prep Clearinghouse, and the Pennsylvania Department of Education. The results of the study are also being communicated via conference presentations and publications in journals devoted to research in vocational education.

<u>Indicator I3.</u> - Partnerships that enable the flow of ideas among the academic, public or private sectors.

A Stellar Relic in the Milky Way: The Lowest Metallicity Star Known
Exploding stars that add heavier chemical elements continuously contaminate the gas of our galaxy, which was presumably composed of only hydrogen and helium initially. Consequently, the oldest stars should contain very little of these elements. Now, a research group of astronomers from the U.S., Germany, Sweden, Australia, and Brazil has found a giant star with 1/200,000 of the solar content of heavy elements. This is about 20 times more metal-poor than the previous record for any kind of star.

The discovery of this star gives astronomers the unique opportunity of studying stellar gas with a composition close to the state it had directly after the Big Bang. Timothy Beers of Michigan State University and collaborators have conducted a systematic search for the most metal-deficient stars in the outer reaches of our galaxy over the past two decades. The star they found is named HE 0107-5240 (HE stands for Hamburg/European Southern Observatory Survey). It is many thousand times fainter than the faintest stars that can be seen with the naked eye, roughly 16th magnitude.

This is the closest astronomers have come to having direct knowledge of the chemistry of the Universe shortly after the Big Bang. However, it is not the whole story, since in spite of its deficiency of heavy metals, the small abundance of metals seen in this star is evidence of a previous generation of yet older massive stars that exploded as supernovae. HE 0107-5240 may be the first example of a truly second-generation star.

This research provides clues to the earliest environmental conditions in our galaxy, expands our understanding of the history of the Universe, and contributes to the international exchange of ideas.

Curbing Chagas disease in Argentina
Chagas disease is a sizeable public health problem. It infects 10–18 million people in the Americas, including women who may eventually transmit it to their newborns. While the spraying of insecticides against the vector and the screening of blood donors has produced a decreasing disease incidence, experts are now recognizing the importance of mother-child transmission. Congenital cases are mostly asymptomatic, but can seriously affect the newborn's survival and illness rate. Although such cases cannot be prevented because the available drugs have adverse effects, early detection and prompt treatment are frequently successful. However, as screening of pregnant women and newborns has not been routinely conducted, the amount of mother-child transmission has not been established. Using demographic and epidemiological data and a novel but elementary model, the researchers estimated that transmission of infection from infected mothers to newborn infants is 6.3 times greater than officially reported, and may even exceed transmission by biting bugs.

This project represents a partnership between an American academic scientist (Joel Cohen, Rockefeller University), an Argentine academic scientist (Ricardo E. Gürtler, Universidad de Buenos Aires), and an Argentine public health official (Elsa L. Segura, Centro Nacional de Diagnóstico e Investigación en Endemo-epidemias).

The data from this study is important for making policy recommendations and health service planning. The finding reported here is but one piece of a much larger project on the ecology and epidemiology of Chagas disease that is designed to ensure that academic research flows to public health workers and results in measurable public health benefits.

Smart Sensors and Integrated Devices
One of the Integrative Graduate Education and Research Traineeships (IGERT) research projects in the biomedical area, "*Cancer Detection using 3-D Ultrasonic Imaging*", is a collaboration between the Wayne State

University Smart Sensors and Integrated Microsystems program and the Karmanos Cancer Research Institute. Since the beginning of this collaborative effort in 2000, both IGERT trainees and associates have been involved.

The objective of this project is to develop a detection technique with image resolution smaller than 2 mm (typical precursor size of cancer tumors) so that early detection and diagnosis of the tumors could lead to possible therapeutic treatments and higher survival rates. They are working not only on holographic data accumulation and analysis, but also focusing their research efforts on the development of ultrasonic piezoelectric detector sensor arrays based on AlN wideband gap semiconductors. This is truly a multidisciplinary research project that involves faculty from engineering, physics, and medicine as well as medical clinicians. Based on preliminary work, they have been able to secure additional funding of $100,000 through the prestigious Wilson Foundation.

Scientific research groups in the U.S. (supported by NSF) and Europe (supported by the European Community) are working together to create advanced nanoscale materials for a broad range of possible technological applications. A major problem they are addressing is that interfaces between thin film ceramic materials are often unstable. At nanoscale dimensions, stable films with thicknesses engineered by controlling chemical composition will lead to novel physical properties. These findings will enable nanomaterials to be used in new devices, and due to their general applicability to many inhomogeneous films, they promise application to a broader arena. For example one researcher in the group, a spectroscopist affiliated with both the University of Pennsylvania and Dupont, has obtained results that may impact NIH-supported research on biological films.

Wildfire Hazard Estimation

Dr. Frederic Schoenberg, a statistician at the University of California, Los Angeles (UCLA), led a project to accurately estimate wildfire hazard in Los Angeles County and to assess the uncertainty in these estimates. Furthermore, the project sought to determine how various meteorological and environmental variables are related to wildfire hazard.

The researchers worked closely with the Los Angeles (LA) County Fire Department, the LA County Department of Public Works, the National Parks Service, and atmospheric scientists to obtain detailed records of wildfire occurrences in LA County and of variables such as temperature and precipitation. Among the early findings from analysis of these data was that it is extremely infrequent that a wildfire affects an area that has burned recently. This lends some support to the practice of prescribed burning, which is highly controversial due to the 2000 Los Alamos fire.

In examining other meteorological and environmental variables, the researchers found some expected relationships. For example, up to a point, wildfire incidence increases as temperature increases, but this is true only up to about 70 degrees. Above that, further increases in temperature do not significantly increase the wildfire risk. These findings are consistent with the theory that for wildfire to occur, certain sufficient conditions must exist, but extreme conditions do not increase the wildfire risk. These relationships have important implications in fire management, insurance, and public policy at the high-risk end of the spectrum.

One important variable examined by the UCLA researchers was the Burning Index (BI), a conglomerate measure of wildfire risk that is widely used by the Fire Department, Forest Service, and National Parks Service. The researchers were able to find better ways of combining BI records from different weather stations to obtain more accurate estimates of wildfire risk. Because the LA County Fire Department is committed to a national program involving the use of BI for predicting wildfire danger, the question of how to optimally use this information is critical.

This example enhanced the training of all the researchers, some of whom are women. It also advanced the theory of statistical modeling methods in a way that had potential for direct societal impact.

Indicator I4. - Leadership in fostering newly developing or emerging areas.

Constraint Based Genome-Scale Model of *E. coli*

For many years, drug manufacturers have manipulated the genetic code in *E. coli* strains, creating species that can produce important substances, such as the hormone insulin for use by people with diabetes or the experimental cancer drug angiostatin. Using the new constraints-based techniques Bernhard Palsson[14] and his colleagues developed, drug manufacturers and bioprocessing companies could use computers to determine the genetic code that could yield the most efficient and productive versions of *E. coli,* and then use adaptive evolution to create bacterial strains that have the desired properties.

Palsson has created a computer model that accurately predicts how *E. coli* metabolic systems adapt and evolve when the bacteria are placed under environmental constraints. Palsson, along with Rafael Ibarra[15] and Jeremy Edwards[16] report their findings in the November 14, 2002 issue of Nature, and indicate that their model is the only existing genome-scale model of *E. coli*. The new model takes a whole-system approach. Changing one aspect of a genetic code could be irrelevant if an organism adapts and evolves, says Palsson. The constraints-based models allow the *E. coli* to evolve more naturally along several possible paths.

The investigators based their digital bacteria on earlier laboratory studies and *E. coli* genome sequences, and detailed genetic codes that have been augmented with experimental information about the function of every gene. Such digital models are known as "*in silico*" experiments -- a play on words referring to biological studies conducted on a computer.

Scientists may use the approach to design new bacterial strains on the computer by controlling environmental parameters and predicting how microorganisms adapt over time. Then, by recreating the environment in a laboratory, researchers may be able to coax living bacteria into evolving into the new strain. The resulting strains may be more efficient at producing insulin or cancer-fighting drugs than existing bacterial colonies engineered by researchers using standard techniques.

Bernhard Palsson has created a constraints-based computer model that accurately predicts how *E. coli* metabolic systems adapt and evolve when the bacteria are placed under environmental constraints.

Electronic Structure for the 21st Century

Gabriel Kotliar co-organized an international workshop held at the Kavli Institute of Theoretical Physics (KITP) located at the University of California at Santa Barbara. The workshop entitled "*Realistic Theories of Correlated Electron Material*" brought together researchers with the aim of combining theoretical and computational advances to work toward a quantitative and predictive approach to strongly-correlated electron materials.

These materials are of significant interest, both scientifically and in several cases technologically. They include: Mott-insulators, insulators that would be metals were it not for strong electron-electron interactions; high temperature superconductors and related compounds; heavy fermion materials, a class of compounds that exhibit unusual metallic, magnetic, and superconducting states; and low-dimensional organometallic compounds which yield novel metallic, superconducting, and insulating states. Combining a quantum many body theory technique known as dynamical mean field theory (DMFT) with modern density-functional-theory based techniques was a main thrust of the workshop.

The workshop has brought together two communities that have been contentious in recent years to focus on the challenging strongly correlated electron materials problem with an aim to making significant progress. There was

[14] Department of Bioengineering, University of California at San Diego
[15] GenVault Corporation in Carlsbad, California
[16] now at the University of Delaware at Newark

also strong participation from international researchers and national laboratories. KITP provides an environment where researchers can gather for extended periods (three weeks or more) for substantial collaboration. KITP schedules about four or so workshops per year on a variety of topics spanning physics, materials research, and astronomy. The experience involves an intense exchange of ideas from formal and informal presentations to one-on-one interactions.

This activity makes use of facilities at the Kavli Institute for Theoretical Physics to attack a challenging problem in condensed matter and materials physics. It brings together the methods and techniques developed by two research communities with differing cultures. The intense interaction also involves professional development as techniques and ideas are exchanged among these communities, and an environment is created to encourage further collaborative work.

International Roundtable in Comparative Developmental Physiology
This NSF-supported workshop, held in June 2002, promoted discussions about comparative developmental physiology, an emerging scientific area that links comparative animal physiology and evolutionary developmental biology. Among the 33 participants, the seasoned scientists came away with new perspectives while the 15 junior faculty members, postdocs, and graduate students were newly enthused about the future of the field and their role in it.

From the workshop's papers and intense discussions, the meeting's organizers have compiled a multi-authored book, "*New Directions in Comparative Developmental Physiology*," to be published by Cambridge University Press. In order to enhance communication among the participants, a listserve has been established. In addition, a Web site for the general community now exists at Developmental Physiology. More than 800 hits in one month suggest that the workshop instilled a sense of identity and enthusiasm in a community of comparative physiologists and developmental biologists that had not previously been cohesive or even self-aware.

This workshop promoted discussions about comparative developmental physiology, a newly developing area of biology. The meeting and the resulting listserve, Web site, and book have fostered this emerging scientific area.

IP-Based Embedded Systems Design
The project emphasizes new design methods to deal with today's high-capacity embedded computer chips. The most fundamental change in required methods is a unified view of hardware and software. The project develops methods for tuning highly configurable system-on-a-chip designs, including memory reconfiguration and hardware/software partitioning, to specific embedded applications.

The main research outputs of the project are the techniques embodied in a prototype system-on-a-chip exploration tool called Platune. An embedded system typically runs one or a few applications for its lifetime. Tuning a system-on-a-chip architecture to that application can greatly reduce power and improve performance, but the number of possibilities has thus far prevented designers from doing a good job of tuning. The project developed efficient search methods to rapidly explore the enormous tuning solution space and to quickly find the best set of architecture configurations.

Tony Givargis, the key graduate student involved in the research, and now an Assistant Professor at the University of California, Irvine, developed an easy to use prototype tool, Platune, that is presently used by several researchers and in several classes worldwide. Platune's website is http://www.cs.ucr.edu/~dalton/Platune/.

One outcome is a new textbook, "*Embedded System Design*"[17] that is the first to present embedded system design at the level of principles, emphasizing the new unified hardware/software computing view that is

[17] John Wiley and Sons, 2002, by Frank Vahid and Tony Givargis

essential in today's world of embedded computing.

The widely used software tool is facilitating research and education in this new area. The ideas are exploring the new area of embedded systems and developing new models to analyze and design these systems.

Left-Handed Materials

The direction that light bends when passing through a physical material depends on its index of refraction. Normally, this index is positive, but 35 years ago, it was predicted by a Russian theorist that materials with a negative index could exist. Unlike conventional positive-index materials, which require curved surfaces or material inhomogeneities to focus light, a flat slab of material with a negative index of refraction could act as a lens.

A project at the Massachusetts Institute of Technology's Center for Bits and Atoms[18] has experimentally realized an artificially structured composite material that exhibits a negative index in the microwave regime. Following techniques introduced two years ago by a group at the University of California, Santa Barbara (UCSB), the group was able to use metallic wires and ring resonators patterned on microwave substrates arranged in a three dimensional pattern. Their measurements produce the first conclusive experimental evidence showing that transmission through these materials obeys Snell's Law with a negative index, and provides preliminary evidence of focusing behavior.

Beyond its fundamental interest, this example of designing and fabricating the structure of an artificial material could transform the practice of wireless communications by adding a long-sought converging electromagnetic element.

The result was announced at the American Physical Society's March Meeting: http://www.aps.org/meet/MAR03/baps/vpr/general.html and a number of press stories reported on this result.

A novel, surprising, and almost bizarre material has been invented, with potential applications in a variety of areas, such as wireless communications.

[18] CCR-0122419

TOOLS

Indicator T1. Development or provision of tools that enables discoveries or enhances productivity of NSF research or education communities.

Data Mining the National Virtual Observatory

As part of their mission to create the infrastructure to support computational science, National Partnership for Advanced Computational Infrastructure (NPACI) researchers at the San Diego Supercomputer Center (SDSC) have developed the Storage Resource Broker (SRB). The Information Age is driving an explosion in data generation across all scientific disciplines, and researchers are facing unprecedented challenges in acquiring, managing, analyzing, and mining the abundance of data and publishing their results in digital libraries. This SRB middleware lets researchers powerfully and flexibly manage not only their own data but also create virtual data collections that span widespread locations and diverse formats. Freeing scientists from manual data management, the SRB greatly expands researchers' ability to share data and collaborate, forming a key component of the Grid and accelerating the advance of science.

In astronomy, researchers from 17 institutions are collaborating to establish standards that will support the National Virtual Observatory (NVO), a discipline-wide, expandable database of astronomical images, catalogs, measurements, and scientific publications that will unite more than 100 terabytes of data collected from 50 ground- and space-based telescopes and instruments.

By linking all of this data, along with analysis and visualization tools, in the form of easily-accessible Web services, the project will make a "virtual observatory" available to professional researchers, amateur astronomers, and students alike, greatly broadening and speeding astronomy research and education. The SRB is used as a data grid within the NVO, and is already managing two important collections, the 2-Micron All Sky Survey (2MASS) and the Digital Palomar Observatory Sky Survey (DPOSS). Together, these are the largest data collections under SRB management at SDSC, totaling 18 terabytes of data in more than five million files.

High-Performance Probes Developed at NHMFL

A unique capability of the National High Magnetic Field Laboratory (NHMFL) is to develop high-performance probes for nuclear magnetic resonance (NMR) spectroscopy and imaging. These probes, which are used, for example, to study membrane proteins and materials chemistry under high magnetic fields, are not commercially available. The unique magnets at the NHMFL generate unique instrumentation requirements, and the outstanding instrumentation staff of the NHMFL works with an international group of application scientists, users, academic and industrial collaborators to meet user needs. Probes have been developed to support the NHMFL user programs in NMR studies of inorganic solids and for magnetic resonance imaging (MRI). More probes are in development for biological and inorganic solids. One such probe has been used to obtain spectra sensitive enough to resolve different valence states in a solid sample. Other probes used for solid-state NMR provide measurements over a wide temperature range for samples smaller than 5 mm. Still other probes have been developed for stray-field imaging. High-sensitivity cryoprobes for solution NMR experiments are in great demand, and probes are currently being developed for NMR at the highest fields available.

These probes enable investigations of the behavior of a wide variety of materials that would otherwise be impossible or much too time-consuming.

Internet Satellite Connection to Under-served Sites

The Internet Satellite Project (ISP) uses a satellite infrastructure for purposes of enhancing research, instruction and learning in a diverse set of institutions of higher education. The project has brought advanced computer networking

applications to geographically remote campuses, including tribal colleges, historically black colleges and Hispanic-serving institutions. Different sites are taking advantage of access to remote instruments, data sources, and other instructional and learning resources not available locally.

The project has encouraged and enabled collaboration among a diverse student population and has also allowed access by the research university community to cultural and human resources from otherwise inaccessible institutions and extension offices. A total of approximately 70 geographically remote institutions enjoy advanced Internet connectivity through this project.

Most Detailed Images of the Early Universe
Using a powerful new instrument deployed at South Pole, a team of cosmologists lead by the University of California at Berkeley has produced the most detailed images of the early Universe ever recorded. The research team has published their measurements of the most subtle temperature differences in the Cosmic Microwave Background (CMB) radiation. The CMB is the remnant radiation that escaped from the rapidly cooling Universe about 400,000 years after the Big Bang. The new results provide additional evidence to support the currently favored model of the Universe in which 30% of all content is a strange form of dark matter that does not interact with light and 65% is in an even stranger form of dark energy that appears to be causing the expansion of the Universe to accelerate. Only the remaining five percent of the Universe takes the form of familiar matter like that which makes up planets and stars.

The new sensitive instrument - Arcminute Cosmology Bolometer Array Receiver (ACBAR) produced high-resolution images of the CMB that reveal the seeds that grew to form the largest structures seen in the Universe today. These results add to the description of the early Universe provided by several previous ground-based, balloon-borne and space experiments. Previous to the ACBAR results, the most sensitive, fine angular scale CMB measurements were produced by the NSF-funded Cosmic Background Investigator (CBI) experiment observing from a mountaintop in Chile.

ACBAR is specifically designed to take advantage of the unique capabilities of the 2.1-meter Viper radio telescope, installed by NSF at the Amundsen-Scott South Pole Station in Antarctica. The receiver is an array of 16 detectors that create images of the sky in 3-millimeter wavelength bands near the peak in the brightness of the CMB. In order to reach the maximum possible sensitivity, the ACBAR detectors are cooled to two-tenths of a degree above absolute zero, or about -273 degrees Celsius (-459 Fahrenheit).

This work provides new and unprecedented information about the structure and development of the early Universe.

National Nanofabrication Users Network (NNUN)
The National Nanofabrication Users Network (NNUN) provides the nation's researchers with effective and efficient access to advanced nanofabrication equipment and expertise. The five sites of the NNUN comprise a networked partnership of state-of-art facilities with common as well as complementary infrastructure with emphasis on training and open access, staff expertise and support for experiments, focus on user needs, ease of use, and access, expand the applications of nanotechnology, provide a bridge between disciplines through technical liaison and catalysis of new developments. There is considerable emphasis on education through workshops, short courses, dissemination of results and technology transfer.

Speech Assisted Learning (SAL) for Braille Students
The world's first stand-alone Braille learning station was made possible by an NSF grant to Exceptional Teaching Aids, Inc. of Castro Valley, CA. This small firm specializes in products for the visually impaired. Speech Assisted Learning (SAL), developed under the

Small Business Innovation Research (SBIR) program, offers high quality Braille instruction to more blind students (of all ages) than was ever possible before.

SAL can be used to augment classroom instruction or provide sequentially programmed lessons in several Braille codes. Newly blinded adults are moving more quickly back into the work force and regaining control of their personal and professional lives.

The curriculum courseware consists of data diskettes with corresponding bar-code technology Braille worksheets. Worksheets are placed on the touch screen of the SAL System. Through SAL's synthesized speech, the student listens to spoken tutorials and then is asked questions. The student will indicate an answer by pressing on the worksheet or typing it on the 8-dot keyboard. SAL will then provide spoken feedback as to the accuracy of the answer. A slight press of a finger prompts SAL to speak a word. With a second press, SAL will spell the word with the correct Braille contractions. The curriculum provides educators with everything they need to teach Braille mathematics, science, reading, computer codes, and more. A record-keeping feature allows educators to monitor progress of their students.

Duxbury Systems, Inc. has recently completed software that will allow Exceptional Teaching Aids, Inc. to offer high quality speech and Braille courseware in Spanish. Additional software is available to individuals who want to create their own materials for SAL.

The simplicity of SAL extends the ability of teachers to provide instruction over longer periods of time with amazing, proven results while maintaining student interest. With SAL, Braille has never been easier and faster to teach and learn, promoting self-management skills, vocational options, social interaction, and equality of opportunity in private and professional lives.

Freedom Scientific, licensed by Exceptional, has just recently brought the first SAL units to the market.

This project provides a new and effective approach for the blind in math learning.

Telemicroscopy

Mark H. Ellisman, leader of the National Partnership for Advanced Computational Infrastructure (NPACI) Neuroscience thrust area and director of the National Center for Microscopy and Imaging Research (NCMIR) at the University of California, San Diego has developed a transparent interface, a Telescience Portal for Neurosciences. The Telescience Portal is now in wide multidisciplinary use by structural neurobiologists, molecular and cell biologists, electron microscopists, and computer scientists within and beyond NPACI. Use of the portal, linking instruments and analysis among the Netherlands, Japan, Taiwan, and the United States over a dedicated, state-of-the-art (IPv6) network, was demonstrated at iGrid 2002 in Amsterdam. Moreover, the designers have transferred and used the same technology in a National Institutes of Health (NIH)-funded nationwide effort called the Biomedical Informatics Research Network (BIRN). The BIRN Portal is a direct descendant of the Telescience Portal. For Ellisman and his many collaborators, these portals exemplify the advantages of a full computational infrastructure and can serve as models for others to build on.

NCMIR scientists have made their microscopes capable of remote operation over the Internet, and they have joined with colleagues at Osaka University in Japan to do the same for a more powerful 3 MeV ultrahigh-voltage electron microscope, a unique, world-class resource. They have also inaugurated another international telescience collaboration–with the National Center for High-Performance Computing in Taiwan.

The Telescience Portal is an application environment supplying centralized access to all the tools and applications necessary for performing end-to-end electron tomography. It is Web-enabled, so it can be reached with a single login from any Internet-capable location. One simple Web interface allows the user to accomplish many scientific tasks that invoke many kinds of software, yet the user need not be

expert in any of the software. The portal guides a user through a session, launching whatever software is needed as it is called for.

This project contributes to the development or provision of tools that enable discoveries or enhance productivity of NSF research communities. It adopts a web-based approach for utilization of very expensive scientific instrumentation.

Indicator T2. - Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure.

Constellation Observing System for Meteorology, Ionosphere, and Climate

The Global Positioning System (GPS) provides a wide variety of useful applications from precise geographic positioning for automobile and other navigation to science applications such as monitoring small movements of the Earth's crust. The GPS is a constellation of satellites that transmit radio waves to Earth which are captured by ground receivers and the data used to determine position. As the radio waves pass through the Earth's atmosphere, they are retarded and bent. The altered paths of the radio waves are due to the properties of the atmosphere and are considered "noise" relative to the original radio signal.

NSF funded a proof-of-concept study to determine if this noise can be used to aid studies and prediction of weather, climate and space weather. Based on that successful experiment, radio occultation sounding techniques using GPS radio signals have emerged as a promising basis for a global observing system for weather, climate and space weather. A GPS occultation receiver onboard a low Earth orbiting (LEO) satellite can measure the phase delay of the radio signals transmitted by the GPS satellites as they set or rise with respect to the LEO. From accurate measurements of phase delays, atmospheric refractive bending can be deduced with high precision. Vertical profiles of bending angles can be used to derive refractive index, which is a function of electron density in the ionosphere and a function of temperature and water vapor in the troposphere and stratosphere.

As demonstrated by the NSF-funded study and subsequent ongoing studies, the GPS radio occultation (RO) sounding data are of high accuracy and high vertical resolution, and serve as an excellent complement to the traditional nadir-viewing, passive microwave satellite measurements. As a result of the successful proof-of-concept project, NSF, through an award to the University Corporation for Atmospheric Research, is now leading a consortium of five Federal agencies in partnership with Taiwan, to launch a fleet of GPS RO satellites. The project will culminate in a joint U.S.-Taiwan COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) mission launched in late 2005 and is expected to collect approximately 3,000 RO soundings per day. Compared to present upper air soundings (about 1,400 per day, with most concentrated over mid-latitude continental areas), COSMIC soundings will be twice as many and will cover both oceans and land regions. The COSMIC data will be available in near real-time for global weather and space weather analysis and prediction.

This is a highly leveraged, multi-agency and international project that will result in an unprecedented data set for operational and research purposes.

