NATIONAL • SCIENCE • FOUNDATION

FY 2001 GPRA PERFORMANCE REPORT

March 29, 2002

NATIONAL SCIENCE FOUNDATION ACT OF 1950

"AN ACT to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."

Enabling the Nation's future through discovery, learning and innovation.

REALIZING THE PROMISE OF THE 21ST CENTURY DEPENDS IN LARGE MEASURE ON TODAY'S INVESTMENTS IN SCIENCE, ENGINEERING AND MATHEMATICS RESEARCH AND EDUCATION.

NSF INVESTMENTS – IN PEOPLE, IN THEIR IDEAS, AND IN THE TOOLS THEY USE – WILL CATALYZE THE STRONG PROGRESS IN SCIENCE AND ENGINEERING NEEDED TO SECURE THE NATION'S FUTURE.

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Message from the Director

I am pleased to present the National Science Foundation's Annual Performance Report for Fiscal Year 2001, as required by the Government Performance and Results Act of 1993 (GPRA).

That law requires federal agencies to set clear goals and to explain what they have done to meet them. Again this year, NSF demonstrates a record of solid progress toward some of the most formidable challenges a government organization has ever set for itself. These include raising nationwide achievement in science and engineering, achieving processing electronically all proposals, and ensuring that America has a globally competitive and diverse workforce.

In the aftermath of the terrorist attacks on September 11, the stakes for our investments could not be higher. The future of America – indeed the future of the world – is more dependent upon advances in science and technology than ever before. An inspired science and engineering community is focused on ensuring not just our security, but also our very quality of life. We well remember that our national security includes the condition of our spirit as much as the size of our arsenal, and we are heartened by the echo of President Franklin D. Roosevelt's words in his secret letter to Robert Oppenheimer in 1943: "Whatever the enemy may be planning, American science will be equal to the challenge."

We continue to meet this challenge today as we pursue our principal objectives – enabling discoveries at the frontiers of science and engineering, and encouraging significant improvement in the quality and scope of math, science and engineering education. Once again, the entire world acknowledged the fruits of those efforts. Of the 11 winners of 2001 Nobel Prizes in the sciences, eight had been funded by NSF grants.

Across the science and engineering frontiers, research progresses in ways that may culminate in discoveries this year, next year or in the next decade. This intrinsic uncertainty makes it more difficult for NSF to assess its overall achievements on a year-to-year basis. Nonetheless, the GPRA goals constitute a valuable set of benchmarks, and NSF is proud of its FY 2001 results.

The Foundation has set extremely high standards for success. This is what our tradition of excellence demands, and what taxpayers deserve. This year, we succeeded in realizing 15 of our 23 goals, and for most of the goals we did not meet, we demonstrated measurable improvement over last year's results. You will find a full description of our performance results in this report, *results that draw upon data that are complete and reliable. Because we are also committed to the highest standards of management integrity, we will continue to improve our data collection efforts and management processes.*

NSF remains committed to the highest standards of management effectiveness and administrative integrity as we seek to provide science and engineering outcomes of major significance and widespread benefit to the nation. We look forward to an even more successful year in FY 2002.

Rita R. Colwell,
Director

EXECUTIVE SUMMARY

This report, prepared pursuant to the Government Performance and Results Act (1993), covers activities of the National Science Foundation during Fiscal Year 2001.

The National Science Foundation (NSF) Act of 1950 charges NSF with supporting scientific and engineering research and education programs at all levels. Over time, other responsibilities have been added such as supporting the development and use of computers and other technologies, providing Antarctic research facilities and logistics support, and addressing issues of equal opportunity in science and engineering research and education.

NSF represents about four percent of the total federal budget for research and development, but accounts for one-fifth of all federal support for basic research and 40% of non-life science basic research at academic institutions. About 95% of our funding supports the work of the nation's researchers and educators; the agency's administrative overhead is only five percent.

NSF goals are divided into three broad areas: Strategic Outcome Goals, Management Goals, and Investment Process Goals.

Outcome Goals: Our 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.

Investment Process Goals: Our investment process goals relate to the procedures we use to make awards, fund and manage capital projects, and otherwise serve our customers.

FY 2001 Results: We met 15 of our 23 goals. Foundation staff verified and validated all NSF performance data. In