Gemini Transforms a Desert

Looking well outside our galactic neighborhood, an international team has equipped the Gemini telescopes with a unique and powerful technique that counteracts the fluorescence that contaminates the far-red end of the optical spectrum in the night sky. The result of this work is that Gemini can obtain much deeper spectra in this far region than has ever been possible before. Called "nod and shuffle," this method synchronizes a small shift in the telescope's pointing on the sky with a precise shuffling of the images on a charge-coupled device (CCD) detector to significantly increase the signal-to-noise ratio of the data. Using this technique, Gemini astronomers have discovered that the apparent "redshift desert" of galaxies that was thought to exist at an epoch of about one-third to one-half the age of the universe is actually well-populated with galaxies.

Solving the puzzle of the *Forma Urbis Romae*

The Forma Urbis Romae is a giant marble map of ancient Rome approximately 60 feet wide and 45 feet high. The map is broken into 1,186 pieces, and some pieces are missing. Putting together this "jigsaw" puzzle has been a major unsolved problem in archaeology.

Finding fits among the fragments is difficult because of the weight of the fragments. At Stanford University researchers are using computer shape matching algorithms to search for matches among the fractured side surfaces of the fragments. It is not clear that this will lead to a solution of the problem, but the project will result in a web-accessible relational database giving descriptions and bibliographic information about each fragment. A sample database, containing 28 selected fragments, is currently online. The long-term plan of the project is to make the entire database (1,186 fragments) freely available to the archeological (and computer graphics) research communities, educators, museum curators, and the general public.

U.S. & Europe Sign Agreement for the World's Most Powerful Radio Telescope
NSF director Dr. Rita Colwell and European Southern Observatory (ESO) director general Dr. Catherine Cesarsky have signed a joint agreement to construct and operate the Atacama Large Millimeter Array (ALMA) in Chile. ALMA will provide unprecedented resolution and sensitivity at very high radio frequencies, and will help probe planet and star formation, the formation of early galaxies and galaxy clusters, and the detection of organic molecules in space, among other topics. Expected to be complete in 2011, ALMA will cost approximately $550 million U.S. (FY 2000 dollars) and will “usher in a new age of research in astronomy,” according to Dr. Colwell.

ALMA will expand the frontiers of radio astronomy by facilitating the highest resolution imagery at the highest sensitivity of any existing radio telescope. This international collaboration will involve researchers, technicians, and project management personnel of diverse nationalities. The development, construction, and use of ALMA will be a truly global project.

Indicator T3. - Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal (For example, broad-based, program-wide results that demonstrate success related to management/utilization of large data sets/information bases, or development of information and policy analyses, or use of the Internet to make STEM information available to NSF research or education communities, or exceptional examples of broadly accessible tools shared by NSF research and education communities.)

Automated Compilation and Computational Analysis of Regulatory Networks

GeneWays[19] is a fully automated system designed to extract relations between substances (genes, proteins, RNAs, small molecules, *etc*.) or processes using a natural-language processing technology from full-text research articles published in scientific journals.

GeneWays has been recently applied to discover missing links in the reverse cholesterol transport pathway. Over 120,000 articles from 25 journals were processed using GeneWays pipeline. The extracted information resulted in a knowledge base with over 2.7 million individual statements on molecular interactions, corresponding to over 1.5 million unique molecular interactions. A subset of statements mentioned more than once (> 1 million) corresponds to a collection of highly reliable molecular interactions. GeneWays database is currently the largest existing database of molecular interactions.

The GeneWays system can search tens of thousands of journal articles, extract relevant pathway information for genes and proteins, display those pathways in diagrams, and put the information in a database. This may reduce or eliminate much of the manual work in searching literature and databases for new discoveries and existing relations between substances because the system can analyze and represent relationships in scientific text.

[19] http://genome6.cpmc.columbia.edu/~krautham/geneways/

Mining the Bibliome: Information Extraction from the Biomedical Literature

The many millions of biomedical publications available in electronic form contain a vast quantity of scientific information. Researchers would like access to this information structured in terms of well-defined relations (like "inhibition" or "mutation") among entities of interest (like "gene", "compound" or "cell line"). Recent techniques from computational linguistics can make more of this information accessible to biomedical researchers. This project has developed or adapted software tools that allow human experts to annotate biomedical texts for relevant entities and relations, to mark syntactic structure, and to indicate shallow semantic structure, such as co-reference relations and predicate-argument relations. The software allows multiple independent forms of text annotation to be created and used in an integrated way. This group is producing annotation specifications and training materials for syntactic and semantic annotation of biomedical text. Further details can be found at http://www.ldc.upenn.edu/myl/ITR

The goal of this research is qualitatively better methods for automatically extracting information from the biomedical literature, relying on three techniques: high-accuracy parsing, shallow semantic analysis, and integration of existing databases. An initial step is to create annotated corpora in collaboration with biomedical researchers: two test cases are gene variations in pediatric oncology, and inhibition of CYP450 enzymes.

Analysis of Microbial Communities Using a DNA Array Approach

This research led to the development of an approach termed oligonucleotide fingerprinting of ribosomal RNA genes (OFRG). OFRG analyses were developed for both bacteria and fungi. The PIs are currently in the process of developing an OFRG approach that will be useful for identifying any type of organism (universal OFRG). They are also developing a high throughput OFRG approach. Current OFRG protocols allow analysis of 1536 rDNA clones. Utilization of microarray technologies should allow them to examine tens of thousands

of rDNA clones simultaneously. They have also established a website that will provide downloadable algorithms for data analysis.

They also developed two new approaches for analyzing the data produced by the OFRG analysis. More specifically, they have developed effective new strategies for transforming the signal intensity data from the array experiments into hybridization fingerprints. These advances will increase the accuracy and speed of the analyses. This approach involves new array-based methods and innovative data analysis strategies developed by the research group. Utilization of this new experimental approach should lead to a greater understanding of the organisms inhabiting our planet, their functional roles in ecosystems and their potential for biotechnology.

OFRG provides the first cost-effective experimental approach for analysis of microbial community composition.

Collaborative Research for National eWorkshops: Interactive On-line Workshops
The eWorkshop is an on-line meeting developed by the CeBASE (Center for Empirically Based Software Engineering) team which replaces the usual face-to-face workshop. It is structured to accommodate the needs of a workshop without becoming an unconstrained on-line chat discussion. The goal is to synthesize new knowledge from a group of experts in an efficient and inexpensive format. In addition to a web-based chat tool, an eWorkshop includes a process and a support team to ensure that more than a random discussion results. This process is at the heart of the eWorkshop concept. The support team consisted of the following roles: moderator, director, scribe, tech support, and analyst. The moderator is responsible for monitoring and focusing the discussion (e.g., proposing items on which to vote). The director is responsible for assessing and setting the pace of the discussion and decides when it is time to redirect the discussion onto another topic. As the discussion moves from topic to topic, the scribe highlights the current agenda item and captures the results on the whiteboard area of the screen. When the participants reach a consensus on a particular item through a vote, the scribe summarizes and updates the whiteboard to reflect the outcome. The contents of the whiteboard become the first draft of the meeting minutes. The analyst codes the responses according to a pre-defined taxonomy. The tech support is responsible for handling any problems that may occur with the tools. For example, some participants accidentally close their sessions and have difficulty logging into the meeting for a second time. The eWorkshop has been used in a variety of settings. CeBASE has held several meetings on defect detection, COTS development, and agile development, with attendees from Europe, North America, Hawaii and Japan. Various groups within the DoD are now planning on using the technology to manage meetings without the expense and time of face-to-face gatherings.

The technology and methodology associated with eWorkshops facilitates Software Engineering activities as well as other requirements-driven processes in the increasingly global collaborative environment and significantly reduces the cost of doing so.

Computational Tools for K-12 Science Education
A research collaborative based at the University of Michigan is designing and implementing a learning technologies architecture to allow third party tools to operate and share data using a common, supportive interface suitable for K-12 learners. In learning science, students need to use a broad range of computer applications, from data analysis and simulation tools, from visualization tools to argumentation tools. In order to make such a diverse range of applications learnable and usable by individuals who are not technology experts, the applications must be presented with a common, supportive interface. The researchers are constructing learning technologies architecture to guide educational tool development by others. The research team has produced an integrated learning environment, *Symphony*, which embodies the learning technology architecture. *Symphony* provides a common interface across

tools and provides scaffolds that support learners in coming to understand the science underlying the use of tools. Many prior stand-alone tools have been integrated into the *Symphony* environment and tested in classrooms.

Upon completion, *Symphony,* together with learning technologies architecture should provide a third-party friendly delivery environment for K-16 classrooms.

Development of Biosensors for Rapid Screening

This project has resulted in the development of biosensors that can be directly interfaced with digital computers. The sensor can detect the presence and motion of individual cells, using an array of many cell-sized sensing sites that can be individually addressed using electrical signals. Electrical sensing makes it possible to easily connect the sensor to a computer and to rapidly and efficiently monitor many cells. Such an electronic array can be used for live cell screening, replacing present optical sensing techniques. Optical sensing is slow and inefficient because it requires precise mechanical translation of the microscope followed by focus and complex image processing. The sensor could be used for the rapid screening of new drug candidates. Alternatively the sensor could be used for the detection of biological agents that kill cells. Such an array might provide rapid detection of biological warfare agents. In our work to date the sensing mechanism has been demonstrated and modeling of the sensor has been performed in order to understand the sensing mechanism. Test sensor arrays have been fabricated and are now being tested.

Industry Impact

NSF-funded research had broad societal impact by transitioning research advances into industry enabling new capabilities in the commercial arena. The project "*Supporting Complex Application Requirements in Metasystems*" developed new and enhanced Grid Applications scheduling capabilities and a Grid Programming Model in the Grid computing environment Legion.

This software was used on the NPACI computational grid to enable large Protein Folding simulations and involved researchers both from the University of Virginia and the Scripps Research Institute. In June 2001 the PI launched Avaki[20], commercializing several aspects of *Legion* and collaborating with several pharmaceutical companies for advanced drug design[21]. In addition Avaki announced that IBM will use Avaki's Grid Computing Software at IBM's Grid Innovation Center.

New Statistical Tools for Analyzing Natural Selection at the Molecular Level

By identifying natural selection at the level of the DNA, Dr. Rasmus Nielsen[22] of Cornell University is addressing questions about molecular evolution and identifying genomic regions of special functional importance. Nielsen has developed new statistical methods for identifying and interpreting patterns of selection. These methods will provide a more powerful and versatile tool for identifying selection at the level of the DNA sequence. Nielsen is also developing methods for estimating the age, distribution and correlated evolution of changes in DNA. The new methods are being applied to several data sets, particularly data sets of viral sequences such as HIV-1 sequences. One of the questions addressed is how often compensatory mutations occur in the evolution of drug resistance in the HIV-1 virus. The new methods will be applicable in many genomic studies, particularly for identifying regions or sites of functional importance. As it is perfected, the software for using these methods is made available on Dr. Nielsen's website.

These new statistical tools will be of broad use in the community of scientists who are addressing questions about how evolution operates at the molecular level. They will be particularly useful for analyzing the large data sets that genomic projects are producing.

[20] www.avaki.com

[21] Gene logic Inc., Infinity Pharmaceuticals, Structural Bio Infomatics

[22] http://www.bscb.cornell.edu/Homepages/Rasmus_Nielsen/files.html

II. SUMMARY OF PERFORMANCE RESULTS

Overall, we were successful in achieving 70% (14 of 20) of our performance goals.

RESULTS FOR STRATEGIC OUTCOME GOALS: We achieved all of our four annual performance goals related to our strategic outcome goals (100%) in FY 2003.

FY 2003 Performance Results	
Number of Goals Achieved	
Outcome Goals	**4 of 4 (100%)**
Management Goals	**10 of 16 (63%)**
TOTAL	**14 of 20 (70%)**

RESULTS FOR MANAGEMENT GOALS: We achieved 10 of our 16 management goals (63%).

FY 2000 – FY 2003 Performance Results
Number of Goals Achieved

	FY 2000	FY 2001	FY 2002	FY 2003
Annual Performance Outcome Goals	**6 out of 8 (75%)**	**4 out of 5 (80%)**	**4 out of 4 (100%)**	**4 out of 4 (100%)**
Management Goals	**12 out of 20 (60%)**	**11 out of 18 (61%)**	**14 out of 19 (74%)**	**10 out of 16 (63%)**
Total	**18 out of 28 (64%)**	**15 out of 23 (65%)**	**18 out of 23 (78%)**	**14 out of 20 (70%)**

Note: In FY 2000 and FY 2001, Management Goals include goals that have been identified in previous years as Investment Process Goals.

The following table provides a summary of NSF's FY 2003 results.

ANNUAL PERFORMANCE GOALS FOR NSF'S STRATEGIC OUTCOMES

Strategic Outcome	FY 2003 Annual Performance Goal	Results for National Science Foundation
People Strategic Outcome **Outcome Goal III-1:** Developing "a diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens."	***Performance Goal III-1a:*** **NSF's performance for the People Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators:** • Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future. • Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities. • Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal. FY 2003 Result: External expert assessment found that NSF has demonstrated significant achievement for each of the performance indicators associated with this goal.	**FY 2001:** NSF successful for related goal. **FY 2002**: NSF successful for related goal. **FY 2003: NSF is successful for goal III-1a.** • Demonstrated significant achievement • Demonstrated significant achievement. • Demonstrated significant achievement.

ANNUAL PERFORMANCE GOALS FOR NSF'S STRATEGIC OUTCOMES (continued)

Strategic Outcome	FY 2003 Annual Performance Goal	Results for National Science Foundation
People Strategic Outcome	***Performance Goal III-1b:*** **NSF will significantly enhance the quality of K-12 mathematics and science education available to all students in Math and Science Partnership schools.** Performance Indicators: • to support high quality programs addressing issues related to teacher workforce capacity, including preservice education and inservice professional development of math and science teachers as well as alternative routes into the profession (e.g., scientists and engineers becoming teachers.) • infrastructure needed to improve math and science education and to measure improvement, i.e., the adoption of appropriate assessments of student achievement, as well as the initiation of the collection of achievement data that can be disaggregated by ethnicity, socioeconomic status, gender, etc. FY 2003 Result: Significant achievement was demonstrated for both indicators.	**(New Goal)** **FY 2003: NSF is successful for goal III-1b.** • Demonstrated significant achievement. • Demonstrated significant achievement.

ANNUAL PERFORMANCE GOALS FOR NSF'S STRATEGIC OUTCOMES (continued)

Strategic Outcome	FY 2003 Annual Performance Goal	Results for National Science Foundation
Ideas Strategic Outcome **Outcome Goal III-2:** Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."	***Performance Goal III-2:*** **NSF's performance for the Ideas Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators:** • Discoveries that expand the frontiers of science, engineering, or technology; • Connections between discoveries and their use in service to society; • Partnerships that enable the flow of ideas among the academic, public or private sectors; • Leadership in fostering newly developing or emerging areas. FY 2003 Result: External expert assessment found that NSF has demonstrated significant achievement for each of the performance indicators associated with this goal.	**FY 2001:** NSF successful for related goal. **FY 2002**: NSF successful for related goal. **FY 2003: NSF is successful for goal III-2.** • Demonstrated significant achievement. • Demonstrated significant achievement. • Demonstrated significant achievement. • Demonstrated significant achievement.

ANNUAL PERFORMANCE GOALS FOR NSF'S STRATEGIC OUTCOMES (continued)

Strategic Outcome	FY 2003 Annual Performance Goal	Results for National Science Foundation
Tools Strategic Outcome **Outcome Goal III-3:** Providing "broadly accessible, state-of-the-art and shared research and education tools."	***Performance Goal III-3:*** **NSF's performance for the Tools Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators:** • Development or provision of tools that enables discoveries or enhances productivity of NSF research or education communities. • Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure. • Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal. FY 2003 Result: External expert assessment found that NSF has demonstrated significant achievement for each of the performance indicators associated with this goal.	**FY 2001:** NSF successful for related goal. **FY 2002**: NSF successful for related goal. **FY 2003: NSF is successful for goal III-3.** • Demonstrated significant achievement. • Demonstrated significant achievement. • Demonstrated significant achievement.

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Proposal and Award Processes		
Use of Merit Review	***Performance Goal IV-1:*** At least 85 percent of basic and applied research funds will be allocated to projects that undergo merit review. FY 2000 Goal 80% FY 2000 Result 87% FY 2001 Goal 85% FY 2001 Result 88% FY 2002 Goal 85% FY 2002 Result 88% FY 2003 Goal 85% FY 2003 Result 89%	**FY 1999:** NSF successful for related goal **FY 2000:** NSF successful **FY 2001:** NSF successful **FY 2002:** NSF successful **FY 2003: NSF is successful for goal IV-1.**
Implementation of Merit Review Criteria – Reviewers	***Performance Goal IV-2:*** At least 70 percent of reviews with written comments will address aspects of both generic review criteria. FY 2001 Result 69% FY 2002 Result 84% FY 2003 Goal 70% FY 2003 Result 90%	**FY 2001:** NSF not successful for related goal **FY 2002:** NSF successful for related goal **FY 2003: NSF is successful for goal IV-2.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Proposal and Award Processes		
Implementation of Merit Review Criteria – Program Officers	***Performance Goal IV-3:*** For at least 80 percent of decisions to fund or decline proposals, program officers will comment on aspects of both generic review criteria. FY 2001 Result: Program reports prepared by external experts during FY 2001 GPRA reporting led NSF to conclude it was successful in implementation of both merit review criteria by program managers. FY 2002 Result: A statistically determined sample of FY 2002 review analyses was evaluated by NSF staff to determine the extent of Program Officer usage of both review criteria. It was determined that approximately 78% of review analyses commented on aspects of both merit review criteria. FY 2003 Result: NSF staff evaluated a statistically determined sample of FY 2003 review analyses to determine the extent of Program Officer usage of both review criteria. It was determined that approximately 53% of review analyses commented on aspects of both merit review criteria. To improve performance in the future, the issue of what constitutes program officer comments on aspects of both generic review criteria will be examined and clarified.	**FY 2001:** NSF successful for related goal **FY 2002:** NSF successful for related goal **FY 2003: NSF is not successful for goal IV-3.**
Customer Service - Time to Prepare Proposals	***Performance Goal IV-4:*** Ninety-five percent of program announcements will be publicly available at least three months prior to the proposal deadline or target date. FY 1998 Baseline 66% FY 1999 Result 75% FY 2000 Goal 95% FY 2000 Result 89% FY 2001 Goal 95% FY 2001 Result 100% FY 2002 Goal 95% FY 2002 Result 94% FY 2003 Goal 95% FY 2003 Result 99% FY 2003 Result: In FY 2003, 99% (119 of 120) of program announcements and solicitations were made available at least 90 days before the proposal deadline or target date.	**FY 1999:** NSF not successful **FY 2000:** NSF not successful **FY 2001**: NSF successful **FY 2002**: NSF not successful **FY 2003: NSF is successful for goal IV-4.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Proposal and Award Processes		
Customer Service - Time to Decision	***Performance Goal IV-5:*** For 70 percent of proposals, be able to inform applicants whether their proposals have been declined or recommended for funding within six months of receipt. FY 1998 Baseline 59% FY 1999 Result 58% FY 2000 Goal 70% FY 2000 Result 54% FY 2001 Goal 70% FY 2001 Result 62% FY 2002 Goal 70% FY 2002 Result 74% FY 2003 Goal 70% FY 2003 Result 77%	**FY 1999:** NSF not successful **FY 2000:** NSF not successful **FY 2001:** NSF not successful **FY 2002:** NSF successful **FY 2003: NSF is successful for goal IV-5.**
Award Portfolio		
Award Size	***Performance Goal IV-6:*** NSF will increase the average annualized award size for research grants to a level of $125,000, compared to a goal of $113,000 in FY 2002. FY 1998 Baseline $90,000 FY 1999 Result $94,000 FY 2000 Result $105,800 FY 2001 Goal $110,000 FY 2001 Result $113,601 FY 2002 Goal $113,000 FY 2002 Result $115,666 FY 2003 Goal $125,000 FY 2003 Result $135,609 FY 2003 Result: NSF sought a very ambitious one-year increase of over 10% in average annualized award size -- from $113,000K to $125,000. In contrast to previous years, in FY 2003 collaborative proposals submitted as individual proposals from the collaborating institutions were counted as a single proposal as NSF treats them as a single proposal for review and award/decline decisions. If such collaborative proposals are counted individually, the average annualized award size for FY 2003 is $121,380.	**FY 2001:** NSF successful **FY 2002:** NSF successful **FY 2003**: **NSF is successful for goal IV-6.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Award Portfolio		
Award Duration	***Performance Goal IV-7:*** NSF will maintain the FY 2002 goal of 3.0 years for the average duration of awards for research grants. FY 1998 Baseline 2.7 years FY 1999 Goal 2.8 years FY 1999 Result 2.8 years FY 2000 Result 2.8 years FY 2001 Goal 3.0 years FY 2001 Result 2.9 years FY 2002 Goal 3.0 years FY 2002 Result 2.9 years FY 2003 Goal 3.0 years FY 2003 Result 2.9 years FY 2003 Result: Progress on this goal is budget dependent. Program Directors must balance competing requirements: increasing award size, increasing duration of awards, and/or making more awards. NSF will continue to focus on increasing award size and duration in order to improve the efficiency of the research process.	**FY 1999:** NSF successful **FY 2000:** Goal not included in Performance Plan **FY 2001:** NSF not successful **FY 2002:** NSF not successful **FY 2003: NSF is not successful for goal IV-7**.

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Award Oversight and Facilities Management		
Construction and Upgrade of Facilities	***Performance Goal IV-8:*** For 90 percent of construction, acquisition and upgrade projects, keep any negative cost and schedule variances to less than 10 percent of the approved project plan. FY 2003 Result: Data collected from Facilities Managers external to NSF indicate that 88% (30 out of 34) of facilities kept any negative cost and schedule variances to less than 10 percent of the approved project plan. NSF will continue to work with Facility Managers to improve performance in this area.	**FY 2003: NSF is not successful for goal IV-8.**
Operations and Management of Facilities	***Performance Goal IV-9:*** For 90 percent of facilities, keep operating time lost due to unscheduled downtime to less than 10 percent of the total scheduled operating time. FY 1999 Result: Reporting database under development. FY 2000 Result: Of the 26 reporting facilities, 22 (85%) met the goal of keeping unscheduled downtime to below 10% of the total scheduled operating time. FY 2001 Result: Of the 29 reporting facilities, 25 (86 percent) met the goal of keeping unscheduled downtime to below 10 percent of the total scheduled operating time. FY 2002 Result: Of the 31 reporting facilities, 26 (84 percent) met the goal of keeping unscheduled downtime to below 10 percent of the total scheduled operating time. FY 2003 Result: We were not successful in achieving this goal. Data collected from Facilities Managers external to NSF indicate that 87% (26 out of 30) facilities kept scheduled operating time lost to less than 10 percent. NSF will continue to work with Facility Managers to improve performance in this area.	**FY 1999:** Inconclusive for related goal **FY 2000:** NSF not successful for related goal **FY 2001:** NSF not successful **FY 2002:** NSF not successful **FY 2003: NSF is not successful for goal IV-9.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Business Practices		
Electronic Business	***Performance Goal IV-10:*** NSF will continue to advance "e-business" by receiving through FastLane and processing electronically 90 percent of Principal Investigator award transfers. FY 2003 Result: 99.8% of Principal Investigator award transfers were processed electronically.	**(New Goal)** **FY 2003: NSF is successful for goal IV-10.**
Electronic Business	***Performance Goal IV-11:*** NSF will continue to advance "e-business" by implementing Phase III of the Electronic Jacket application. Performance Indicator: Implementation of the electronic capability for assigning proposal processing tasks, forwarding proposals to other programs as necessary, and delegating proposal action authority. FY 2003 Result: NSF is not successful for this goal. Phase III is expected to be available for NSF staff use prior to the end of the first quarter of FY 2004.	**(New Goal)** **FY 2003: NSF is not successful for goal IV-11.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Business Practices		
Information Technology Security	***Performance Goal IV-12:*** NSF will maintain and enhance the agency-wide security program to ensure adequate protection of NSF's IT infrastructure and critical assets. Performance Indicators: • 95 percent of major systems will have approved security plans on file. • 95 percent of major systems will have documented certification and accreditation. FY 2002 Result: NSF initiated actions to meet the requirements of the Security Act, OMB Circular A-130, and the National Institute of Standards and Technology Security Self-Assessment Guide for Information Technology Systems. The agency met all four FY 2002 performance indicators. FY 2003 Result: As planned, security plans have been developed and approved for 95% of major systems. Ninety-five percent have been certified and accredited.	**FY 2002:** NSF successful for related goal. **FY 2003: NSF is successful for goal IV-12.**
Human Resources and Workplace		
NSF Staff – Diversity	***Performance Goal IV-13:*** NSF will ensure that diversity considerations are embedded in activities related to agency staffing of scientists and engineers (S&E). Performance Indicator: Initiate development of a NSF S&E diversity plan. FY 2003 Result: A multi-disciplinary team of employees from various levels in the organization was established and began development of the NSF S&E Diversity plan.	**(New Goal)** **FY 2003: NSF is successful for goal IV-13.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Human Resources and Workplace		
	Performance Goal IV-14: NSF will show an increase over FY 2000 in the total number of appointments to NSF science and engineering staff and management from underrepresented groups. FY 2000 Result: 35 females and 19 members of underrepresented minority groups were hired. FY 2001 Result: 38 females and 22 members of underrepresented minority groups were hired. FY 2002 Result: 41 females and 27 members of underrepresented minority groups were hired. FY 2003 Result: As of September 30, 2003, 48 females and 25 members of underrepresented minority groups were hired compared to our goal of appointing more than the 46 females and 25 underrepresented minority groups to NSF science and engineering staff and management positions in FY 2003. In FY 2003 we have expanded the scope of our goal to include additional S&E positions in the agency. Broadening the positions included in this measure allows us to assess our efforts throughout all professional recruitment opportunities, including executive hiring. The baseline to be used will be total S&E hires from underrepresented groups in FY 2000. In FY 2004 additional emphasis will be placed on the hiring of female and minority employees. An additional staff member will be hired to specifically address diversity issues. In addition, the Diversity Plan, which is under development, will help provide strategies for recruiting and retaining a diverse staff.	**FY 2000:** NSF successful for related goal **FY 2001:** NSF successful for related goal **FY 2002:** NSF successful for related goal **FY 2003: NSF is not successful for goal IV-14.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2003 Annual Performance Goal	Results for National Science Foundation
Workforce		
Workforce Learning	***Performance Goal IV-15:*** NSF will align or develop competency-based curricula, through the NSF Academy, that provide cross-functional, work-based team learning opportunities. Performance Indicator: Initiate development of new courses or revision of existing courses to address program management, leadership development, and technology and business process training. FY 2002 Result: During FY 2002, 76 courses were offered, 30 of which were new. In addition, 3 courses were revised to be more responsive to the needs and requirements of our staff. FY 2003 Result: Twenty-four new courses were developed and 26 existing courses were revised to address the areas in the indicator statement.	**FY 2002:** NSF is successful for related goal **FY 2003: NSF is successful for goal IV-15.**
Workforce Planning	***Performance Goal IV-16:*** NSF will develop competency-based, occupation classification alternatives that support the agency's strategic business processes and capitalize on its technology enabled business systems. Performance Indicators: • Identification of workforce competencies for all current NSF job families. • Initiate identification of competency-based, classification alternatives. FY 2002 Result: NSF met its goal related to strategic business processes. A Request for Proposals was released in March 2002. A contract to conduct the business analysis was awarded in June 2002. A report on initial review of workforce competencies and skill mix was completed and delivered to NSF. FY 2003 Result: Job families and their corresponding competency models have been identified for all of NSF's core missions and support functions. The NSF Human Capital Plan outlines strategies and lays out action plans to develop a more uniform occupation classification system.	**FY 2002:** NSF is successful for related goal **FY 2003: NSF is successful for goal IV-16.**

SUPPORTING INFORMATION

FOR FY 2003 GPRA REPORTING

Performance Reporting Requirements and Where to Find Them in Our Report

The Government Performance and Results Act of 1993 requires each Federal agency to report, no later than 180 days following the close of each fiscal year, to the President and the Congress on its performance for the previous fiscal year.

According to OMB Circular No. A-11 Part 6, Section 230-2, dated July 2003, each report must include the following elements[1]:

1. *A comparison of your actual performance with the projected (target) levels of performance as set out in the performance goals in your annual performance budget (or your annual performance plan for for fiscal years prior to FY 2005);*
2. *An explanation, where a performance goal was not achieved, for why the goal was not met;*
3. *A description of the plans and schedules to meet an unmet goal in the future, or alternatively, your recommended action regarding an unmet goal where you have concluded it is impractical or infeasible to achieve that goal;*
4. *An evaluation of your performance budget (although use the FY 2004 performance plan for the FY 2003 report) for the current fiscal year, taking into account the actual performance achieved in the fiscal year covered by your report;*
5. *An assessment of the reliability and completeness of the performance data included in the report); and*
6. *Actual performance information for at least four fiscal years.*

Other features as they apply to the agency[2]:

1. Program evaluations;
2. Information on use of non-Federal parties;
3. Classified appendices not available to the public;
4. Budget information.

[1] Elements 1-4 and 6 are provided with each goal discussed in our report. Element 5 is discussed in Section VI.
[2] Information on program evaluations is given in Appendices 6 and 7. The other features are discussed in Section IX.

NSF STRATEGIC OUTCOME GOALS

III. NSF STRATEGIC OUTCOME GOALS

Introduction to Section III: NSF Strategic Outcome Goals

NSF assessment activities are based on an OMB-approved alternative reporting format that utilizes external experts for qualitative, retrospective evaluations of Foundation outcome results. In years prior to FY 2002, NSF used external independent assessments of NSF's outcome goal indicators provided by Committees of Visitors and Directorate Advisory Committees[3].

These committees provided assessment at program, divisional, or directorate levels. In FY 2002, NSF created a new external advisory committee – the Advisory Committee for GPRA Performance Assessment (AC/GPA) – to provide advice and recommendations to the National Science Foundation (NSF) Director regarding the Foundation's performance under the Government Performance and Results Act (GPRA) of 1993.

The charge to the NSF AC/GPA asked for development and transmittal to NSF of a report that included:

(1) An assessment of NSF retrospective results for indicators associated with the PEOPLE, IDEAS, and TOOLS strategic outcome goals;
(2) Comments on the quality/relevance/balance of NSF award portfolios; and
(3) Comments on NSF investment portfolios for their potential future impact.

The format of Section III is the following:

- An NSF assessment of performance with respect to the strategic outcome goal;
- Comments by the AC/GPA concerning the strategic outcome goal; and
- For each indicator or area of emphasis associated with a strategic outcome goal:
    - Comments by the AC/GPA,
    - Retrospective and prospective examples selected by AC/GPA.

A Diverse, Balanced Portfolio

Maintaining a diverse, balanced portfolio of high quality is an essential aspect of any investment strategy, and this holds true for investments NSF makes in science and engineering research and education. We recognize that there is a significant probability of failure associated with high-risk research, that there is often a lack of experimental data or methodologies, little consensus on theory, information and/or approach. If successful, however, such high-risk research can result in a significant advance in a scientific or technological field. In addition to our regular grants, our Small Grants for Exploratory Research (SGER) are meant to encourage Program Officers to invest in new, innovative concepts and ideas and to support small-scale, high-risk exploratory work.

Both Committee of Visitors (COV) and the AC/GPA assessed our investment portfolio for FY 2001, FY 2002 and FY 2003 with respect to quality and balance. The vast majority of their comments indicated that investments made by the Directorates contained an appropriate balance of high-risk, multidisciplinary or innovative activities. Some comments from the AC/GPA on quality and balance follow.

[3] See Section V for further details on these committees.

AC/GPA Comments on Quality

"In constructing its assessment of the overall quality of the retrospective portfolio of outcomes and outputs, the Committee relied on an extensive database of NSF supported projects provided by NSF program staff, individual project reports, reports from external Committees of Visitors (COVs) and other information. In addition, individual members of the Committee possess deep familiarity with various aspects of NSF's portfolio; thus, the Committee was able to rely in part on its own expertise and independent assessment.

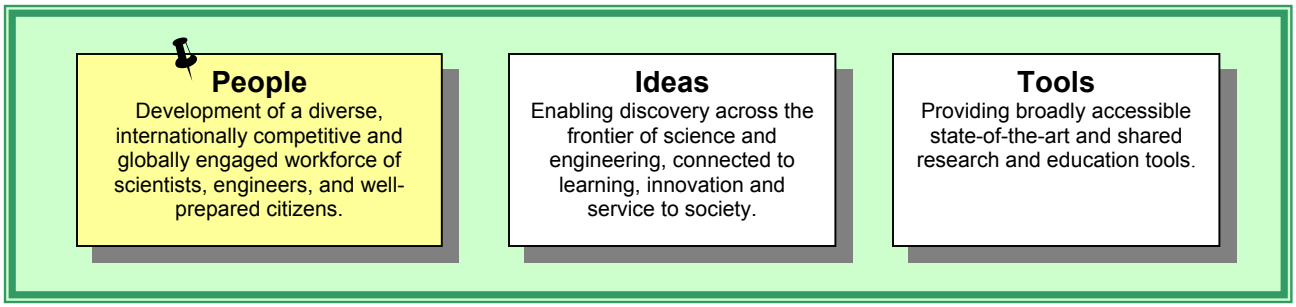
The Committee concluded that the quality of the retrospective portfolio was high in all three outcome goals. The breadth, depth, and diversity of the collective set of projects funded by NSF not only represent significant achievement, but also represent a spectrum of research modes. NSF supports individual investigators, multiple investigator teams, large centers, as well as shared facilities, databases and other infrastructure vital to support the national research enterprise."

AC/GPA Comments on Innovative, Risky, and Multi-disciplinary Research and Education

"With regard to innovative, "risky", and multi-disciplinary research and education, the Committee saw evidence of accomplishment as well as continuing leadership by NSF in this area. It is reasonable to accept that some fraction of the research that NSF funds will not lead to new paradigms or transform our thinking. No obvious formula exists to guide NSF as to the fraction of the portfolio that should be multi-disciplinary (defined as research or education activities that cross traditional discipline boundaries and creates synergistic interactions at those junctions). This type of research could, in many cases, be considered "high risk" since it often involves competing data, methods, theories and experimental approaches. The Committee notes that the COVs are explicitly asked to examine this issue and in most cases have concluded that the balance is appropriate. In addition, program managers continue to encourage high-risk proposals through the Small Grants for Exploratory Research (SGER) mechanism. NSF's Small Business Innovation Research Program (SBIR/STTR) is also recognized as a leader in the federal government in supporting novel research and technology with potentially high payoff. Lastly, the Committee notes that the encouraging trend continues for cross-disciplinary programs wherein multiple NSF directorates collaborate to fund a single research activity (e.g., mathematics and biology, environmental research, cyberinfrastructure). While this can serve as a proxy for investment in high-risk, multi-disciplinary research and education, more definitive analyses of these investments is needed."

III. NSF OUTCOME GOALS

A. PEOPLE



PEOPLE STRATEGIC OUTCOME GOAL: Developing "a diverse, internationally competitive and globally engaged workforce of scientists and engineers, and well-prepared citizens."

Annual Performance Goal III-1a: Our performance for this goal is successful when, *in the aggregate*, results reported in the period FY 2003 demonstrate significant achievement in the majority of the following indicators:

- Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future;
- Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities;
- Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal.

✓ Goal Achieved

To achieve this outcome, we invest in the best and brightest students, researchers and educators to ensure a well-prepared workforce and citizenry. We provide support for formal and informal science, mathematics, engineering and technology education at all levels – pre K-12, undergraduate, graduate – in addition to professional development and public science literacy projects that engage people of all ages in life-long learning. Our efforts serve as a catalyst and a test bed for a gradual change in the process and philosophy of educating the workforce.

RESULT FOR PERFORMANCE GOAL III-1a: External experts provided examples of significant achievement during FY 2003 reporting. Comments by the AC/GPA and examples they selected are presented for each of the performance indicators and areas of emphasis for this goal.

Implications for the FY 2004 Performance Plan: This goal will be continued in FY 2004.

PEOPLE: Comments by the Advisory Committee for GPRA Performance Assessment (AC/GPA)

The following statements concerning NSF achievement with respect to the Indicators and Areas of Emphasis for the PEOPLE goal are excerpted from the AC/GPA Report on NSF's PEOPLE portfolio. Additional comments as well as examples in support of significant achievement for each indicator are available at http://www.nsf.gov/pubs/2004/nsf04207/acgpa_report_2003.pdf

"The NSF Strategic Outcome Goal for People is: Developing a "diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens." NSF is to be commended for its many programs at all levels that strive to provide the nation with a diverse and competitive science and engineering workforce. While there is still room for improvement, NSF's efforts to engage administrators, faculty, and students at all levels in this strategic outcome goal have produced significant results. Progress has been made toward the attainment of both annual performance goals. The Committee judges that NSF has made significant achievement in three of the five indicators for this outcome goal (P1, P2, P3 associated with the first annual performance goal). For indicators P4 and P5 (associated with the second annual performance goal), both of which are focused exclusively on the very new Math and Science Partnership program (MSP), while there was evidence of future achievement, the Committee did not have enough information to reach a conclusion about NSF's performance."

INDICATOR 1: Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future.

RESULT: *Demonstrated significant achievement.*

"Under the first indicator, *"Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future,"* NSF is funding a host of programs that provide a path to achievements for a diverse, internationally competitive, and globally engaged workforce of scientists, engineers and well-prepared citizens. Examples of programs that support this indicator are: Research Experiences for Undergraduates and Research Experiences for Teachers. While there were no accomplishments in the database for the Minority Institutions Infrastructure Grants program, the Committee notes that this program also supports this indicator. In particular, a very successful activity that supports the development of a diverse science, technology, engineering and mathematics (STEM) workforce has been the Research Experiences for Undergraduates (REU) program that NSF has now institutionalized across the Foundation through REU sites, REU supplements, collaborative Research in Undergraduate Institutions programs, and other mechanisms. Innovative implementation of the Research Experiences for Undergraduates (REU) concept has provided excitement both within and among institutions that has led, in some cases, to groundbreaking research results prompted by the involvement of undergraduate students. While not specifically cited here, the Louis Stokes Alliances for Minority Participation (LSAMP) continues to represent one of the most important programs, contributing to significant achievement for this indicator. The Committee notes that it also strongly supports the second indicator for the Ideas goal. The point here is that LSAMP participation now extends to over 30 alliances representing over 400 individual institutions. The impact extends to over 206,000 underrepresented minority students. The original goal of LSAMP was to increase the number of underrepresented minorities receiving undergraduate degrees in science, engineering, and mathematics. While significant progress has been made in achieving this goal,

LSAMP has recently been expanded to include a strong emphasis on graduate studies as well. Just in the last three years over 80 LSAMP students have completed the doctorate in science, engineering or mathematics and are working in their fields. An additional 20 LSAMP students are currently enrolled in Ph.D. programs. While the numbers are still small, this program has had a significant positive impact on the number of doctoral degrees received by underrepresented minorities in the U.S. and thus contributes materially to this indicator."

INDICATOR 2: Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities.

RESULT: *Demonstrated significant achievement.*

"Projects and accomplishments under the second indicator, "*Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities"* are impressive and contribute significantly toward the attainment of the overall People goal. While the portfolio supporting this indicator is strong, the Foundation will be challenged in the future to sustain current programs that have this indicator as their primary focus and to enhance all the programs in its People portfolio. Nearly every NSF program has the opportunity to impact this indicator. The LSAMP cited above is a good example of this "cross fertilization." In light of this, the Committee believes that NSF has both the obligation and the opportunity to use a varied armamentarium of programmatic initiatives (from all Directorates and programs) to the achievement for this indicator."

INDICATOR 3: Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal.

RESULT: *Demonstrated significant achievement.*

"Under the third indicator, *" Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE Outcome Goal,"* the NSF portfolio contains important examples of education and research programs that are designed to enable students, educators and researchers to explore the challenges of science, technology, engineering and mathematics and related fields. Overall there is a balance of programs supporting learning and exploration at the K-12 level; teacher and faculty development activities; curriculum development and dissemination activities for K-12 and college classrooms; mass media, print and web-based public awareness activities; and activities to encourage women and underrepresented minorities to develop interest and pursue STEM careers."

Emphasis Areas for GPRA Reporting

- **PreK-12 Education, e.g., Systemic Reform;**
- **Undergraduate Education, e.g., REU;**
- **Graduate and Professional Development, e.g., IGERT, GK-12, CAREER;**
- **Centers for Learning & Teaching (CLT);**
- **Broadening Participation, e.g., Partnerships for Innovation, Programs that serve underrepresented groups**

"NSF is investing in a broad range of activities that aim to improve the performance of preK-12 students in mathematics and science. There are awards focused on issues relating to preK-12, undergraduate and graduate students. There are also awards that support center type activities as well as activities that are designed to encourage participation from underrepresented groups. The Committee provides some outcome accomplishments that highlight NSF's investment in specific areas."

*"**PreK-12 Education -*** Under an integrated program for middle school science teachers, a new middle school curriculum was developed from collaboration among university faculty, community college faculty, science content teachers and science education teachers. This project also contributed to prepare middle school science teachers.

The Houston Urban Systemic Initiative reported rather impressive results in improving K-12 student performance. For example, it was reported that the Texas Assessment Academic Skills mathematics test for all students indicated an eight percentage point increase at the 3rd grade level and a three percentage point increase at the 5th and 8th grade levels."

"***Undergraduate Education -*** Over the years, an increasing number of undergraduate students have been involved in research through NSF funding. Principal investigators could seek supplemental funding under the Research Experiences for Undergraduates (REU) program to engage undergraduate students in their projects. About ten years ago, NSF institutionalized this activity by funding REU sites where undergraduate students from different universities were brought together for a period of time to gain research experience.

NSF funds projects that have created unique opportunities for undergraduate students. For instance, an award to the Association of American State Geologists made it possible for undergraduate students to conduct field work with professionals outside of the university setting and prepared them for a successful career in earth sciences."

"***Graduate and Professional Development*** – There are various forms of NSF support for graduate students. Some of the support is used to fund collaborative research. An IGERT award was used to fund a parallel multi-unit neurophysiological recording lab. The supported students were doing rotations in the lab and brought their background from different disciplines to bear in the project. An IGERT award in the neuroscience and computational/physical science areas brought together researchers and graduate students from eight departments to work on projects that transcend disciplines."

"***Centers for Learning and Teaching (CLT)*** – The retrospective examples all represent innovative, primarily multi-institutional efforts that appear to be highly promising in terms of their impact on the development and enhancement of diversity in STEM education and research. All of these projects have

initiated the recruitment of faculty and graduate students who are involved in studies and publishable efforts that should lead to tangible and important outcomes in the near future. Nonetheless, since they are all still in the initial stages of their five-year awards, the full significance of the impact is yet to be determined."

"***Broadening Participation -*** Many NSF funded activities serve to promote science and engineering to a wide audience. For example, a TV mini-series called "*The Shape of Life*" that presented an evolution of the animal kingdom was broadcast nationwide by PBS. In the production of the program, media professionals collaborated with researchers from different universities. A summative evaluation indicated that the program was well received by many viewers. Another example involved career enhancement of high school teachers through improvement of mathematics curriculum in the Greater Philadelphia area. There are also examples of NSF providing support for teacher education. These projects resulted in two new mathematics textbooks that employed research-based teaching strategies."

Annual Performance Goal III-1b: NSF will significantly enhance the quality of K-12 mathematics and science education available to all students in Math and Science Partnership schools.

Our performance for this goal is successful when, in the aggregate, results reported for the period FY 2003 show:

- Evidence in the award portfolio of the infrastructure to support high quality programs addressing issues related to teacher workforce capacity, including preservice education and inservice professional development of math and science teachers as well as alternative routes into the profession (e.g., scientists and engineers becoming teachers.);
- Evidence within Partnership school systems of the infrastructure needed to improve math and science education and to measure improvement, i.e., the adoption of appropriate assessments of student achievement, as well as the initiation of the collection of achievement data that can be disaggregated by ethnicity, socioeconomic status, gender, etc.

✓ Goal Achieved

The Math and Science Partnership (MSP) program responds to a growing national concern: the lackluster performance of U.S. children in mathematics and science. No Child Left Behind, which enunciates the President's vision for K-12 education, articulates this concern and identifies the main underlying factors for the poor performance of U.S. students: too many teachers teaching out of field, too few students taking advanced coursework, and too few schools offering challenging curricula and textbooks.

The MSP builds on the nation's dedication to improve mathematics and science education through support of partnerships that unite the efforts of local school districts with science, mathematics, engineering and education faculties of colleges and universities and with other stakeholders. The MSP seeks to improve student outcomes in mathematics and science for all students, at all K-12 levels. As the achievement of students rises, the MSP expects to significantly reduce achievement gaps in mathematics and science education among diverse student populations.

In FY 2003, each partnership school system documented the current status of the K-12 science and mathematics curriculum, its teacher workforce, professional development needs, assessment and accountability systems, and policies. School systems collected baseline student participation and achievement data with comparisons to state and/or national averages on achievement in math and science. Higher education partners described their history in educating mathematics and science teachers and prior involvement of math and science faculty in K-12 education. Funded awards provide details of plans for increasing numbers of math and science teachers participating in professional development and for increasing involvement of math and science faculty in teacher education.

RESULT FOR PERFORMANCE GOAL III-1b: Although the AC/GPA stated that there was not enough data available to assess achievement on this goal, assessment done by NSF staff at the conclusion of FY 2003 found that significant achievement was demonstrated for both indicators associated with this goal.

Implications for the FY 2004 Performance Plan: Math and Science Partnerships will continue to be analyzed as one of the programs contributing to the People Strategic Outcome Goal and within the Program Assessment Rating Tool for Collaborations.

INDICATOR 1: Evidence in the award portfolio of the infrastructure to support high quality programs addressing issues related to teacher workforce capacity, including preservice education and inservice professional development of math and science teachers as well as alternative routes into the profession (e.g., scientists and engineers becoming teachers).

RESULT: ***Demonstrated significant achievement.***

INDICATOR 2: Evidence within Partnership school systems of the infrastructure needed to improve math and science education and to measure improvement, i.e., the adoption of appropriate assessments of student achievement, as well as the initiation of the collection of achievement data that can be disaggregated by ethnicity, socioeconomic status, gender, *etc.*

RESULT: ***Demonstrated significant achievement.***

NSF reviewed the MSP proposals, the results of the merit review process, the project strategic plans, and an analysis provided by Westat, Inc. to reach its conclusion on the achievement of the GPRA performance indicators related to the MSP program (Goal III-1b).

The following statement concerning NSF achievement with respect to the PEOPLE goal III-1b is excerpted from the IBM Business Consulting Services GPRA Performance Measurement Verification and Validation Repor[4]*t.*

"Based on our review, we verify the reliability of the processes NSF used to collect, process, maintain and report data for this goal and the analyses of the MSP proposals and strategic plans performed by NSF staff, external panels of reviewers, and Westat. We also validate that the Directorate of Education and Human Resources reached a reasonable conclusion that NSF achieved Goal III-1B based on the quality of the performance information and analyses of the MSP program results to date."

Comments by the Advisory Committee for GPRA Performance Assessment (AC/GPA)

The following statements concerning NSF achievement with respect to the PEOPLE goal III-1b are excerpted from the AC/GPA Report on NSF's PEOPLE portfolio.

"This is a new initiative for NSF with the first awards granted in fall 2002. Consequently, the portfolio is limited and materials substantiating and documenting achievement (or the lack of one) are insufficient. In its inaugural year NSF funded seven awards to Comprehensive projects. There are early indications based on the awards given last fall, that the "infrastructure to support high quality programs addressing issues related to teacher workforce capacity, including pre-service education and in-service professional development of math and science teachers as well as alternative routes into the profession" is being addressed by the funded programs. The three-year *Building Evaluation Capacity of STEM Projects* provides assistance to MSP projects and their stakeholders in designing and implementing context-sensitive, user-friendly evaluation approaches, as well as in developing and sustaining a culture of evidence that supports decision-making based on data. The MSP awarded programs are expected to

[4] Page 146 of IBMBCS Report.

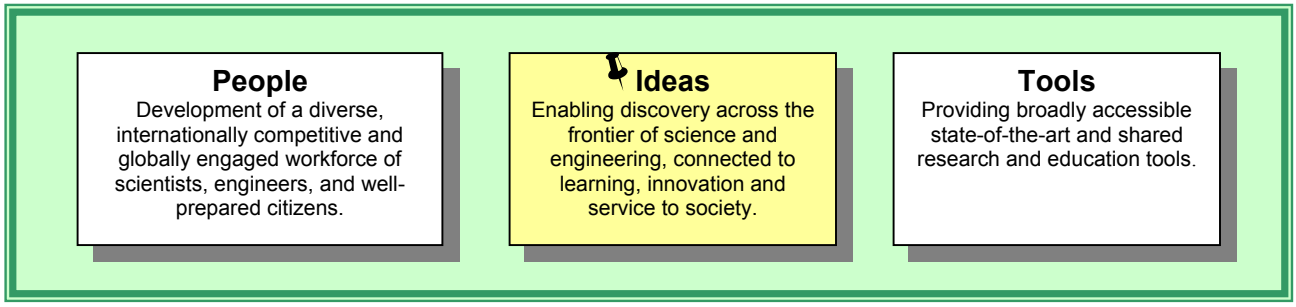
improve student success and teacher capacity and quality in science and mathematics in the future. A major component of the Math and Science Partnership program is the implementation of change in mathematics and science education practices in both higher education and in K-12, to result in improved student achievement across the K-12 continuum. Several of the funded projects aim to improve teachers' content knowledge and ability to use effective pedagogical strategies that ensure student learning."

"All of these programs have just started and there is insufficient information at this time to conclude that together they constitute a portfolio that demonstrates significant achievement."

"Program is too new. Not enough information to make a judgment. The first MSP awards were made in September 2002. Consequently, there is not enough information to determine whether there has been significant achievement for this indicator. However, the Committee notes that NSF has funded similar partnerships before and some of those partnerships are still ongoing. The Committee would have preferred to have those partnerships included in this indicator so that a more concrete assessment could have been made regarding NSF's contribution to improving the performance of K-12 students in mathematics and science. Based on the MSP awards made, however, the committee feels that attempts are being made to improve student performance and that in the future there will be information to document the level of improvement achieved."

NSF STRATEGIC OUTCOME GOALS

B. IDEAS



STRATEGIC OUTCOME GOAL III-2: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."

Annual Performance Goal III-2: Our performance is successful when, *in the aggregate*, results reported in the period FY 2003 demonstrate significant achievement in the majority of the following indicators:

- Discoveries that expand the frontiers of science, engineering, or technology;
- Connections between discoveries and their use in service to society;
- Partnerships that enable the flow of ideas among the academic, public or private sectors;
- Leadership in fostering newly developing or emerging areas.

✓ Goal Achieved

NSF invests in ideas to provide a deep and broad fundamental science and engineering knowledge base. Investments in ideas support cutting-edge research that yields new and important discoveries and promotes the development of new knowledge and techniques within and across traditional boundaries. The results of NSF-funded research and education projects provide a rich foundation for broad and useful applications of knowledge and the development of new technologies. Support in this area also promotes the education and training of the next generation of scientists and engineers by providing them with an opportunity to participate in discovery-oriented projects.

RESULT: NSF achieved this goal. External experts provided examples of significant achievement during FY 2003 reporting. Comments by the AC/GPA and examples they selected are presented for each of the performance indicators and areas of emphasis for this goal.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: This goal will be continued in FY 2004.

IDEAS: Comments by the Advisory Committee for GPRA Performance Assessment

The following statements concerning NSF achievement with respect to the Indicators and Areas of Emphasis for the IDEAS goal are excerpted from the AC/GPA Report on NSF's IDEAS portfolio. Additional comments as well as examples in support of significant achievement for each indicator are available at http://www.nsf.gov/pubs/2004/nsf04207/acgpa_report_2003.pdf

"Based on a review of extensive documentation of NSF supported research projects provided by the Committees of Visitors, the database of accomplishments assembled by NSF, project reports, and NSF budget and other information, the Committee concludes that NSF has demonstrated significant achievement in all four indicators for the Ideas Strategic Outcome Goal, *enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."* The Committee reached this conclusion based on the evaluation of the results related to the indicators (see Appendix) as well as an evaluation of priority and emphasis areas.

The results reported in this section span NSF's research directorates and are indicative of both breadth and depth in the scientific and educational communities supported by NSF. The Committee was very excited about and impressed with the research outcomes. This research holds considerable promise for expanding fundamental understanding of the origins of our universe and of humankind's long-term survivability and well-being. NSF researchers were awarded several notable prizes for their research, including a Nobel Prize for Bose-Einstein condensate work, the prestigious Japan prize for complex systems, chaos and fractals, and the Panofsky prize for experimental particle physics. In addition, NSF funded 80 percent of mathematicians who received 2003 Sloan fellowships. Such notable achievements by these researchers reflect the caliber and importance of the research that NSF supports.

Equally striking, the record of accomplishments includes considerable research directly connected to important societal concerns, including earthquake behavior, wildfire management, avalanche prediction, global climate change and its effects on society, novel insecticides from spider neurotoxins that are not toxic to humans, brain function, and preservation of historical artifacts. This research has both a currency of application and the promise of new and deeper understanding of the fundamental science that can yield future societal benefit.

The Committee is impressed with NSF's continuing endeavor to foster integration of research and education. Also noteworthy is NSF's continuing objective and recent accomplishments in increasing the participation of underrepresented groups in the sciences. These outcomes include recruiting students and providing mentoring to guide and encourage them to become active members of the scientific community. There are several excellent examples of these efforts in the Mathematical Sciences Priority Area.

The record of performance for FY 2003 is noteworthy as well for the extent of collaborations between U.S. academic researchers and a large and diverse set of partners in the public and private sectors in the U.S. as well as scientists in other countries.

NSF's achievements represent a spectrum of research modes, including single investigator projects and larger, multi-disciplinary projects involving researchers at a single institution or researchers at several institutions. It is clear from the Committee's review that NSF is actively building a research capacity to address problems at the interface of scientific disciplines and even the emergence of new fields at the frontiers of science. Examples of these efforts include initiatives in Biocomplexity in the Environment, Mathematical Sciences, and Human and Social Dynamics."

INDICATOR 1: Discoveries that expand the frontiers of science, engineering, or technology.

RESULT: ***Demonstrated significant achievement.***

"The Committee was impressed by the importance of the research findings, the degree to which the research frontiers crossed traditional disciplinary boundaries, and the breadth of discoveries. Examples include new findings in brain cell research, a Nobel prize for Bose-Einstein condensate, research uncovering order in Chaos, which led to the Japan prize, high energy physics research that resulted in the American Physical Society's prestigious Panofsky award, a multidisciplinary study on understanding earthquake behavior, cognitive science research into the creation of false memories in children, anthropological research on fertility control in China, and a sociological study of incarceration and its impact on family."

INDICATOR 2: Connections between discoveries and their use in service to society.

RESULT: ***Demonstrated significant achievement.***

"A review of the summaries clearly indicates that NSF funding has enabled researchers to collaborate and produce a broad range of research findings that will improve the quality of life for peoples of the world. The seven project summaries chosen for illustrative purposes, from a group of 104 projects, have made discoveries that provide significant service to society. These range from projects with important climate implications including glacier studies and Antarctic ice sheets, to improving the lead time for severe weather forecasts, to the development of insecticides without harmful environmental effects and the use of spider venom toxins which affect insects but not mammals, to the preservation of Alaskan native artifacts, to new insights in vocational training of metalworkers."

INDICATOR 3: Partnerships that enable the flow of ideas among the academic, public or private sectors.

RESULT: ***Demonstrated significant achievement.***

"NSF support has provided the basis for an array of partnerships that have contributed to its outcome goal of enabling discovery at the frontier of science and engineering, connected to learning, innovation, and service to society. These partnerships have influenced the content of research agendas, made possible research undertakings that would otherwise not have been possible, increased the likelihood that research findings will contribute to societal benefits in the public and private sectors, benefited from and contributed to improved international collaboration and forged closer linkages between research and education. The dominant forms of these partnerships, as illustrated by the examples below are:

- international collaboration between U.S. scientists and research institutions and scientists and research organizations in other countries;
- interdisciplinary collaboration among scientists in different fields across multiple institutions:
- collaboration between university scientists and public sector organizations that integrate basic and applied research directed at specific national, state or local government problems;
- collaboration between and among universities, government agencies and the private sector directed at integrating research and educational experiences for students."

INDICATOR 4: Leadership in fostering newly developing or emerging areas.

RESULT: ***Demonstrated significant achievement.***

"There is a broad range of developing and/or emerging activities that are taking place under NSF leadership. These research and education activities occur across and among many scientific fields. NSF uses workshops as well as centers (e.g, physics frontier centers) to bring researchers together to identify, seed, and bring coherence to important new research areas.

Emphasis Areas for GPRA Reporting

- **Balance of portfolio, including projects that are innovative, high-risk, or multidisciplinary**
- **Priority Areas: *e.g.*, Biocomplexity in the Environment, Information Technology Research, Nanoscale Science & Engineering, Life & Earth's Environment, Information Technology for the 21st Century, Knowledge & Distributed Intelligence**
- **Core research and education activities**
- **Centers, *e.g.*, STCs, ERCs, MRSECs**
- **EPSCoR**

*"**Balance of Portfolio*** – With regard to innovative, "risky", and multi-disciplinary research and education, the Committee saw evidence of accomplishment as well as continuing leadership by NSF in this area. It is reasonable to accept that some fraction of the research that NSF funds will not lead to new paradigms or transform our thinking. No obvious formula exists to guide NSF as to the fraction of the portfolio that should be multi-disciplinary (defined as research or education activities that cross traditional discipline boundaries and create synergistic interactions at those junctions). This type of research could, in many cases, be considered "high risk" since it often involves competing data, methods, theories and experimental approaches. The Committee notes that the COVs are explicitly asked to examine this issue and in most cases have concluded that the balance is appropriate. In addition, program managers continue to encourage high-risk proposals through the Small Grants for Exploratory Research (SGER) mechanism. NSF's Small Business Innovation Research Program (SBIR/STTR) is also recognized as a leader in the federal government in supporting novel research and technology with potentially high payoff. Lastly, the Committee notes that the encouraging trend continues for cross-disciplinary programs wherein multiple NSF directorates collaborate to fund a single research activity (e.g., mathematics and biology,

environmental research, cyberinfrastructure). While this can serve as a proxy for investment in high-risk, multi-disciplinary research and education, more definitive analyses of these investments is needed."

"***Biocomplexity in the Environment -*** The outcomes from this priority area demonstrate particularly promising efforts in expanding the frontiers of science, engineering and technology. Projects are highly multidisciplinary, collaborative and contain significant educational components. Examples include studies in gene regulation linked to the external environment, remote sensing in aqueous environments, and studies of the interactions between urban development and riparian ecosystems. The NSF supports new interdisciplinary research combining broad areas of biology and chemistry, engineering, mathematics, computational and information technology, and social and material sciences. The NSF's new project portfolio includes the application of novel analytical and sensing methods and instruments and large-scale studies of atmospheric and aquatic environments."

"***Information Technology Research(ITR) -*** The ITR program provides extremely effective interdisciplinary research funding with an information technology basis, with a wide and compelling variety of examples. The first example focuses on epidemiological studies enabled by information technology, the second on interfaces and interactions for "systems" constructed of biological and electronic components, and the third on novel physical methods for implementing functionality required in modern security protocols. These examples demonstrate the important interactions between fields stimulated by collaborative research in information technology. Each of these projects represents an excellent emerging opportunity and all are likely to have significant impact. Concerns exist that some proposals, although representing excellent science, may be more appropriately placed in discipline-specific existing NSF programs rather than ITR that is intended for multidisciplinary approaches. Examples might include research that is either conventional IT, or appears (at least on the surface) to have an inadequate IT component."

"***Nanoscale Science and Engineering -*** Within the confines of areas of investment and emerging opportunities for the field of Nanoscale Science and Engineering, the NSF has sought to strategically invest in research programs that provide a foundation for new technology. The range of conceivable applications is extremely broad, including improvement in pollution control, new medicine delivery modalities, ultra-miniature electronic devices, unique optical material required for photonics applications as well as the impact of these nascent technologies on society in general, Catalysis for Alternate Fuels, Cells as biological nanomachines, Electronic Devices at the Atomic and Molecular Scale: Structure and Charge, Left-Handed Materials, Philosophical and Social Dimensions of Nanoscale Research. Looking to the future, some NSF supported programs have begun to focus on new types of synthesis/symbiosis between electronic systems and biological systems, even down to the genetic level, Development, Functionalization, and Assembly of Nanoscale Biological Sensors, Ink-Jet Production of Nanostructured Matrices and Particles for Controlled Gene Delivery.

"Core Research and Education Activities -"The Committee found the collection of core research activities to be very impressive. Research areas include (but are not limited to) cosmology, quantum science and technology, cyberinfrastructure, computational sciences and environmental sciences. With few exceptions, the accomplishments and examples demonstrate important core research with significant societal value and important investments for future scientific discovery. One excellent example is a collaborative research program that introduces underrepresented minorities to leading-edge research conducted at both Hampton University and the University of Virginia. This example combines important, societally relevant research with education and diversity. Another example is a multidisciplinary research effort that addresses the important issues associated with earthquakes. In yet another example, research into insect-specific neurotoxins has the potential to lead to insecticides

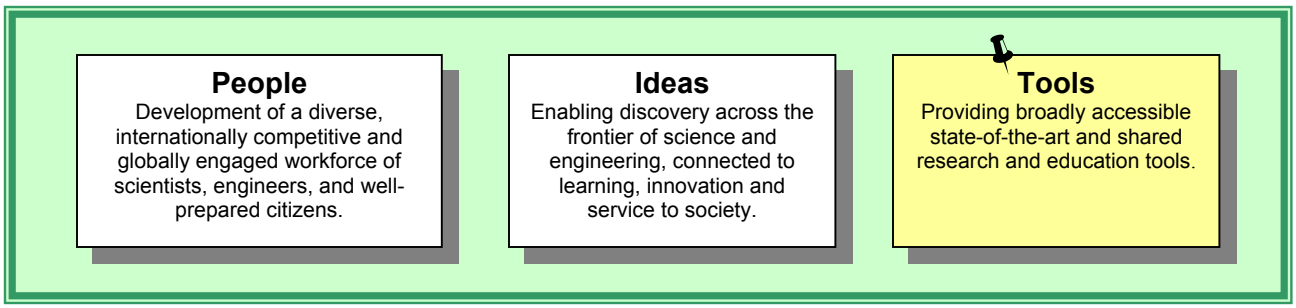
that are not harmful to humans. A new research effort illustrates NSF's leadership in cutting-edge, relevant research. This project is noteworthy because it is one of the first to offer the possibility of using a designed shape and structure formed by aggregates of special surface-active molecules to impose a desired structure onto more stable polymer materials. Finding conditions where these shapes are stable has been an important accomplishment necessary to enable practical production methods."

Centers **–** No comments from AC/GPA.

EPSCoR **–** No comments from AC/GPA.

NSF STRATEGIC OUTCOME GOALS

C. TOOLS



STRATEGIC OUTCOME GOAL III-3: Providing "broadly accessible, state-of-the-art and shared research and education tools."

Annual Performance Goal III-3: Our performance is successful when, *in the aggregate*, results reported in the period FY 2003 demonstrate significant achievement in the majority of the following indicators:

- Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure;
- Provision of broadly accessible facilities, databases or other infrastructure that are widely shared by NSF research or education communities;
- Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal.

✓ Goal Achieved

NSF invests in tools to provide widely accessible, up-to-date science and engineering infrastructure. This strategic outcome supports the parts of NSF's mission directed at (1) programs to strengthen scientific and engineering research potential and (2) an information base on science and engineering appropriate for development of national and international policy.

As emerging research opportunities increasingly involve phenomena at or beyond the limits of our measurement capabilities, many research areas can only be studied and problems solved through the use of new generations of powerful tools. NSF investments provide state-of-the-art tools for research and education, such as instrumentation and equipment, multi-user facilities, digital libraries, research resources, accelerators, telescopes, research vessels and aircraft and earthquake simulators. In addition, resources support large surveys and databases as well as computation and computing infrastructures for all fields of science and engineering research and education. Support includes funding for construction, upgrade, operations, and maintenance of facilities, and for personnel to assist scientists and engineers in conducting research and education at the facilities.

RESULT: External experts provided examples of significant achievement during FY 2003 reporting. Comments by the AC/GPA and examples they selected are presented for each of the performance indicators and areas of emphasis for this goal.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: This goal will be continued in FY 2004.

TOOLS: Comments by the Advisory Committee for GPRA Performance Assessment

The following statements concerning NSF achievement with respect to the Indicators and Areas of Emphasis for the TOOLS goal are excerpted from the AC/GPA Report on NSF's TOOLS portfolio. Additional comments as well as examples in support of significant achievement for each indicator are available at http://www.nsf.gov/pubs/2004/nsf04207/acgpa_report_2003.pdf .

"The Committee concludes that there is significant achievement in all indicators of the TOOLS strategic outcome goal.

The goal of the TOOLS portfolio is to provide broadly accessible, state-of-the art and shared facilities and infrastructure to support research and education across the Foundation. NSF provides support for large, multi-user facilities that allow researchers access to state-of-the-art facilities. Support for these unique national and global facilities is necessary to advance and maintain the U.S. capabilities as the world leader in research. NSF investments include internet-based and distributed user facilities, advanced computer resources, research networks, major research instrumentation, digital libraries, and large databases, all of which contribute to a state-of-the-art research and education infrastructure.

In reaching its overall conclusions, the Committee evaluated the TOOLS Goal Indicators, Areas of Emphasis for Investment in Emerging Opportunities, and Areas of Emphasis for GPRA Reporting. In addition to the TOOLS retrospective accomplishments and prospective examples, the Committee reviewed budget requests, COV reports and documents selected from the NSF ACGPA website, including information on awards. The combination of the documents reviewed and the Committee's collective experience provides a basis for the Committee's overall conclusions and detailed findings.

The Committee concluded that NSF made significant achievements across the entire set of TOOLS Indicators, Emerging Opportunities, and Areas of Emphasis. NSF support of research infrastructure allowed wider and more effective dissemination of data and materials, enhanced the productivity of and enabled the capacity for discovery by researchers and educators, and increasingly expanded access to and availability of resources. NSF-supported activities continue to determine a high rate of progress in many science and engineering disciplines including astronomy and Earth science. Examples of the types of new tools that support the Committee's findings include: widely-available and networked state-of-the-art instruments, World-scale digital libraries and repositories of data from unique sources ranging from many distinct spectral bands in astronomy to real-time data from integrated networks of advanced sensors on phenomena in the Earth's interior, new educational hard- and software that enables the visually impaired to engage in leading-edge research in the sciences and Internet technology that enables capacities for discovery and enhances the productivity of researchers, educators, and students in remote locations.

The Committee observed that there seemed to be a "gap" between the types of projects supported by the Major Research Equipment and Facilities Construction (MREFC) program and those supported by the Major Research Instrumentation (MRI) program. That is, instrumentation and facilities in the range of $2 million to $50 million did not seem to have an obvious "home." This range of instruments and facilities is of great importance to many disciplines and to a wide range of institutional types. Therefore, the Committee recommends that NSF give strong consideration to developing a program to support the acquisition of mid-sized instrumentation in the range of $2-$50 million.

The Committee also observed that NSF has played a large and vital leadership role in developing and providing access to research facilities. The Committee recommends that NSF consider ways in which these facilities investments can be sustained over the long-term to maximize their value to intellectual

endeavor. In this regard, NSF should continue to reassess the balance between ongoing commitments and new opportunities in the Tools portfolio."

INDICATOR 1: Development or provision of tools that enables discoveries or enhances productivity of NSF research or education communities.

RESULT: ***Demonstrated significant achievement.***

"The seven project summaries chosen for illustrative purposes from a group of more than one hundred projects show significant achievement in the several facets of this indicator: The High Performance Nuclear Magnetic Resonance Probes developed at the National High Magnetic Field Laboratory, the Arcminute Cosmology Bolometer Array Receiver and the Telemicroscopy Portal hosted by the National Partnership for Advanced Computational Infrastructure are enabling questions to be posed and discoveries to be made at the very frontiers of knowledge. The Telemicroscopy Portal, National Nanofabrication Users Network, Data Mining of the National Virtual Observatory and the project in Internet Satellite Connection to Under-served Sites support significant achievements in both discovery enabling and productivity enhancing activities by supporting wide utilization of large, centralized facilities, leading-edge instruments and databases through networked facilities. The project on Speech Assisted Learning for Braille students is a significant TOOL development in education infrastructure that enables and enhances the participation of the visually impaired in the nation's science and technology enterprise."

INDICATOR 2: Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure.

RESULT: ***Demonstrated significant achievement.***

"Partnerships with other research and funding agencies, both national and international, have become a successful and integral part of the resources and tools available to support NSF research. Through these partnerships, the reach of NSF research extends far beyond what can be accomplished through the investment of NSF resources alone. Observational, analytical and computational resources are expanded and disciplinary diversity is enhanced. In addition to expanding the infrastructure base, partnerships in the development and operation of large facilities can stimulate interactions in cross-disciplinary research and the application of new technologies in sensor design, data storage and communication.

NSF is a world leader in research and in international collaboration. In some cases, international partnerships are driven by fiscal reality (e.g. experimental facilities for high-energy physics, radio astronomy, deep sea drilling) – the projects would simply not be feasible without significant investment and cost-sharing from international partners. In other cases (e.g. oceanographic facilities, global atmospheric and geophysical networks) the global breadth of the observation systems requires multinational participation. In others, unique geographic requirements demand that the facilities be established outside the U.S., usually in partnership with the host country (e.g. high altitude telescopes, Antarctic support services).

University researchers often gain access to special purpose tools and observational systems, and participate in the development of new systems, through NSF leadership in partnership with other U.S. federal research and mission agencies. For example, experiments in high energy physics depends heavily on shared use of facilities at Department of Energy (DOE) supported national labs. Research throughout

the geosciences is carried out using facilities developed and shared with National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, United States Geological Survey, DOE and Department of Defense. NSF leadership and coordination have been especially important in the myriad of partnerships (national and international; government and private) that impact research in the area of computer science and information technology."

INDICATOR 3: Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal.

RESULT: ***Demonstrated significant achievement.***

"NSF has funded a diverse group of projects that illustrates notable approaches or new paradigms that promote progress toward the TOOLS outcome goals. Significant achievement is demonstrated in the area of software development that could lead to the generation of large databases for the analyses of genes, proteins, RNAs, small molecules, microorganisms and human resources for science and engineering. These databases will be central for the success of future NSF funded projects."

Emphasis Areas for GPRA Reporting

- **Major Research Equipment and Facilities Construction (current and former): e.g., ALMA I, LIGO, Gemini, LHC, NEES, SPSM, Terascale Computing**
- **Major Research Instrumentation (MRI) Program**
- **Science and Engineering policy analyses, information, reports and databases**
- **Scientific databases and tools for using them, including the National STEM Education digital library**

"***Major Research Equipment and Facilities Construction*** **–** NSF has demonstrated significant achievement in the MREFC program. It continues to fund major scientific facilities that provide unique environments for discovery in a range of disciplines. In fact, it is the principal funder of large-scale non-military scientific infrastructure in the nation. It funds a remarkable spectrum of activities that range from the Polar research facilities (which in turn support a diverse research portfolio, including projects in physics and environmental sciences), through an array of widely-differing scientific facilities focused on deepening and improving our fundamental understanding of the universe, to the country's premiere open high performance computing centers. "

"***Major Research Instrumentation*** – NSF has demonstrated significant achievement in the MRI program. This is an outstanding program of enormous importance to the nation's institutions of higher education. Since 1997 the MRI program has funded over 1,200 instrumentation projects at hundreds of colleges and universities."

"***Science and Engineering Policy Analyses, Information, Reports and Databases*** – NSF has demonstrated significant achievement in the funding of the development of scientific databases. In addition to supporting more traditional scientific databases, the NSF has supported the development of

some highly innovative databases (thought of in a broad sense) that are using modern sophisticated IT tools to provide new and deeper insights into widely diverse areas of research."

"***Scientific Databases and Tools for Using Them, Including the National STEM Education Digital Library –*** NSF has demonstrated significant achievement in the funding of the development of scientific databases. In addition to supporting more traditional scientific databases, the NSF has supported the development of some highly innovative databases (thought of in a broad sense) that are using modern sophisticated IT tools to provide new and deeper insights into widely diverse areas of research."

NSF MANAGEMENT GOALS

NSF MANAGEMENT GOALS

Success in achieving our outcome goals is dependent upon the award portfolio developed by our program staff. The following sections provide information on how our management shapes the award portfolio and supports our outcome goals. Management goals focus on means and strategies for successful performance – in merit review and award oversight and management processes, human capital development, and facilities oversight.

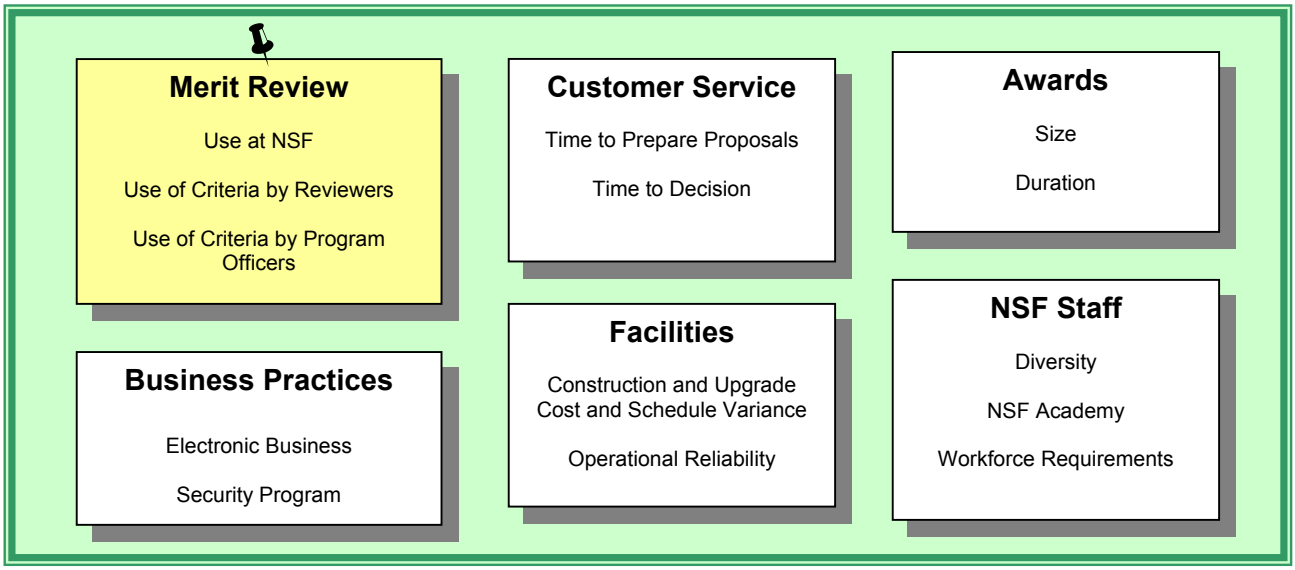
Summary of Results for Management Goals

We achieved 10 of our 16 Management Goals in FY 2003. We achieved our goals for allocation of funds to merit-reviewed projects, use of the two merit review criteria by reviewers, time for the science and engineering community to prepare proposals, the time it takes to make a decision on funding or declining a proposal, average annualized award size, electronic processing of Principal Investigator award transfers, maintenance and enhancement of the agency-wide security program, initiation of an NSF S&E diversity plan, development / revision of courses offered via the NSF Academy, and development of competency-based occupation classification alternatives.

We did not meet our Management Goals for use of the two merit review criteria by program officers, average award duration, facility construction / upgrade cost and schedule performance, operating efficiency at facilities, implementation of Phase III of the Electronic Jacket, and appointments to the NSF S&E staff from underrepresented groups.

As in FY 2002, we engaged an outside accounting firm to verify and validate performance information for our Management goals.

IBM Business Consulting Services (IBMBCS) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for all NSF Management goals on which data have been reported. They concluded that the procedures related to these goals were sufficient and adequate and yielded valid results. We provide the Executive Summary of their entire report, as well as a table listing their conclusions as to whether the processes we used were verifiable and the results valid, in the Appendix.



PROPOSAL AND AWARD PROCESSES

A. MERIT REVIEW

Merit review is the keystone to identification of the most promising People, Ideas, and Tools and is critical to fostering the highest standards of excellence and accountability – standards for which NSF is globally recognized. We evaluate proposals for research and education projects using two criteria – the intellectual merit of the proposed activity and its broader impacts.

Evaluations of proposals and funding decisions made through the process of merit review rely on evaluation by experts. Each year, more than 250,000 merit reviews are conducted to help program officers evaluate the proposals submitted for consideration.

The two NSF merit review criteria are:

What is the intellectual merit of the proposed activity?
How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of the prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

What are the broader impacts of the proposed activity?
How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

Goal IV-1 – Use of Merit Review
✓ Goal Achieved

Goal IV-1: At least 85% of basic and applied research funds will be allocated to projects that undergo merit review.

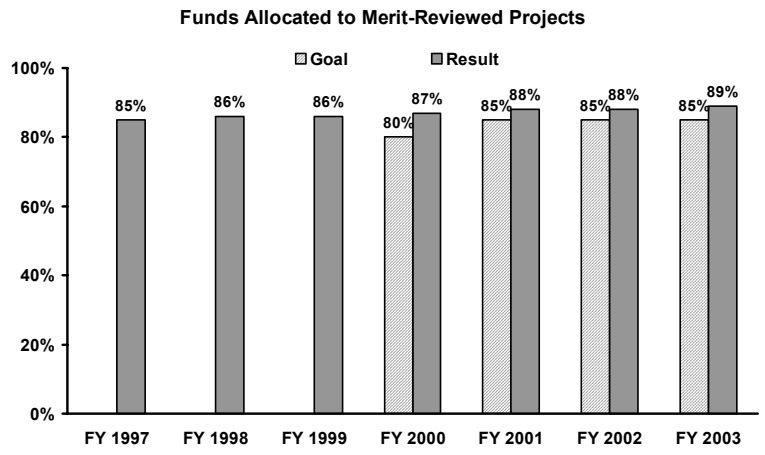
The vast majority of proposals we receive undergo external merit review. The Foundation makes a small number of exceptions to this general requirement in situations where timeliness is crucial such as for studies of volcanic eruptions or earthquakes or where objective external reviewers may be difficult to find. It also considers exceptions when researchers propose such new ideas that knowledgeable external reviewers do not exist.

As of FY 2000 NSF utilizes OMB's definition of merit-reviewed scientific research[1]. NSF has established the 85% target to be consistent with the OMB recommended range of 70% to 90%.

RESULTS: NSF successfully achieved this goal.

PERCENT OF FUNDS TO PROJECTS THAT UNDERGO MERIT REVIEW								
	FY 1997	**FY 1998**	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Baseline	85%							
Goal			N/A	80%*	85%	85%	85%	85%
Result		86%	86%	87%	88%	88%	**✓89%**	

* The 80% estimated goal, recalculated from NSF's original goal of 90%, is based on the FY 2000 OMB definition of merit-reviewed scientific research.



IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: An examination of our performance over the last six years shows that we have consistently exceeded our current goal of 85%. We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

*Goal not established for FY 1997 – FY 1998, related goal for FY 1999.

[1] *"Merit-reviewed scientific research with competitive selection and external (peer) evaluation: Intramural and extramural research programs where funded activities are competitively awarded from a pool of qualified applicants following review by a set of external scientific or technical reviewers (often called peers) for merit. The review is conducted by appropriately qualified scientists, engineers, or other technically-qualified individuals who are apart from the people or groups making the award decisions, and serves to inform the program manager or other qualified individual who makes the award."*

Goal IV-2 – Reviewer Use of Both Merit Review Criteria
✓ Goal Achieved

Goal IV-2: At least 70% of reviews with written comments will address aspects of both generic review criteria.

On September 20, 1999, NSF issued Important Notice 125, *Merit Review Criteria*, to Presidents of Universities and Colleges and Heads of other NSF Grantee Organizations. It reminded proposers of the importance of ensuring that, in addition to the criterion related to intellectual merit, the criterion relating to broader impacts be considered and addressed in the preparation and review of proposals submitted to NSF. Over the past four years, NSF has implemented a number of process enhancements to assist proposers in responding to and complying with this requirement, such as posting examples illustrating activities likely to demonstrate broader impacts on the NSF website. The requirement to address both merit review criteria is in every NSF program announcement and solicitation and reminders have been added to the Project Summary and Project Description screens in FastLane. NSF has emphasized the importance of compliance with this requirement during outreach to constituent communities, including at Regional Grants Conference.

To reinforce the importance of this requirement, NSF issued Important Notice 127 in July 2002. It specified that effective October 1, 2002, NSF would return without review proposals that do not separately address both merit review criteria within the Project Summary. This requirement is clearly stated in the relevant sections of the Grant Proposal Guide (GPG) and a Proposal Preparation Checklist has been added to the GPG to aid in assuring compliance with NSF proposal preparation guidelines.

The FastLane site that reviewers utilize to provide their reviews to NSF reminds them to address each merit review criterion and provides separate text boxes for the reviewers to use for each criterion. It requests that reviewers provide "detailed comments on the quality of this proposal with respect to **each** of the two NSF Merit Review Criteria identified below, noting specifically the proposal's strengths and weaknesses…. In addition, please provide an overall rating and **summary statement** that includes comments on the relative importance of the two criteria in assigning your rating."

RESULTS: This goal was achieved. NSF data indicates that **90%** of reviews received by NSF address both review criteria compared with the 84% response rate in FY 2002 and 69% response rate in FY 2001. In FY 2001 assessment focused on the percent of reviews that addressed only the broader impacts criterion. Based on the assumption that all reviews address the intellectual merit criterion, the 69% value shown here represents a maximum percent for proposals addressing both review criteria. In FYs 2002 and 2003, the assessment explicitly included the use of both criteria.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

Goal IV-3 – Program Officer Use of Both Merit Review Criteria
✖ Goal Not Achieved

Goal IV-3: For at least 80% of decisions to fund or decline proposals, program officers will comment on aspects of both generic review criteria.

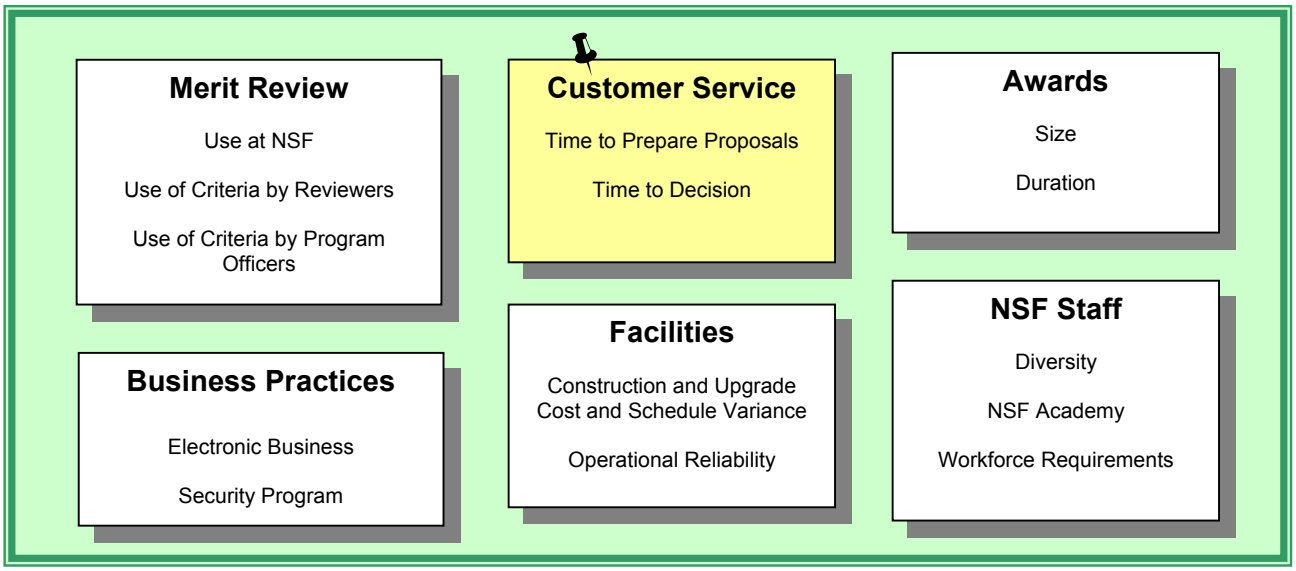
After a proposal has been subjected to external peer review, a NSF Program Officer makes a recommendation concerning support of the proposal. The matters to be discussed in this recommendation are described in our Proposal and Award Manual, Chapter VI, Section B-4. We state "*Program Officers must comment on the intellectual merit and the broader impacts of the proposed activity*."

RESULTS: NSF is not successful for this goal. During FY 2003 we examined a statistically determined sample of FY 2003 review analyses to determine the extent of Program Officer usage of both review criteria. We found, overall, that approximately **53**% of review analyses contained comments on both merit review criteria.

WHY WE DID NOT ACHIEVE THIS GOAL: There were a number of factors that contributed to NSF's failure to achieve this goal. In some cases, program officers did not address aspects of both review criteria. In other cases, the review analysis contained generic or boilerplate comments on aspects of both review criteria, rather than specific comments with respect to the particular proposal in question. Some review analyses contained only the reviewer and/or panel comments on both review criteria. In all these situations, NSF evaluated the review analysis as not meeting the goal.

STEPS WE WILL TAKE TO ACHIEVE THIS GOAL: The issue of what constitutes program officer comments on aspects of both generic review criteria will be examined and clarified.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.



PROPOSAL AND AWARD PROCESSES

B. CUSTOMER SERVICE

Customer service has a potential impact on the number and quality of proposals received and thus on our ability to meet all Outcome goals. In 1995, we adopted a set of customer service standards, primarily related to the merit review process, treating grantees and potential grantees (*applicants*) as the primary *customers* for NSF's administrative processes. In a survey, applicants valued three standards most highly: (1) clear guidelines for proposal content and preparation, (2) a minimum of three months between release of program announcements and proposal deadlines, and (3) notification of proposal funding recommendation within six months of proposal submission.

For our FY 2003 Performance Plan, we focused on the latter two of these standards, ones to which our staff have devoted special attention since the standards were adopted. The first of these standards (provision of clear guidelines) is addressed in internal processes.

Goal IV-4 – Time to Prepare Proposals
✓ Goal Achieved

Goal IV-4: Ninety-five percent of program announcements will be publicly available at least three months prior to the proposal deadline or target date.

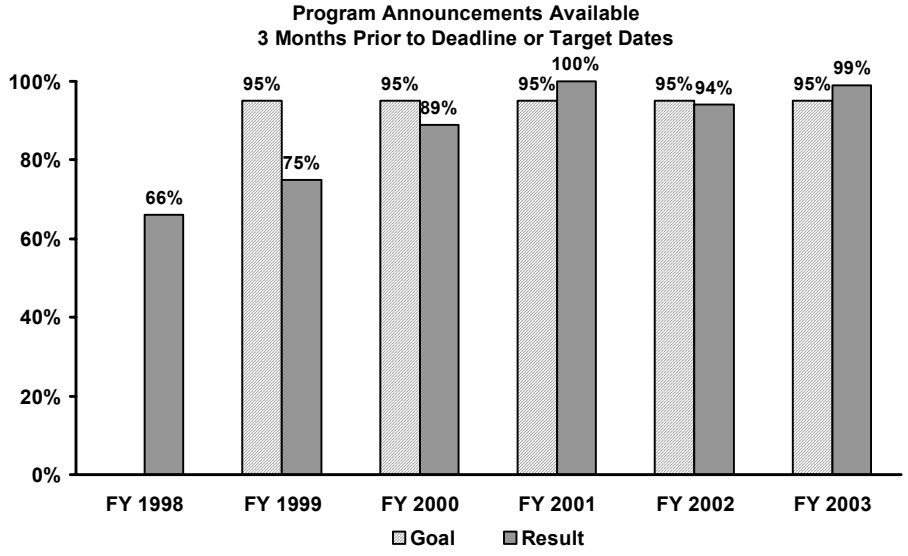
We realize that researchers and educators require sufficient time to prepare submissions. To encourage new investigators and solicit quality proposals, and based on responses to customer surveys, program announcements and solicitations should be available a minimum of 90 days prior to the deadline for submission. We define this time as the time between the posting of the announcement on the web and the deadline for proposal submission given in the web posting.

RESULTS: We were successful in achieving this goal. In FY 2003, **99%** (119 out of 120) of program announcements and solicitations were made available at least 90 days before the proposal deadline[2].

PERCENT OF PROGRAM ANNOUNCEMENTS AND SOLICITATIONS AVAILABLE AT LEAST 3 MONTHS PRIOR TO PROPOSAL DEADLINE OR TARGET DATES

	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004
Baseline	66%						
Goal		95%	95%	95%	95%	95%	95%
Actual		75%	89%	100%	94%	**✓99%**	

*No goal established for FY 1998



IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

[2] A number of continuing programs have standing or previously established deadline dates. Some of these programs reissue announcements within 90 days of a proposal due date. As long as that deadline date was previously announced, thereby providing the community with at least 90 days to prepare a proposal, the announcement is considered to be in compliance with this GPRA goal.

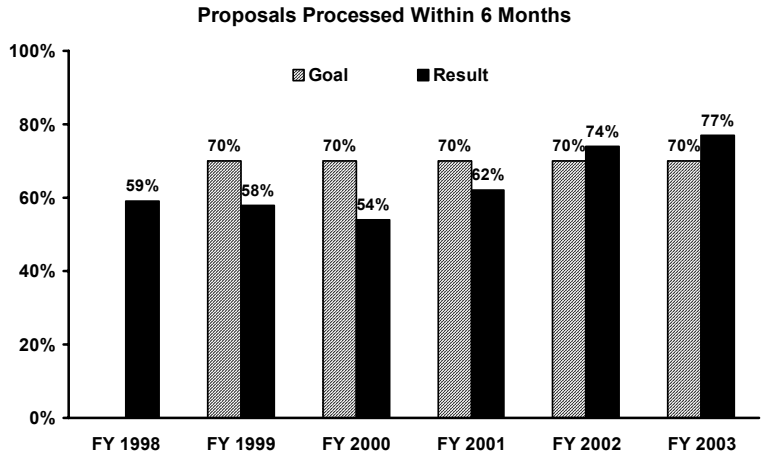
Goal IV-5 – Time to Decision
✓ Goal Achieved

Goal IV-5: For 70 percent of proposals, be able to inform applicants whether their proposals have been declined or recommended for funding within six months of receipt.

One of the most significant issues raised in customer satisfaction surveys is the amount of time it takes us to process proposals. We recognize the importance of this issue.

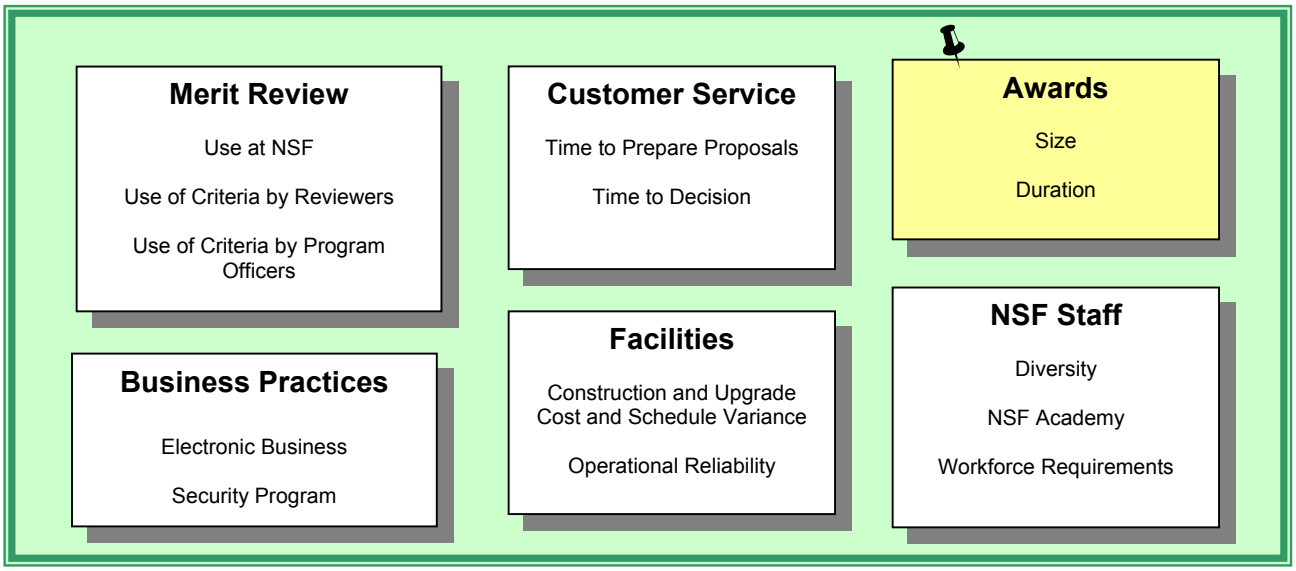
RESULTS: We were successful in achieving this goal. In FY 2003 we processed **77%** of all proposals within six months of receipt.

PERCENT OF PROPOSALS PROCESSED WITHIN 6 MONTHS OF RECEIPT								
	FY 1997	**FY 1998**	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Baseline	61%							
Goal			70%	70%	70%	70%	70%	70%
Actual		59%	58%	54%	62%	74%	**✓77%**	



In FY 2004, we will continue to focus on improving the efficiency of proposal processing.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.



AWARD PORTFOLIO

C. AWARDS

The size and duration of NSF awards impact research and education activities at many institutions. Increasing award size and duration will allow scientists and engineers to devote more time to productive research and education in comparison to the time spent preparing proposals. Adequate award size and duration are important both to obtaining high quality proposals and to ensuring that proposed work can be accomplished as planned.

Goal IV-6 – Increased Average Annualized Award Size
✓ Goal Achieved

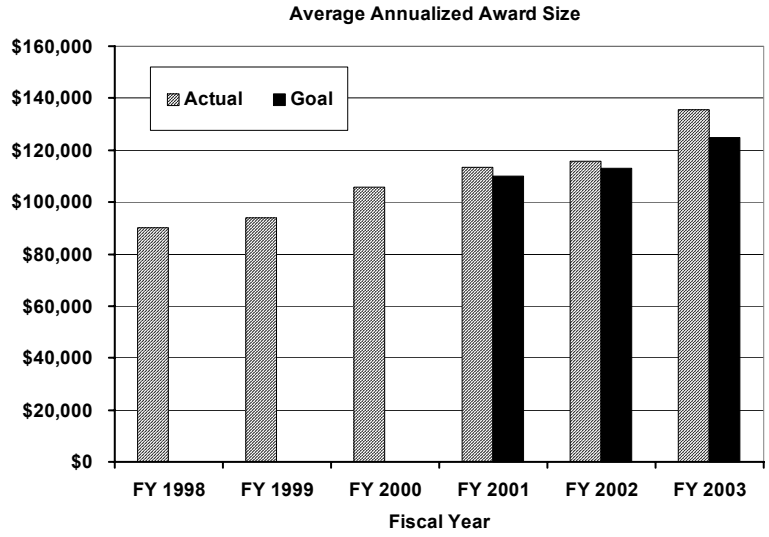
Goal IV-6: NSF will increase the average annualized award size for research grants to a level of $125,000, compared to a goal of $113,000 in FY 2002.

NSF is continuing its goal of increasing award size[3]. Our long-term goal is to reach an average annualized award size of $250,000.

Adequate award size is important both for attracting high-quality proposals and for ensuring that proposed work can be accomplished as planned. Larger awards increase the efficiency of the system by allowing scientists and engineers to devote a greater portion of their time to actual research rather than to proposal writing and other administrative work.

RESULTS: We were successful in achieving this goal.

AVERAGE ANNUALIZED AWARD SIZE FOR RESEARCH GRANTS							
	FY 1998	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Baseline	$90,000						
Goal				$110,000	$113,000	$125,000	$128,000
Actual		$94,000	$105,800	$113,601	$115,666	✓**$135,609**[4]	



IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan. Individual programs have award size targets in NSF PARTs.

[3] The award size and duration performance goals are applicable only to competitive research grants (a subset of awards that focuses on awards to individual investigators and small groups).
[4] In FY 2003 collaborative proposals submitted as individual proposals from the collaborating institutions were counted as a single proposal as NSF treats them as a single proposal for review and award/decline decisions. If such collaborative proposals are counted individually, the average annualized award size for FY 2003 is $121,380.

Goal IV-7 –Average Award Duration
✖ Goal Not Achieved

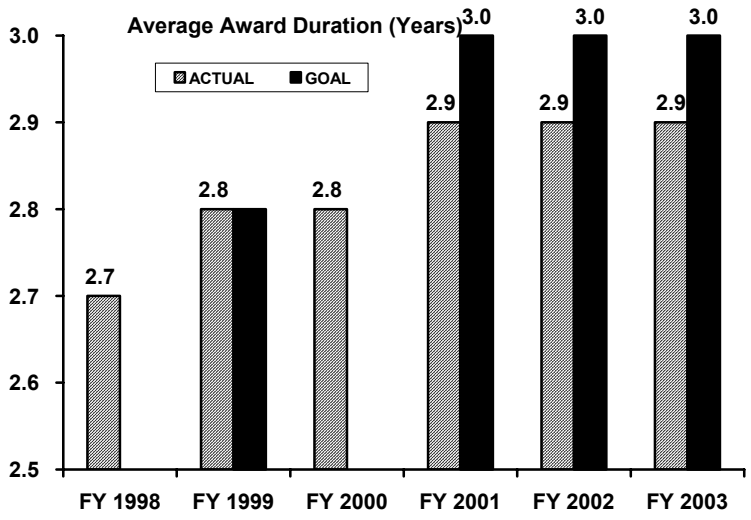
Goal IV-7: NSF will maintain the FY 2002 goal of 3.0 years for the average duration of awards for research grants.

Our long-term goal is to reach an average award duration of 5 years[5].

RESULTS: We were not successful in achieving this goal.

AVERAGE AWARD DURATION FOR RESEARCH GRANTS							
	FY 1998	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Baseline	2.7 years						
Goal		2.8 years	N/A	3.0 years	3.0 years	3.0 years	3.0 years
Actual		2.8 years	2.8 years	2.9 years	2.9 years	**×2.9 years**	

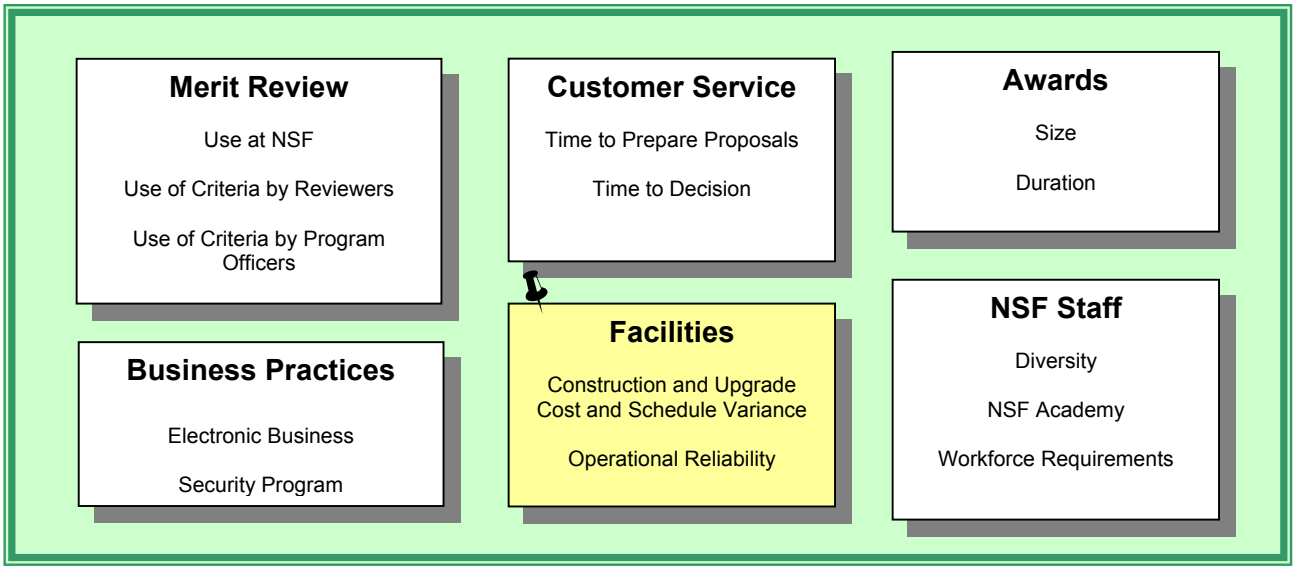
WHY WE DID NOT ACHIEVE THIS GOAL: NSF is committed to its long-term goal of increasing award duration to 5 years. Even though the Foundation was not able to reach the target for FY 2003, there is now a much higher level of awareness and appreciation of the importance of continuing to work toward the long-term goal.



STEPS WE WILL TAKE TO ACHIEVE THIS GOAL: Progress on this goal is budget dependent. Program Directors must balance competing requirements: increasing award size, increasing duration of awards, and/or making more awards. NSF will continue to focus on increasing award size and duration in order to improve the efficiency of the research process.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

[5] The award size and duration performance goals are applicable only to competitive research grants (a subset of awards that focuses on awards to individual investigators and small groups).



AWARD OVERSIGHT AND MANAGEMENT

D. FACILITIES

NSF has responsibility for supporting the operation of multiple user facilities that provide state-of-the-art equipment with unique capabilities. In addition, we put a high premium on initial planning for construction and upgrade of facilities. Planning for unique, state-of-the-art facilities must take into account the exploratory nature of the facilities themselves as such facilities test the limits of technological capability.

In FY 2003 24% of our budget was allocated to the support of "Tools." Within Tools, FY 2003 funding for the Major Research Equipment and Facilities Construction (MREFC) account was approximately $149 million, an increase of $33 million over FY 2002.

Although we have done well in the past in keeping large projects on schedule and within budget, OMB asked us to develop a plan for costing, approval, and oversight of major facility projects. In response, we have completed a Large Facility Projects Management and Oversight Plan that was submitted to OMB in September 2001. This facilities plan has four major foci:

- Enhance organizational and staff capabilities to improve coordination, collaboration, and shared learning among our staff and external partners;
- Implement comprehensive guidelines and procedures for all aspects of facilities planning, management, and oversight;
- Improve the process for reviewing and approving Large Facility Projects; and
- Practice coordinated and proactive oversight of all facility projects to ensure success.

We have established a new position–Deputy, Large Facility Projects–to enable the efficient and effective evolution of our large facility projects from pre-formulation through operations. This position was filled on a permanent basis in FY 2003.

In order to report on the performance goals related to Facility Operations and Construction and Upgrades, we initiated, in FY 1999, development of a Facilities Reporting System. This is linked to the Performance Reporting System, a module of the existing FastLane system. The module is used to collect information on operations and construction from Facilities Managers external to NSF.

In FY 2001[6] and FY 2002 NSF engaged IBM Business Consulting Services to review the process for collection and reporting of GPRA data for the facilities goals. IBM Business Consulting Services' recommendations, along with NSF's own review of the facilities goals and associated data collection methods, were further examined by NSF staff in FY 2002. As a result NSF revised its goals for facilities construction, acquisition, and upgrade to incorporate earned value management, a widely accepted technique for measuring project progress. The data collection system and procedures were revised to reflect this change.

[6] In FY 2001 the firm we engaged was Pricewaterhouse Coopers, LLP. The unit that conducted the review has been sold to IBM and is now part of IBM Business Consulting Services.

Goal IV-8 – Construction and Upgrade of Facilities
✖ Goal Not Achieved

Goal IV-8: For 90 percent of construction, acquisition and upgrade projects, keep any negative cost and schedule variances to less than 10 percent of the approved project plan.

In FY 2001 and FY 2002 NSF undertook a comprehensive internal review of the facilities goals. As of FY 2003 NSF improved the construction goals by combining cost and schedule performance into a single goal. The revised goal assesses performance based on the Earned Value technique, a widely accepted project management tool for measuring progress that recognizes that cost or schedule data alone can lead to distorted perceptions of performance.

RESULTS: We were not successful in achieving this goal. Data collected from Facilities Managers external to NSF indicate that **88%** (30 out of 34) of facilities kept any negative cost and schedule variances to less than 10 percent of the approved project plan.

WHY WE DID NOT ACHIEVE THIS GOAL: Causes of cost and schedule variances include unanticipated repairs of major equipment, vendor delays in supplying critical components and the opportunity with a small delay to acquire significantly higher computing capacity without a corresponding increase in cost.

STEPS WE WILL TAKE TO ACHIEVE THIS GOAL: NSF program staff will continue to work with project managers to identify obstacles to successful performance and to ensure that progress will be made toward the achievement of this goal in FY 2004.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan. This goal appears in NSF's Facilities PART.

Goal IV-9 – Operating Time
✖ Goal Not Achieved

Goal IV-9: For 90 percent of operational facilities, keep scheduled operating time lost to less than 10 percent.

To provide the flexibility necessary for NSF to report realistic goals, we maintained the level deemed "successful" at 90% of the facilities.

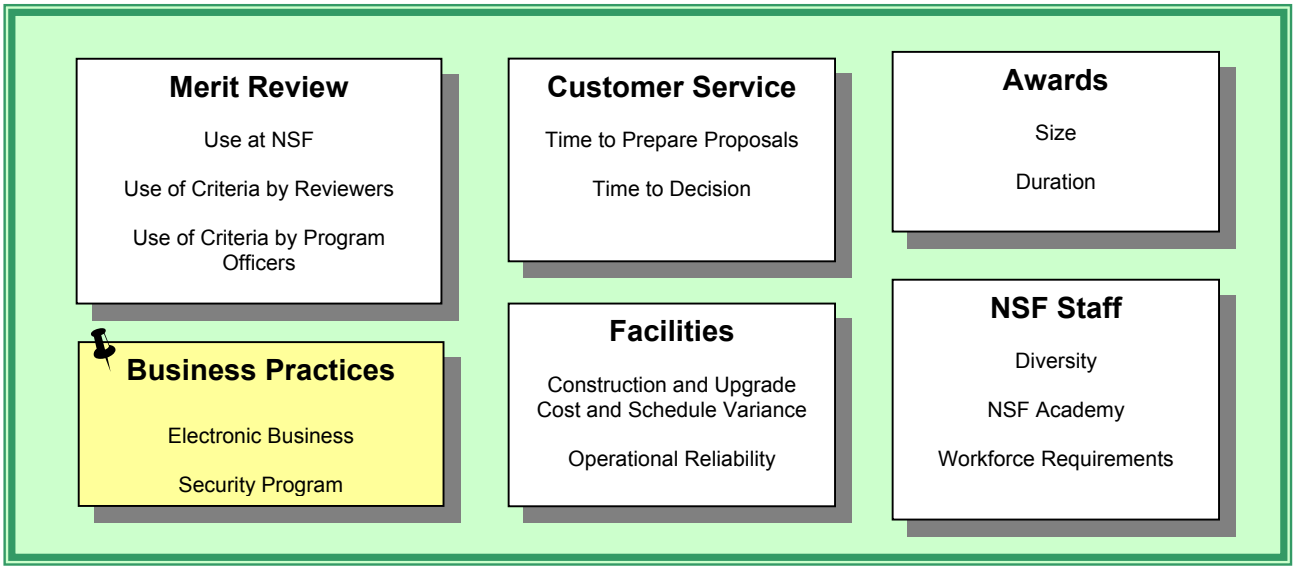
RESULTS: We were not successful in achieving this goal. Data collected from Facilities Managers external to NSF indicate that **87%** (26 out of 30) of facilities kept scheduled operating time lost to less than 10 percent.

OPERATING TIME LOST						
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Goal	Keep operating time lost due to unscheduled downtime to less than 10% of the total scheduled operating time.	Keep operating time lost due to unscheduled downtime to less than 10% of the total scheduled operating time.	For 90% of facilities, keep operating time lost due to unscheduled downtime to less than 10% of the total scheduled operating time.	For 90% of facilities, keep operating time lost due to unscheduled downtime to less than 10% of the total scheduled operating time.	For 90% of operational facilities, keep scheduled operating time lost to less than 10%.	For 90% of operational facilities, keep scheduled operating time lost to less than 10%.
Actual	Majority of facilities successful.	22 of 26 (85%) reporting facilities met goal.	25 of 29 (86%) reporting facilities met goal.	26 of 31 (84%) reporting facilities met goal.	26 of 30 (87%) reporting facilities met goal.	

WHY WE DID NOT ACHIEVE THIS GOAL: Some causes of scheduled operating time losses include repairs and maintenance exceeding expected durations and instrumentation technical performance issues exceeding anticipated levels.

STEPS WE WILL TAKE TO ACHIEVE THIS GOAL: NSF program staff will continue to work with project managers to identify obstacles to successful performance and to ensure that progress will be made toward the achievement of this goal in FY 2004.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan. This goal appears in NSF's Facilities PART.



E. BUSINESS PRACTICES

Goal IV-10 – Electronic Award Transfers

✓ Goal Achieved

Goal IV-10: NSF will continue to advance "e-business" by receiving through FastLane and processing electronically 90 percent of Principal Investigator award transfers.

This goal focuses on award transfers between organizations, a process that is initiated when a Principal Investigator moves from one institution or organization to another. The addition to FastLane of the capability to process a Principal Investigator award transfer was frequently requested by the grantee community.

RESULTS: NSF is successful for this goal. Approximately 99.8% of PI award transfers were processed electronically in FY 2003. There were 462 PI award transfers processed, and all but one was accomplished electronically.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: This goal will not be continued in FY 2004.

Goal IV-11 – Electronic Jacket
✖ Goal Not Achieved

Goal IV-11: NSF will continue to advance "e-business" by implementing Phase III of the Electronic Jacket application.

Performance Indicator: Implementation of the electronic capability for assigning proposal processing tasks, forwarding proposals to other programs as necessary, and delegating proposal action authority.

This goal focuses on development of an Electronic Jacket (eJacket). The Electronic Jacket is part of the Foundation's effort to create an integrated, paperless proposal and award-processing environment at NSF. Presently, paper "jackets" (folders) are used for retaining the official records associated with proposals and awards. As NSF moves toward processing through electronic systems, the Electronic Jacket will become the primary electronic environment for internal proposal and award processing.

The eJacket extends NSF's paperless processing environment to internal systems and works seamlessly with FastLane. Using eJacket, NSF staff can process a proposal from submission through closure, and will eventually have the ability to archive all proposals electronically. Designed by a group of NSF employees representing a large cross-section of job functions throughout NSF, the system not only displays information electronically but also integrates with other corporate applications to create a total workflow system.

The eJacket project is multi-phased. Phase I replaced the client-server version of NSF's Electronic Jacket with a web-based system that provides secure anywhere, anytime access and added the ability to transfer files, e-mails and diary notes into the eJacket. Phase II was implemented in FY 2003 and incorporated various independent, internal FastLane systems into the eJacket and permitted staff to take actions on reviews, proposals and post-award requests without leaving the eJacket system. Phase III, originally planned for implementation in FY 2003, will permit staff in program offices to process proposals electronically from submission through closure for declines; provide a fully functional, personalized "My Work" area to notify staff of proposals, reviews and reports submitted in their area; and provide the ability to share information and responsibilities with other NSF organizations. Additional phases are planned for future years.

RESULTS: NSF is not successful for this goal. Phase III capabilities were developed as planned but implementation (roll-out) was delayed to ensure staff was properly trained and ready to use the new capabilities.

WHY WE DID NOT ACHIEVE THIS GOAL: Although Phase III capabilities were developed as planned, implementation (roll-out) was delayed to ensure staff was properly trained and ready to use the new capabilities. Additional efforts for outreach and training, and testing for pilot deployments are underway to assure a smooth transition.

STEPS WE WILL TAKE TO ACHIEVE THIS GOAL: We will continue to provide staff training and will implement Phase III of the eJacket in FY 2004.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: This goal will not be continued in FY 2004.

Goal IV-12 – IT Security
✓ Goal Achieved

Goal IV-12: NSF will maintain and enhance the agency-wide security program to ensure adequate protection of NSF's IT infrastructure and critical assets.

Performance Indicators:

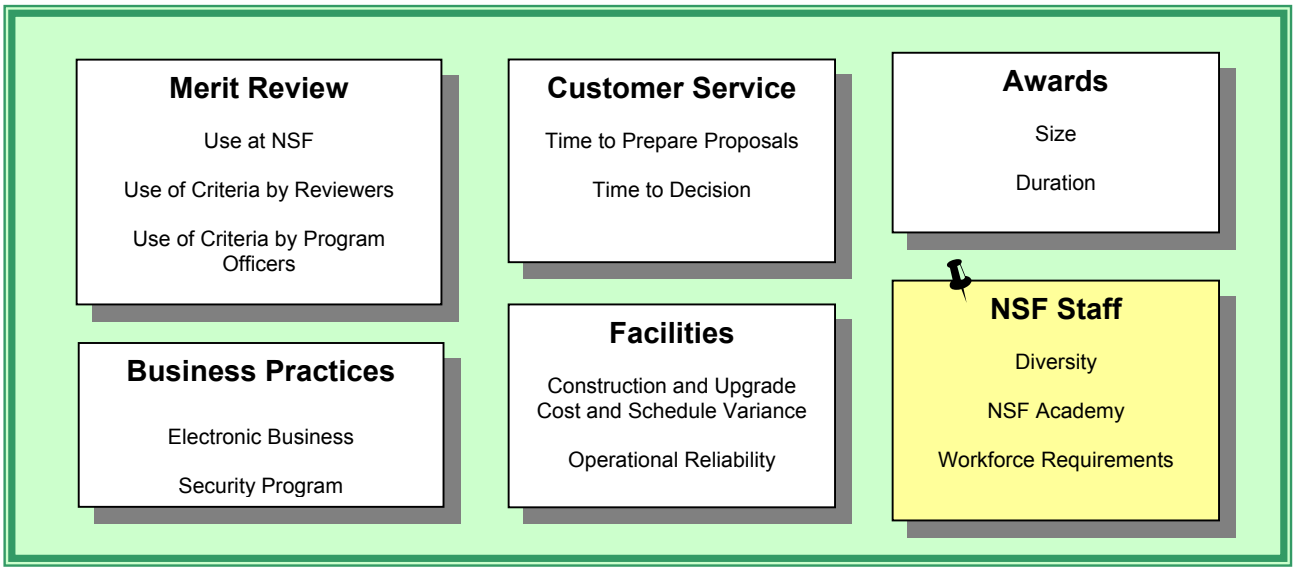
- **95 percent of major systems will have approved security plans on file.**
- **95 percent of major systems will have documented certification and accreditation.**

NSF added an Information technology security goal in FY 2002 and continues this emphasis in FY 2003, in-line with requirements mandated by the Government Information Security Reform Act (Security Act or GISRA). The Security Act addresses program management and evaluation aspects of security, and was designed to ensure proper management and security for the information resources supporting Federal operations and assets.

NSF's information security (IS) program encompasses all aspects of information security, including policy and procedures, risk assessments, self-assessments and security plans; incident prevention, detection and response; infrastructure security component audits and penetration tests; and training and education. NSF's Security Program focuses on assuring that the NSF infrastructure and critical assets are appropriately protected while maintaining an open and collaborative environment for scientific research and discovery.

RESULTS: NSF is successful for this goal. As planned, security plans have been developed and approved for 95% of major systems. Ninety-five percent of these systems have been certified and accredited. The United States Antarctic Polar Program is the custodian of the remaining system that requires certification and accreditation.

IMPLICATIONS FOR FY 2004 PERFORMANCE PLAN: Information security is an on-going effort reported through various means (e.g. Federal Information Systems Management Act (FISMA) reports and the Electronic Government scorecard in the President's Management Agenda). We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.



F. HUMAN RESOURCES AND WORKPLACE

Goal IV-13 – Staff Diversity
✓ Goal Achieved

Goal IV-13: NSF will ensure that diversity considerations are embedded in activities related to agency staffing of scientists and engineers.

Performance Indicator: Initiate development of a NSF S&E diversity plan.

NSF recognizes that a diverse workforce – e.g., one that includes members of underrepresented groups and reflects institutional and geographic differences – broadens the agency outlook and talent base and enables it to better serve both its research and education communities and ultimately all citizens.

RESULTS: We were successful in achieving this goal. A multi-disciplinary team of employees from various levels in the organization was established and began development of the NSF S&E Diversity plan. Demographic data from FY 1998 through FY 2002 was compiled for each Directorate and Division and for NSF in total to help determine appropriate diversity goals. Data were also collected on the geographic and institutional diversity of NSF IPAs and VSEEs where available. Findings from the NSF Business Analysis and Human Capital Planning Team were also used to inform strategies for recruiting, developing and retaining a diverse staff. Strategies and Action Plans were incorporated into the Human Capital Management Plan to further integrate diversity considerations into NSF's human capital management.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

Goal IV-14 – Staff Diversity – Staff Appointments
✖ Goal Not Achieved

Goal IV-14: NSF will show an increase over FY 2000 in the total number of appointments to NSF science and engineering staff and management from underrepresented groups.

The NSF Strategic Plan notes that a diverse, capable, and motivated staff is one of the critical factors for our success. We are committed to diversifying our staff of scientists and engineers (S&E) in both permanent and visiting positions.

RESULTS: NSF is not successful for this goal. While we achieved the goal with respect to the hiring of women, we did not with respect to the number of minorities hired. FY 2003 results were identical to the FY 2000 baseline for minority hires.

In FY 2003 we have expanded the scope of our goal to include additional S&E positions in the agency. Broadening the positions included in this measure allows us to assess our efforts throughout all professional recruitment opportunities, including executive hiring. The baseline to be used will be total S&E hires from underrepresented groups in FY 2000.

APPOINTMENTS TO SCIENCE & ENGINEERING POSITIONS FROM UNDERREPRESENTED GROUPS						
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Goal	Efforts to attract underrepresented groups	More than 16 Female, 15 Minority	More than 16 Female, 15 Minority	More than 35 Female, 19 Minority	More than 46 Female, 25 Minority	More than 46 Female, 25 Minority
Actual	Achieved[7]	35 Female 19 Minority	38 Female 22 Minority	41 Female 27 Minority	48 Female 25 Minority	

WHY WE DID NOT ACHIEVE THIS GOAL: While we continue to focus on the hiring of female and minority science and engineering staff, we were not able to attain our goal, due in part to the revised, more comprehensive goal that was implemented this year.

STEPS WE WILL TAKE TO ACHIEVE THIS GOAL: For FY 2004 additional emphasis will be placed on the hiring of female and minority employees. An additional staff member will be hired to specifically address diversity issues. In addition, the Diversity Plan, which is under development, will help provide strategies for recruiting and retaining a diverse staff.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

[7] In FY 1999, our goal was "In FY 1999, as all appointments for scientists and engineers are considered, the recruiting organization will demonstrate efforts to attract applications from groups that are underrepresented in the science and engineering staff as compared to their representation among Ph.D. holders in their fields."

Goal IV-15 – Workforce Learning
✓ Goal Achieved

Goal IV-15: NSF will align or develop competency-based curricula, through the NSF Academy, that provide cross-functional, work-based team learning opportunities.

> **Performance Indicator: Initiate development of new courses or revision of existing courses to address program management, leadership development, and technology and business process training.**

This goal reflects the Foundation's commitment to cultivate a world-class staff to sustain the level of excellence required to fulfill the NSF mission.

Originally conceived in September 2000, the Academy is evolving in incremental steps. Consolidation of training functions commenced in FY 2001, initial seed money was provided in FY 2002, and additional funding was provided for FY 2003 to initiate a broader curriculum and expanded programs. Once fully operational, the Academy will serve as the central locus of learning, and provide continual learning opportunities for NSF staff. Development of new and revised courses reflected the needs and requirements of NSF staff.

RESULTS: NSF is successful for this goal. Twenty-four new courses were developed and twenty-six existing courses revised to address the areas in the indicator statement. E-learning, classroom training and satellite broadcasts were methodologies utilized to provide training. In addition, a Certificate program in Project Management, in partnership with George Washington University, was also initiated.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

Goal IV-16 – Workforce Planning
✓ Goal Achieved

Goal IV-16: NSF will develop competency-based, occupation classification alternatives that support the agency's strategic business processes and capitalize on its technology enabled business systems.

Performance Indicators:

- **Identification of workforce competencies for all current NSF job families.**
- **Initiate identification of competency-based, classification alternatives.**

NSF requires a multi-year strategic business analysis effort to assess its core business processes and supporting human capital and technology requirements in order to prepare for anticipated budget growth and an accompanying increase in the complexity of the NSF portfolio and to address new and existing management challenges presented by the President's Management Agenda and identified by NSF, the NSF Inspector General, the General Accounting Office, and others.

RESULTS: Job families and their corresponding competency models have been identified for all of NSF's core functions and support functions. The NSF Human Capital Plan outlines strategies and lays out action plans to develop a more uniform occupation classification system. The competency based classification system will be the basis for recruitment, selection, and development of NSF employees as well as succession planning and workforce planning initiatives at NSF.

IMPLICATIONS FOR THE FY 2004 PERFORMANCE PLAN: We are currently reviewing our 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations and NSF's new strategic plan.

OTHER INFORMATION

V. ASSESSMENT AND EVALUATION PROCESS

We employ a mix of both qualitative and quantitative goals, and make use of both qualitative information and quantitative data in determining annual progress towards achieving goals. Our strategic outcome goals are generally expressed in a qualitative form, and most management goals are quantitative.

STRATEGIC OUTCOME GOALS

We have traditionally made use of various types of assessments and evaluations to monitor non-quantitative research and education outcomes, the quality of our investments, and the processes we use. Formalized examination takes place during merit review of proposals, COV and AC/GPA assessments, and GPRA reporting. Additionally, programs and plans are assessed and evaluated throughout the year on a continuing basis by NSF staff. Elements of GPRA reporting are highlighted in the figure below.

MANAGEMENT GOALS

We make use of internal data systems to monitor and report progress in achieving the quantitative management goals. For these goals, performance results are assessed and reviewed by our administrative staff and managers, with selected goals audited by external third parties. Selected results are verified and validated by a third party.

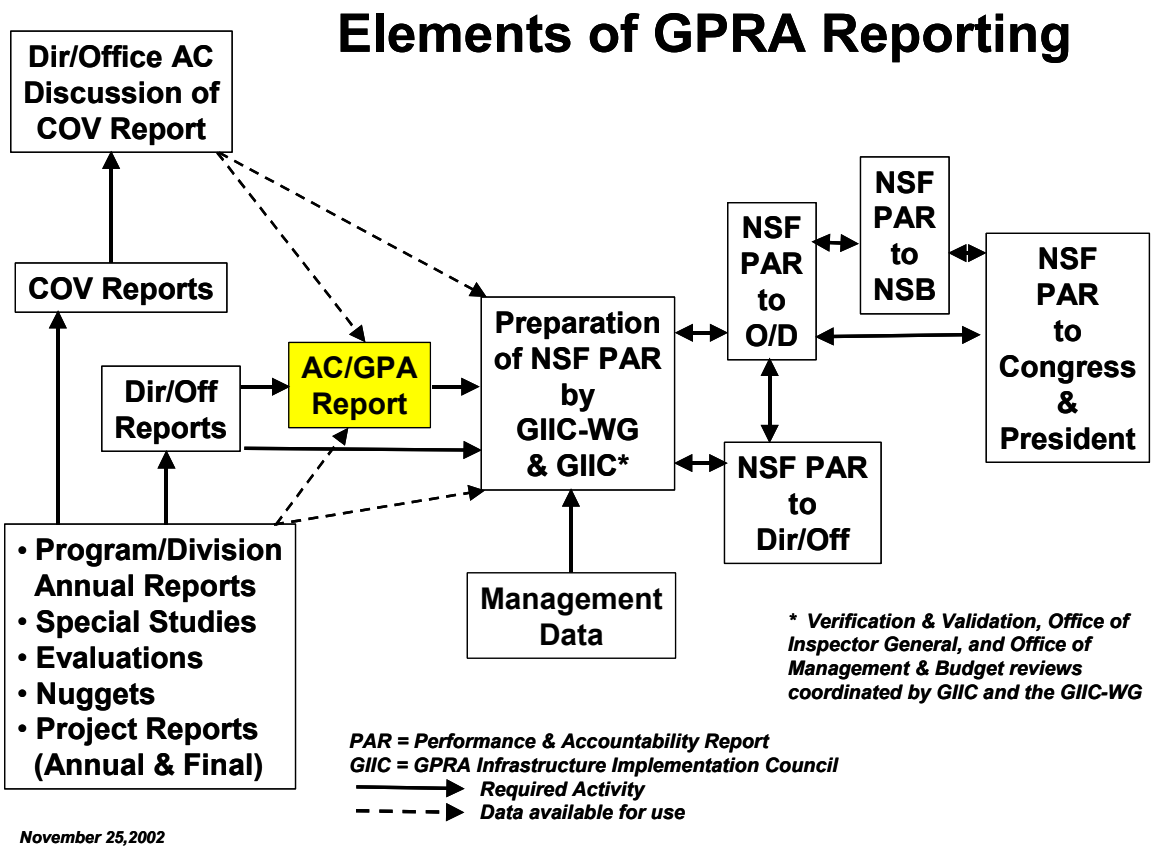
The assessment process for the quantitative goals is straightforward. We collect relevant data using internal corporate data systems and compare the result with the performance level targeted for the fiscal year. Progress towards achievement of most quantitative goals is reviewed by senior management on a quarterly basis. In FY 2000, an agency-wide GPRA module that collects data relevant to the quantitative goals was created to allow staff to track progress throughout the year. Development of that module continues.

Project Assessment During NSF Merit Review

Applicants and grantees provide results from previous NSF support, information about existing facilities and equipment available to conduct the proposed activity, biographical information on the Principal Investigators, other sources of support, federally required certifications and certifications specific to NSF. Such information is required at the time of application, at the time of an award, and in annual and final project reports. It is reviewed by NSF staff, is utilized during merit review, and is available to external committees (COVs and the AC/GPA) conducting performance assessment. The merit review process provides a rigorous, first phase of assessment of NSF's research and education portfolio. Thus, at the onset, this process selects for support only the most competitive one-third of proposals submitted for consideration.

Program Officers review the annual progress of awards. The progress report includes information on significant accomplishments, on progress achieved in the prior year, and on plans for the next year, and points out issues that may impact progress or completion of the project on schedule and within budget. On approval of this report by the Program Officer, NSF releases funds for the ensuing year.

All materials associated with the review of a proposal as well as subsequent annual reports are available to Committees of Visitors. NSF staff also prepares materials (reports, evaluations, highlights) for use by COVs and the AC/GPA in developing their reports and making their assessments.



Program Assessment by Committees of Visitors (COVs)

NSF's Committees of Visitors provide program assessments that are used both in program management and in annual GPRA reporting.

Each COV typically consists of five to twenty external experts who review one or more programs over a two or three day period. These experts are selected to ensure independence, programmatic coverage, and balanced representation. They typically represent academia, industry, government, and the public sector.

All COVs are asked to complete a report template with questions addressing how programs contribute to NSF's goals. Committees of Visitors are asked to address (A) the integrity and efficiency of the *processes* involved in proposal review; and (B) the results, including quality and other factors, of NSF's investments.

The FY 2003 COVs were asked to comment on program activities as they relate to NSF's strategic outcome goals. COVs are asked to justify their judgements and provide supporting examples or statements.

COVs are subcommittees of NSF Directorate Advisory Committees. As such, their reports, along with responses from the responsible Directorate addressing recommendations made by the COVs, are submitted to the parent Advisory Committee. NSF staff also reviews the reports.

Advisory Committee (AC) Reporting on Directorate/Office Performance

Advisory Committees advise the seven directorates and the Office of Polar Programs. They are typically composed of 18-25 external experts who have broad experience in academia, industry, and government. Advisory Committees are chartered and hence are subject to Federal Advisory Committee Act (FACA) rules. The role of the ACs is to provide advice on priorities, address program effectiveness, and review COV reports and directorate responses to COV recommendations.

In FY 2001 and previous years, directorate advisory committees assessed directorate progress in achieving NSF-wide GPRA goals. With the advent of the AC/GPA (see below), advisory committees no longer assess directorate progress towards these goals.

Advisory Committee for GPRA Performance Assessment (AC/GPA)

During FY 2002 NSF determined that a more effective and efficient process for the assessment of NSF performance with respect to the strategic outcome goals was to have a single external committee of experts review all Foundation accomplishments with respect to strategic goal indicators and areas of emphasis. This committee would then provide an assessment of NSF-wide performance with respect to these strategic goal indicators.

A request to create such an advisory committee, named the Advisory Committee for GPRA Performance Assessment (AC/GPA), was approved in the summer of 2002. Its first meeting was held in September. A second meeting, to assess FY 2003 achievement with respect to Outcome Goals, was held near the end of June 2003. The AC/GPA had access to information provided by each of the NSF Directorates and the Office of Polar Programs. It also had access to COV reports. The AC/GPA provided NSF with a report concerning NSF performance with respect to the indicators of each strategic goal. The report also discussed NSF areas of emphasis, priority areas, the quality of the NSF portfolio, balance within the portfolio, and other topics.

The Committee was given access to an extensive collection of information via a secure Website approximately two months prior to the meeting. Information made available to the Committee in this manner included, but was not limited to: brief descriptions ("nuggets") of judgmentally-sampled NSF-supported project outcomes and examples for FY 2003; all electronic Project Reports on NSF-funded awards submitted by Principal Investigators; Committee of Visitor (COV), Directorate and Advisory Committee reports of program assessments conducted by external programmatic expert panels that are routinely used by NSF program management; and other materials. The FY 2002 Committee's "*Report of the Advisory Committee for GPRA Performance Assessment*" was available for their use on NSF's website[1].

Agency GPRA Reporting

The COV and AC/GPA reports prepared by external experts address a broad set of issues ranging from staffing and quality of merit review to specifics of a scientific project. The GPRA components of these reports are used in assessing NSF's progress toward achieving its People, Ideas, and Tools outcome goals (Goals III-1a, III-1b, III-2 and III-3.).

The criterion for success for each of the People (III-1a), Ideas, and Tools annual performance goals can be stated:

[1] *www.nsf.gov/od/gpra/reports/transmittal_letter.doc*

"NSF is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the [associated indicators]."

This criterion is utilized for judgements about agency success for GPRA People-Ideas-Tools outcome goals. The agency decision for NSF is based on analysis of the statements contained within the AC/GPA and the COV reports.

NSF staff examines statements of significant accomplishment included in COV and the AC/GPA reports to ensure that ratings for the qualitative outcome goals and indicators are justified. In addition, they check for supporting evidence or examples sujpporting such judgements.

Principal factors contributing to NSF's decision that the agency is successful in FY 2003 for annual performance outcome goals III-1a, III-2, and III-3 related to People, Ideas, and Tools include:

1. The AC/GPA report that found that:
   - NSF indicator portfolios documented "significant achievement" with respect to all indicators for annual performance outcome goals III-1a, III-2, and III-3.
   - The extensive number and quality of retrospective examples demonstrating significant achievement for the 12 indicators associated with NSF's three outcome goals.
2. The NSF COV reports available as of June 30, 2003.

With respect to Goal III-1b, involving activities associated with the Math and Science Partnership, the AC/GPA determined that because of the relative newness of the program there was not enough data available in June 2003 for them to determine whether the two indicators associated with this goal had been achieved. However, assessment done by NSF staff, including information provided by an external group (Westat, Inc.), at the conclusion of FY 2003 found that significant achievement was demonstrated for both indicators associated with this annual program goal. This was a factor contributing to NSF's decision that the agency is successful in FY 2003 for annual performance outcome goal III-1b.

In previous years, selected goals were verified and validated (V&V) by external third parties. For the FY 2003 Performance and Accountability Report, **all goals**, both strategic outcome and management, were verified and validated by external third parties. The V&V process and this year's results are discussed in Section VI of this Performance and Accountability Report.

VI. Verification and Validation (V&V)

The Foundation has both qualitative and quantitative GPRA goals. Its qualitative goals include annual performance goals that support the three broad strategic outcome goals related to People, Ideas, and Tools. The outcome goals are presented in a format that requires qualitative assessment of achievement. These assessments are based largely on information included in reports prepared by committees of independent, external experts (e.g. Committees of Visitors and the Advisory Committee for GPRA Performance Assessment) who assess the quality of program results based on their collective experience-based norms. NSF's quantitative goals focus on management activities, with the majority presented in a format that enables quantitative assessment of progress toward goal achievement. Assessment for these goals is based on data collected with NSF's central data systems.

QUALITY OF REPORTED PERFORMANCE INFORMATION

NSF recognizes the ongoing need to improve data systems for collecting performance information and data. We view the improvement of the quality of data and data systems as an evolutionary process and intend to maintain it as a priority as budget and time allow. Implementing GPRA has enabled NSF to gather information in a structured way and to address issues in a more formal, focused manner than in the past[1].

In their October 2003 report[2] IBM Business Consulting Services (IBMBCS) addressed system aspects of NSF data quality for the Awards system, Enterprise Information System, Financial Accounting System, FastLane, Integrated Personnel System, and the Proposal, Principal Investigator (PI), and Reviewer System. IBM Business Consulting Services "*We reviewed NSF's information systems to evaluate the controls that are in place to produce reliable data. The control techniques presented in the table below are based on interviews with NSF managers and staff—rather than a full application review. Pursuant to GAO's assessment guide, we relied on previously conducted work and on departmental sources to determine whether there were any known problems with the data sources or the data itself that would cast doubt on the credibility of the information. It is important to note that we evaluated the same systems that were in place last year, and this year focused on any changes to the systems. In some instances, departmental sources clarified points from last year, which are documented in the Application Controls Matrix on the next page.*"

DATA V&V ACTIVITIES

We used a V&V process similar to the one used in FY 2002 to verify and validate selected FY 2003 GPRA performance information. In FY 2000 and FY 2001, we engaged an external third party, (PricewaterhouseCoopers LLP (PwC)), to verify and validate selected GPRA performance results as well as the process through which supporting data was compiled. The business unit within PwC responsible for this type of activity was sold to IBM in 2002 and is part of IBM Business Consulting Services (IBMBCS). For FY 2003 data verification and analyses, we engaged IBMBCS to document the processes we follow to collect, process, maintain, and report selected performance data. They identified relevant controls and commented on their effectiveness. Based on General Accounting Office (GAO) guidance, they provided an assessment of the validity and verifiability of the data, policies, and procedures we used to report results for the FY 2003 goals. For the outcome goals, IBM Business Consulting Services reviewed the processes NSF used to obtain external assessment of NSF activities with respect to these

[1] GPRA data quality was a management challenge cited by the OIG in FY 2002.
[2] Page 88 of the IBMBCS report.

goals. IBM Business Consulting Services also provided high-level review of NSF's information systems based on GAO standards for application controls[3].

In their October 2003 report[4], IBM Business Consulting Services states: "*From our FY 2003 review, we conclude that NSF has made a concerted effort to assure that it reports its performance results accurately and has effective systems, policies, and procedures to promote data quality. Overall, we verify that NSF relies on sound business practices, internal controls, and manual checks of system queries to report performance. NSF maintains adequate documentation of its processes and data to allow for an effective verification and validation review. Further, we validate the reliability of NSF's third and fourth quarter results through our successful recalculation or reconfirmation of these results based on processes, data and systems.*"

TYPES AND SOURCES OF PERFORMANCE DATA AND INFORMATION

Most of the data that underlie achievement assessments for strategic outcome goals originate outside the agency and are submitted to us through the Project Reporting System, which includes annual and final project reports for all awards. Through this system, performance information/data such as the following are available to program staff, third party evaluators, and other external committees:

- Information on People – student, teacher and faculty participants in NSF activities; demographics of participants; descriptions of student involvement; education and outreach activities under grants; demographics of science and engineering students and workforce; numbers and quality of educational models, products and practices used/developed; number and quality of teachers trained; and student outcomes including enrollments in mathematics and science courses, retention, achievement, and science and mathematics degrees received;
- Information on Ideas – published and disseminated results, including journal publications, books, software, audio or video products created; contributions within and across disciplines; organizations of participants and collaborators (including collaborations with industry); contributions to other disciplines, infrastructure, and beyond science and engineering; use beyond the research group of specific products, instruments, and equipment resulting from NSF awards; and role of NSF-sponsored activities in stimulating innovation and policy development; and
- Information on Tools – published and disseminated results; new tools and technologies, multidisciplinary databases; software, newly-developed instrumentation, and other inventions; data, samples, specimens, germ lines, and related products of awards placed in shared repositories; facilities construction and upgrade costs and schedules; and operating efficiency of shared-use facilities.

Most of the data supporting management goals can be found in NSF's central systems. These central systems include the Enterprise Information System (EIS); FastLane, with its Performance Reporting System and its Facilities Performance Reporting System; the Online Document System (ODS); the Proposal, PI, and Reviewer System (PARS); the Awards System; the Electronic Jacket; and the Financial Accounting System (FAS). These systems are subject to regular checks for accuracy and reliability.

The Division of Human Resources Management/Office of Information and Resource Management (HRM/OIRM) maintains information related to staff recruitment and staff training, under the guidance of the Chief Information Officer. The Office of Equal Opportunity Programs (OEOP) databases are also available for reporting purposes.

[3] An executive summary of the IBMBCS report is provided in the Appendix of this Chapter.
[4] Page 1 of the IBMBCS report.

Data / Information Limitations

For outcome goals, the collection of qualitative data during assessment may be influenced by factors such as a lack of long-term data/information to assess the impact of outcomes, the potential for self-reporting bias, the unpredictable nature of discoveries, and the timing of research and education activities. For the quantitative management goals, the assessment may be influenced by factors such as accuracy of data entry into central computer systems, lack of experience in using new reporting systems or modules, or individual non-responsiveness (e.g., self-reporting of diversity information; workplace surveys).

Finally, external expert assessments (presented in COV and AC/GPA reports) may lack sufficient justification or may provide incomplete information. To address this issue NSF is continuing to modify its reporting templates and improve guidance to committees and staff in order to improve the completeness and consistency of the reports. This will aid in compiling qualitative information. Additionally, we have focused on clarifying language in goal and indicator statements.

Judgmental Sampling

With respect to NSF's four annual performance outcome goals, since it is impractical for an external committee to review the contributions to the associated performance goals by each of the over 20,000 active awards, NSF Program Officers provided the Committee with about 800 summaries of notable results relevant to the performance indicators. The Committee also had access to recent Committee of Visitor (COV) reports of program assessments conducted by external programmatic expert panels that are routinely used by NSF program management.

Collections obtained from expert sampling of outstanding accomplishments and examples ("nuggets") from awards, together with COV reports, formed the primary basis for determining, through the recommendations of the external Advisory Committee for GPRA Performance Assessment, whether or not NSF demonstrated significant accomplishments in its FY 2002 GPRA Strategic Outcome Goals for People, Ideas and Tools. The approach to nugget collection is a type of non-probabilistic sampling, commonly referred to as "judgmental" or "purposeful" sampling, that is best designed to identify notable examples and outcomes resulting from NSF's investments. It is the aggregate of collections of notable examples and outcomes that can, by themselves, demonstrate significant agency-wide achievement in the Strategic Outcome Goals.

In their October 2003 report[5], IBM Business Consulting Services states: "*We also note that prior to the AC/GPA meeting and in response to a FY 2002 AC/GPA recommendation, NSF discussed the issue of nugget sampling with senior management and staff with expertise in statistics. Ultimately, NSF determined that judgmental sampling was appropriate given the nature of the AC/GPA's qualitative review. During the AC/GPA meeting, a number of committee members expressed satisfaction with the nugget sampling technique, especially given the availability of other types of performance information. Some committee members noted that their subcommittees went far beyond the nuggets in making their judgments. We concur with this assessment."* Additional comments from IBM Business Consulting Services can be found in the Appendix to this Chapter.

[5] Page 123 of the IBMBCS report.

VII. TRANSITION FROM FY 2003 TO FY 2004

This section compares goals contained in the FY 2003 Revised Final GPRA Performance Plan with those contained in the FY 2004 GPRA Final Performance Plan. Note that NSF is evaluating the FY 2004 Performance Plan based upon Program Assessment Rating Tool (PART) evaluations, results from a recent survey of NSF applicants, and suggestions to focus management goals on the ones most critical to the NSF mission. Significant changes between the FY 2003 Goals and the current FY 2004 goals are discussed. Minor wording revisions that were made to clarify goals are not included.

Strategic Outcome Goal	FY 2003 Goal (Revised Final Plan)	FY 2004 Goal (Final Plan)	Explanation of Change
PEOPLE – Developing "a diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens."	*III-1a: NSF's performance for the People Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators:* Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future; Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities; Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal. III-1b: NSF will significantly enhance the quality of K-12 mathematics and science education available to all students in Math and Science Partnership schools. Performance Indicators: Evidence in the award portfolio of the infrastructure to support high quality programs addressing issues related to teacher workforce capacity, including preservice education and inservice professional development of math and science teachers as well as alternative routes into the profession (e.g., scientists and engineers becoming teachers.) Evidence within Partnership school systems of the infrastructure needed to improve math and science education and to measure improvement, i.e., the adoption of appropriate assessments of student achievement, as well as the initiation of the collection of achievement data that can be disaggregated by ethnicity, socioeconomic status, gender, etc.	III-1: NSF's performance for the People Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future; Contributions to development of a diverse workforce through participation of underrepresented groups in NSF activities; Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal.	Unchanged. Not included separately. MSP is evaluated in III-1 and in the Program Assessment Rating Tool for Collaborations.

Strategic Outcome Goal	FY 2003 Goal (Revised Final Plan)	FY 2004 Goal (Final Plan)	Explanation of Change
IDEAS -- Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."	III-2: NSF's performance for the Ideas Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: Discoveries that expand the frontiers of science, engineering, or technology; Connections between discoveries and their use in service to society; Partnerships that enable the flow of ideas among the academic, public or private sectors; Leadership in fostering newly developing or emerging areas.	III-2: NSF's performance for the Ideas Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: Discoveries that expand the frontiers of science, engineering, or technology; Connections between discoveries and their use in service to society; Partnerships that enable the flow of ideas among the academic, public or private sectors; Leadership in fostering newly developing or emerging areas.	Unchanged.
TOOLS -- Providing "broadly accessible, state-of-the-art and shared research and education tools."	III-3: NSF's performance for the Tools Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: Development or provision of tools that enables discoveries or enhances productivity of NSF research or education communities; Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure; Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal.	III-3: NSF's performance for the Tools Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: Development or provision of tools that enables discoveries or enhances productivity of NSF research or education communities; Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure; Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal.	Unchanged.

Performance Area	FY 2003 Goal (Revised Final Plan)	FY 2004 Goal (Final Plan)	Explanation of Change
Use of Merit Review	IV-1: At least 85 percent of basic and applied research funds will be allocated to projects that undergo merit review.	IV-1: At least 85 percent of basic and applied research funds will be allocated to projects that undergo merit review.	Unchanged.
Implementation of Merit Review Criteria - Reviewers	IV-2: At least 70 percent of reviews with written comments will address aspects of both generic review criteria.	IV-2: At least 70 percent of reviews with written comments will address aspects of both review criteria.	Unchanged.
Implementation of Merit Review Criteria – Program Officers	IV-3: For at least 80 percent of decisions to fund or decline proposals, program officers will comment on aspects of both generic review criteria.	IV-3: For at least 90 percent of decisions to fund or decline proposals, Program Officers will comment on aspects of both review criteria.	The target level for this goal has been increased from 80 percent to 90 percent.
Time to Prepare Proposals	IV-4: 95 percent of program announcements will be publicly available at least three months prior to the proposal deadline or target date.	IV-4: 95 percent of program announcements will be publicly available at least three months prior to the proposal deadline or target date.	Unchanged.
Time to Decision	IV-5: For 70 percent of proposals, be able to inform applicants whether their proposals have been declined or recommended for funding within six months of receipt.	IV-5: For 70 percent of proposals, be able to inform applicants whether their proposals have been declined or recommended for funding within six months of deadline of target date, or receipt date, whichever is later.	The wording of the goal has been revised slightly to reflect the method used to calculate the "time to decision."
Award Size	IV-6: Increase average annualized award size for research grants to $125,000.	IV-6: NSF will increase the average annualized award size for research grants to $128,000.	The target level for this goal has been increased by $3,000.
Award Duration	IV-7: Maintain the FY 2002 goal of 3.0 years for the average duration of awards for research grants.	IV-7: The average duration of awards for research grants will be 3.0 years.	Unchanged
Facilities –Construction and Upgrade	IV-8: For ninety percent of construction, acquisition and upgrade projects, keep any negative cost and schedule variances to less than 10 percent of the approved project plan.	IV-8: For ninety percent of construction, acquisition and upgrade projects, keep any negative cost and schedule variances to less than 10 percent of the approved project plan.	Unchanged.
Facilities – Operations and Management	IV-9: For ninety percent of operational facilities, keep scheduled operating time lost to less than 10 percent.	IV-9: For ninety percent of operational facilities, keep scheduled operating time lost to less than 10 percent.	Unchanged.

Performance Area	FY 2003 Goal (Revised Final Plan)	FY 2004 Goal (Final Plan)	Explanation of Change
Cost Efficiency – Videoconferencing	No goal included.	IV-10: NSF will assess the cost efficiencies associated with administrative processes. Performance Indicator: Calculation of the agency-wide cost-savings realized by the use of videoconferencing.	A cost efficiency goal related to savings resulting from the use of videoconferencing has been added.
Electronic Business	IV-10: NSF will continue to advance "e-business" by receiving through FastLane and processing electronically 90 percent of PI award transfers. IV-11: NSF will continue to advance "e-business" by implementing Phase III of the Electronic Jacket application. Performance Indicator: Implementation of the electronic capability for assigning proposal processing tasks, forwarding proposals to other programs as necessary, and delegating proposal action authority.	IV-11: NSF will integrate its internal electronic grants process with the E-government initiative. Performance Indicators: 90 percent of program announcements will be posted to Fed Grants. 75 percent of declined proposals will be processed using E-decline signatures.	The Foundation is moving towards an electronic environment capable of performing all internal and external functions from proposal submission through final project closeout. The FY 2004 goal retains the emphasis on E-business while continuing progress on new tasks in this area.
Security Program – Information Technology and Physical Security	IV-12: NSF will maintain and enhance the agency-wide security program to ensure adequate protection of NSF's IT infrastructure and critical assets. Performance Indicators: 95 percent of major systems will have approved security plans on file. 95 percent of major systems will have documented certification and accreditation.	IV-12: NSF will maintain and enhance the agency-wide security program to ensure adequate protection of NSF's infrastructure and critical assets. Performance Indicators: 95 percent of NSF's major systems will achieve Level 3 compliance in accordance with the NIST Security Self-Assessment Framework. Implementation of a "Smart ID" pilot to provide staff with a standard identification card for authentication and access control.	For FY 2004 the performance indicators retain the emphasis on information technology security while continuing progress on new tasks in this area. The "Smart ID" pilot indicator has been added.

Performance Area	FY 2003 Goal (Revised Final Plan)	FY 2004 Goal (Final Plan)	Explanation of Change
NSF Staff – Diversity	IV-13: NSF will ensure that diversity considerations are embedded in activities related to agency staffing of scientists and engineers. Performance Indicator: Initiate development of a NSF S&E diversity plan. IV-14: NSF will show an increase over FY 2000 in the total number of appointments to NSF science and engineering staff and management from underrepresented groups.	IV-13: NSF will ensure that diversity considerations are embedded in activities related to agency staffing of scientists and engineers. Performance Indicator: NSF will complete development of the NSF S&E diversity plan initiated in FY 2003 and begin implementation of its recommendations. IV-14: NSF will show an increase over FY 2000 in the total number of appointments to NSF science and engineering staff and management from underrepresented groups.	Future goals and associated performance indicators have not yet been developed. The recommendations of the FY 2003 internal, ad hoc task force will guide their development. Unchanged.
Workforce Learning	IV-15: NSF will align or develop competency-based curricula, through the NSF Academy, that provide cross-functional, work-based team learning opportunities. Performance Indicator: Initiate development of new courses or revision of existing courses to address program management, leadership development, and technology and business process training.	IV-15: The NSF Academy will develop a broad array of competency-based learning opportunities that will enable all staff to perform critical functions supporting NSF's vision and goals. Performance Indicators: - Identification of staff requiring Facilities / Center Project Management training. - Initiation of development of a curriculum that leads to certification in Facilities / Center Project Management.	The FY 2004 indicator retains the emphasis on workforce learning while implementing specific curricula
Workforce Planning	IV-16: NSF will develop competency-based, occupation classification alternatives that support the agency's strategic business processes and capitalize on its technology enabled business systems. Performance Indicators: Identification of workforce competencies for all current NSF job families. Initiate identification of competency-based, classification alternatives.	IV-16: NSF will develop competency-based occupation classification alternatives that support the agency's strategic business processes and capitalize on its technology enabled business systems. Performance Indicators: - Identification of workforce competencies needed to support the majority of NSF's strategic business processes. - Development of new positions or revision of position descriptions in order to address emerging business process requirements.	The FY 2004 indicators retain the emphasis on workforce planning. The first indicator expands NSF's focus to association of workforce competencies with NSF's business processes. The addition or revision of positions in accordance with the identified competencies is added as an indicator.

VIII. OTHER FEATURES

INFORMATION ON USE OF NON-FEDERAL PARTIES

This GPRA performance report was written and prepared solely by NSF staff.

Non-Federal external sources of information we used in preparing this report include:

- Reports from awardees demonstrating results.
- Reports prepared by evaluators – Committees of Visitors (COV) and Advisory Committees – in assessing our programs for progress in achieving Outcome Goals.
- Reports prepared by a consulting firm to assess the procedures we use to collect, process, maintain, and report performance goals and measures.
- Reports from facilities managers on construction/upgrade costs and schedules and on operational reliability.
- Data collected by Westat, Inc. and used by NSF staff in the assessment of NSF Strategic Outcome Goal III-1b.

Specific examples:

Highlights or sources of examples shown as results may be provided by Principal Investigators who received support from NSF.

We use external committees to assess the progress of our programs toward qualitative goal achievement. External evaluators provide us with reports of programs, and provide feedback to us on a report template we prepare. Examples are COV and Advisory Committee reports that provide an independent external assessment of NSF's performance.

We engaged an independent third-party, IBM Business Consulting Services, to conduct a review of data and information used in performance reporting. IBM Business Consulting Services reviewed NSF's performance data and information pertaining to our outcome goals, and management goals. This additional independent review helped to eliminate potential reporting bias that can develop in self-assessments. It also provides assurance of the credibility of performance reporting information and results.

CLASSIFIED APPENDICES NOT AVAILABLE TO THE PUBLIC

None to report.

ANALYSIS OF TAX EXPENDITURES

None to report.

WAIVERS OF ADMINISTRATIVE REQUIREMENTS

None to report.

APPENDIX

National Science Foundation

Government Performance and Results Act (GPRA) Performance Measurement Validation and Verification

Report on FY 2003 Results

October 2003

1 Executive Summary

The National Science Foundation (NSF), as a Federal agency, is subject to the performance reporting requirements of the Government Performance and Results Act (GPRA). Accordingly, NSF developed a series of performance goals to help the agency meet its mission, goals, and objectives. General Accounting Office (GAO) auditing standards require federal agencies to provide confidence that the policies and procedures that underlie GPRA performance reporting are complete, accurate and consistent. As such, the Foundation asked International Business Machines Corporation (IBM) Business Consulting Services to assess the validity of the data and reported results of its performance goals and verify the reliability of the methods used to compile and report data for these goals.[1] This is the fourth consecutive year that we have performed this assessment.

While we have traditionally conducted our assessment after the end of the fiscal year (FY), this year the Foundation asked us to conduct a comprehensive review of the first three quarters of GPRA results for FY 2003 with an update review at the end of the fiscal year once final results are reported. The purpose of this earlier third quarter assessment is to allow NSF to meet an accelerated GPRA reporting deadline, mandated by the Office of Management and Budget (OMB). Beginning in FY 2005, NSF and other federal agencies must submit their Performance and Accountability Reports (PAR) to OMB by November 15. NSF expects to submit its FY 2003 PAR by November 15, 2003, moving to the new deadline one year in advance of the statutory requirement. The earlier review also allows NSF to make any necessary adjustments to its processes or reports prior to the end of the fiscal year, based on our assessment.

We commend NSF for undertaking this fourth-year effort to confirm the reliability of its GPRA data and results and its processes to collect, process, maintain, and report data for its performance goals. From our FY 2003 review, we conclude that NSF has made a concerted effort to assure that it reports its performance results accurately and has effective systems, policies, and procedures to promote data quality. Overall, we verify that NSF relies on sound business practices, internal controls, and manual checks of system queries to report performance. NSF maintains adequate documentation of its processes and data to allow for an effective verification and validation review. Further, we validate the reliability of NSF's third and fourth quarter results through our successful recalculation or reconfirmation of these results based on processes, data and systems.

The scope of our independent verification and validation review includes an assessment of NSF's Management Goals and Strategic Outcome Goals as described in the NSF FY 2003 GPRA Revised Final Performance Plan.

1.1 Review of Management Goals

The FY 2003 Management Goals we reviewed fall under four categories:

- Six new goals being reviewed for the first time
- Ten goals, which we reviewed in prior years, receiving an update review in FY 2003

As part of our review of the processes and results for these Management goals, we:

- Assessed the accuracy of NSF's performance data and reported outcomes of performance goals and indicators

[1] GAO defines "verification" as a means to check or test performance data in order to reduce the risk of using data that contains significant errors. GAO defines "validation" as a way to test data to ensure that no error creates significant bias.

- Described the reliability of the processes NSF uses to collect, process, maintain, and report data
- Reviewed system controls to confirm that quality input results in quality output
- Created detailed process descriptions and process maps for those goals being reviewed for the first time
- Identified changes to processes and data for those goals receiving an update review

We applied GAO's *Guide to Assessing Agency Annual Performance Plans* (GAO/GGD-10.1.20) to guide our review. Based on GAO guidance, we assessed whether NSF's processes to collect, process, maintain and report data meet the following criteria:

- Does the process provide for periodic review of collection, maintenance, and processing procedures to ensure they are consistently applied and continue to be adequate?
- Does the process provide for periodic sampling and review of data to ensure completeness, accuracy, and consistency?
- Does the process rely on independent audits or other established procedures for verifying and validating financial information when performance measures require the use of financial information?
- Does NSF address problems in verification and validation procedures, known to GAO or the agency?
- Does the agency recognize the potential impacts of data limitations should they exist?

We did not consider the appropriateness of NSF's performance goals or indicators in our assessment of the validity of NSF's reported results. Rather, our validation is based strictly on whether NSF achieved or did not achieve its performance goals based on the indicators established by NSF in its FY 2003 Revised Final Performance Plan.

1.2 Review of Strategic Outcome Goals

In addition to its Management Goals, NSF measures its performance against annual performance goals associated with its three qualitative Strategic Outcome Goals: People, Ideas and Tools. A critical component of NSF's performance assessment in these areas is the Advisory Committee for GPRA Performance Assessment (AC/GPA), a group of external science experts who offer an independent opinion on whether NSF demonstrated significant achievement in a series of performance indicators associated with People, Ideas and Tools.

NSF asked us to verify the quality of the processes used to support the judgments of the AC/GPA and to validate the credibility of the AC/GPA's judgments based on the strength of these processes. Specifically, our methodology consisted of the following:

- Reviewed background information
- Observed the AC/GPA meeting, which took place at NSF on June 24-26, 2003
- Discussed the process with NSF staff and AC/GPA members
- Documented the AC/GPA process in narratives and process maps
- Verified the quality of the AC/GPA process to yield reliable results
- Assessed the validity of the AC/GPA performance assessment based on the quality of the processes
- Offered issues for consideration, as NSF seeks to improve the process in future years

To validate the reliability of the AC/GPA process, we developed a series of criteria, on which we assessed the quality of the processes. These criteria are:

- Expertise, independence and level of knowledge of the AC/GPA membership
- Quality, timeliness, impartiality, and relevance of the information available to the AC/GPA
- Independence of the committee's judgment from NSF influence
- Committee's determination of "significant achievement" with respect to the annual performance indicators
- Documentation and transparency of the AC/GPA process and results
- NSF's response to AC/GPA recommendations made as a result of the FY 2002 process

1.2.1 Review of Goal III-1B related to Math and Science Partnerships

NSF also asked us to review its processes to collect, process, maintain, and report data for Goal III-1B, which is an annual performance goal under the Strategic Outcome Goal of People. Goal III-1B is related to NSF's Math and Science Partnership Program (MSP). The AC/GPA determined that it could not reach an opinion of whether NSF had demonstrated significant achievement for Goal III-1B due to insufficient information. Consequently, NSF provided us with a comprehensive set of performance information and process documentation, from which we sought to verify the reliability of NSF's processes and performance information for NSF senior management to reach a valid and reasonable conclusion on achievement of the goal.

1.3 Results and Recommendations

Based on our third and fourth quarter review, we verified the reliability of the processes used to collect, process, maintain and report data for all 16 Management Goals. Overall, NSF relies on sound business processes, system and application controls, and manual checks of system queries to report performance. We believe that these processes are valid and verifiable. We also validated the accuracy of the results reported by NSF as of the third and fourth quarters.

We also verified and validated that the AC/GPA process to evaluate NSF's achievement against its Strategic Outcome Goals involves a robust collection of performance information, reviewed qualitatively by a highly qualified and diverse Committee of science experts, with sufficient documentation and transparency to assure accountability and confidence in the AC/GPA's assessments.

Finally, we verified the reliability of the processes NSF used to collect, process, maintain and report data for Goal III-1B related to Math and Science Partnerships (MSP) and validated that the Directorate of Education and Human Resources (EHR) reached a reasonable conclusion that NSF achieved Goal III-1B based on the quality of the performance information and analyses of the MSP program results to date.

We summarize the results of our review for each performance goal in the following tables. We indicate the third and fourth quarter results of each goal as reported by NSF in the "Q3 Result" and "Q4 Result" columns. In the "Process Verified" column, a check symbol (✓) indicates that we were able to verify the reliability of NSF's processes to collect, process, maintain and report data. In the "Result Validation" column, a check symbol indicates that we were able to validate the accuracy of NSF's reported results for the corresponding performance goal. Finally, where appropriate, we also summarize any recommendations or issues for consideration we determined through our review of each goal. The full results of our review are discussed in greater detail in the balance of this report.

New NSF FY 2003 Management Goals: Verification and Validation Summary

FY 2003 GPRA Management Goal	Q3 Result	Q4 Result	Process Verified	Result Validated	Recommendations/Issues for Consideration Summary
IV-8: For 90 percent of construction, acquisition and upgrade projects, keep any negative cost and schedule variances to less than 10 percent of the approved project plan.	No results	Not achieved 88%	✔	✔	• Place more stringent criteria on principal investigators (PIs) to estimate percent of project completed • Consider requiring Program Officers (POs) to maintain documentation to support PI estimates • Institute tighter guidelines for accepting/ rejecting PI submissions via Fastlane
IV-9: For 90 percent of operational facilities, keep scheduled operating time lost to less than 10 percent.	No results	Not achieved 87%	✔	✔	• Consider requiring POs to maintain documentation to support PI estimates • Institute tighter guidelines for accepting/ rejecting PI submissions via Fastlane
IV-10: NSF will continue to advance "e-business" by receiving through FastLane and processing electronically 90 percent of Principal Investigator award transfers.	99.78%	Achieved 99.78%	✔	✔	N/A
IV-11: NSF will continue to advance "e-business" by implementing Phase III of the Electronic Jacket application. *Performance Indicator:* Implementation of the electronic capability for assigning proposal processing tasks, forwarding proposals to other programs as necessary, and delegating proposal action authority.	In progress Phase III is in testing phase	Not achieved Phase III functionality complete. Implementation in progress in accordance with the Implementation Strategy Plan.	✔	✔	If goal is continued next fiscal year, revise goal language to replace “forwarding proposals” with “routing proposals” to be consistent with terms used in the e-jacket application
IV-12: NSF will maintain and enhance the agency-wide security program to ensure adequate protection of NSF’s IT infrastructure and critical assets. *Performance Indicators:* • 95% of major systems will have approved security plans on file. • 95% of major systems will have documented certification & accreditation.	In progress 18 of 19 systems with security plans; 9 of 19 systems certified/accredited	Achieved 18 of 19 systems with security plans and accredited and certified	✔	✔	Maintain all security plans and certification and accreditation packages in one centralized location
IV-13: NSF will ensure that diversity considerations are embedded in activities related to agency staffing of scientists and engineers (S&E). *Performance indicator:* Initiate development of a NSF S&E diversity plan.	Achieved Committee formed to draft diversity plan	Achieved	✔	✔	N/A

NSF Management Goals Receiving an Update Review in FY 2003: Verification and Validation Summary

FY 2003 GPRA Management Goal	Q3 Result	Q4 Result	Process Verified	Result Validated	Recommendations/Issues for Consideration Summary
IV-1: At least 85 percent of basic and applied research funds will be allocated to projects that undergo merit review.	87%	Achieved 89%	✔	✔	Capture and maintain EIS raw data used to calculate quarterly results.
IV-2: At least 70 percent of reviews with written comments will address aspects of both generic review criteria.	89%	Achieved 90%	✔	✔	• Supplement quantitative assessment of goal with qualitative review of a sample of merit review responses to assure both criteria are adequately addressed. • Capture and maintain EIS raw data used to calculate quarterly results.
IV-3: For at least 80 percent of decisions to fund or decline proposals, program officers will comment on aspects of both generic review criteria.	53%	Not achieved 53%	✔	✔	• Evaluate a smaller, more frequent sample of Form 7s to address problem areas throughout the year. • Standardize and automate Form 7 with possibly separate text boxes for PO responses.
IV-4: Ninety-five percent of program announcements will be publicly available at least three months prior to the proposal deadline or target date.	99%	Achieved 99%	✔	✔	Continue to review quarterly data to assure consistency and reliability of data processed by Clearance Officer.
IV-5: For 70 percent of proposals, be able to inform applicants whether their proposals have been declined or recommended for funding within six months of receipt.	82%	Achieved 77%	✔	✔	• Continue to pursue more automation of processes to calculate goal results. • Capture and maintain EIS raw data used to calculate quarterly results.
IV-6: NSF will increase the average annualized award size for research grants to a level of $125,000, compared to a goal of $113,000 in FY 2002.	$108,715	Achieved $135,609	✔	✔	Capture and maintain EIS raw data used to calculate quarterly results.
IV-7: NSF will maintain the FY 2002 goal of 3.0 years for the average duration of awards for research grants.	2.9	Not achieved 2.9	✔	✔	Capture and maintain EIS raw data used to calculate quarterly results.

FY 2003 GPRA Management Goal	Q3 Result	Q4 Result	Process Verified	Result Validated	Recommendations/Issues for Consideration Summary
IV-14: NSF will show an increase over FY 2000 in the total number of appointments to NSF science and engineering staff and management from underrepresented groups.	26 females 13 minorities	Not achieved 48 females 25 minorities	✔	✔	• Establish formal procedures to verify accuracy of data entered into IPERS. • Automate process to compile demographic information from directorates.
IV-15: NSF will align or develop competency-based curricula, through the NSF Academy, that provide cross-functional, work-based team learning opportunities. *Performance Indicator:* Initiate development of new courses or revision of existing courses to address program management, leadership development, and technology and business process training.	Achieved 15 new courses 21 revised courses	Achieved 24 new courses 26 revised courses.	✔	✔	▪ Revise the performance indicator to be more quantifiable and to set a minimum number of new or revised courses necessary to achieve the goal. ▪ Update NSF Academy online course catalog more frequently than annually
IV-16: NSF will develop competency-based, occupation classification alternatives that support the agency's strategic business processes and capitalize on its technology enabled business systems. *Performance Indicators:* • Identification of workforce competencies for all current NSF job families. • Initiate identification of competency-based, classification alternatives.	In progress Competencies completed for 10 most critical job families Research initiated for classification alternatives	Achieved Competencies completed for all 32 job families Research initiated for classification alternatives	✔	✔	N/A

NSF FY 2003 Strategic Outcome Goal Performance Indicators: Verification and Validation Summary

FY 2003 Strategic Outcome/Performance Goal	AC/GPA Assessment[2]	Process Verified	Result Validated	Issues for Consideration Summary
People: Developing "a diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens."				The following issues for consideration pertain to all three strategic outcome goals and are based on recommendations offered by the AC/GPA and our observations and assessment of the AC/GPA process: • Consider preparing an NSF-self assessment to be validated by the AC/GPA to maximize the limited time of the Committee members. This issue should be considered in light of the resources available and necessary to perform the self-assessment. • Directorates should provide more direction to programs to develop nuggets to assure that major and cross-directorate programs are adequately represented. • Consider providing AC/GPA with summary table of total award dollars represented by nuggets for each directorate and/or strategic outcome goal • Eliminate "Areas of Emphasis" from process, as the AC/GPA saw no compelling reason to single out
III-1a: NSF's performance for the People Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: • Development of well-prepared researchers, educators or students whose participation in NSF activities provides experiences that enable them to explore frontiers or challenges of the future; • Contributions to development of a diverse workforce through participation of underrepresented groups[3] in NSF activities; • Development or implementation of other notable approaches or new paradigms that promote progress toward the PEOPLE outcome goal.	Achieved	✔	✔	
III-1b: NSF will significantly enhance the quality of K-12 mathematics and science education available to all students in Math and Science Partnership schools. *Performance Indicators:* • Evidence in the award portfolio of the infrastructure to support high quality programs addressing issues related to teacher workforce capacity, including preservice education and inservice professional development of math and science teachers as well as alternative routes into the profession (e.g., scientists and engineers becoming teachers.) • Evidence within Partnership school systems of the infrastructure needed to improve math and science education and to measure improvement, i.e., the adoption of appropriate assessments of student achievement, as well as the initiation of the collection of achievement data that can be disaggregated by ethnicity, socioeconomic status, gender, etc.	Not enough information *(IBM reviewed the processes/data for this goal and validated the reasonableness of NSF' conclusion of achievement of this goal. See Section 9)*	✔	✔	

[2] The results for the annual performance goals associated with the Strategic Outcome Goals reflect the Advisory Committee for GPRA Performance Assessment (AC/GPA) assessment of the performance indicators for each performance goal. It should be noted that he AC/GPA is just one of several mechanisms NSF uses to assess performance in People, Ideas and Tools.

FY 2003 Strategic Outcome/Performance Goal	AC/GPA Assessment[2]	Process Verified	Result Validated	Issues for Consideration Summary
Ideas: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society"				individual programs for consideration. • Assure that subcommittee chairs are appointed and briefed well in advance of the AC/GPA meeting. • Reassess the value of the prospective portfolio in the AC/GPA process, as the AC/GPA will not have access to a full year's worth of grants and the prospective assessment is used for internal purposes only (not for GPRA reporting). • Consider lengthening the duration of the AC/GPA meeting depending on NSF resources and the time restraints of Committee members.
III-2: NSF's performance for the Ideas Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators: • Discoveries that expand the frontiers of science, engineering, or technology; • Connections between discoveries and their use in service to society; • Partnerships that enable the flow of ideas among the academic, public or private sectors; • Leadership in fostering newly developing or emerging areas.	Achieved	✔	✔	
Tools: Providing "broadly accessible, state-of-the-art and shared research and education tools."				
III-3: NSF's performance for the Tools Strategic Outcome is successful when, in the aggregate, results reported in the period demonstrate significant achievement in the majority of the following indicators • Development or provision of tools that enables discoveries or enhances productivity of NSF research or education communities; • Partnerships with local, state or federal agencies, national laboratories, industry or other nations to support and enable development of large facilities or other infrastructure; • Development or implementation of other notable approaches or new paradigms that promote progress toward the TOOLS outcome goal.	Achieved	✔	✔	

[3] For example, women, underrepresented minorities, or persons with disabilities

Nugget Sampling

As in FY 2002, members raised the issue of whether the "nuggets" provided by the Directorates were sufficiently representative of the entire NSF portfolio. The Directorates selected the programs, on which to write nuggets, based on judgmental sampling as opposed to random sampling. The committee discussed the relative value of each.

To assess the relative significance of the nuggets and their distribution across the NSF portfolio of grants, we applied GAO auditing standards related to materiality, relevance and significance.[4] We worked with NSF staff to obtain the total award dollar amounts represented by both the retrospective and prospective nuggets available to the Committee. We also examined the distribution of nuggets by directorate, as reported in the AC/GPA website. The results of our assessment are as follows:

- **Materiality.** From our review, we conclude that the nuggets materially represent a sufficient share of overall NSF resources, committed to funding research, for the AC/GPA to rely upon to make its assessments. We calculated that the nuggets represent awards totaling over **$3.4 billion** in funding, including multi-year commitments from continuing grants. Comparing this figure to NSF's estimated grant awards and future-year commitments toward research in FY 2003, we conservatively estimate that the nugget dollar amounts are equivalent to at least one-third of the awards and commitments made to support People, Ideas and Tools in FY 2003.
- **Relevance.** We also reviewed the relative distribution of the 875 total nuggets by directorate, as reported in the AC/GPA website, and compared it to the estimated FY 2003 funding for each directorate. From this review, we conclude that the judgmentally selected nuggets roughly represent an equivalent level of NSF resources devoted to each directorate. This provides some assurance that relevant elements of NSF's program awards portfolio are being reflected in the nuggets provided to the AC/GPA.
- **Significance.** On the issue of judgmental verses random sampling of nuggets, we believe that the use of judgmental sampling is appropriate for the purposes of the AC/GPA. Judgmental sampling assures that those programs that NSF professional staff judge as scientifically significant are included in the nuggets for use by the Committee. Because of the importance of applying professional judgment in the selection process, the traditional audit approach of random sampling would not meet the standard of "significance" in this instance. It is also important to reiterate that the charge of the AC/GPA is to provide a subjective, qualitative opinion on NSF's outcomes based on a wide range of performance information that extends beyond the nuggets, thus reinforcing the appropriateness of the judgmental sampling approach.

We also note that prior to the AC/GPA meeting and in response to a FY 2002 AC/GPA recommendation, NSF discussed the issue of nugget sampling with senior management and staff with expertise in statistics. Ultimately, NSF determined that judgmental sampling was appropriate given the nature of the AC/GPA's qualitative review. During the AC/GPA meeting, a number of committee members expressed satisfaction with the nugget sampling technique, especially given the availability of other types of performance information. Some committee members noted that their subcommittees went far beyond the nuggets in making their judgments. We concur with this assessment.

[4] While we applied GAO auditing standards, this review does not qualify as an audit.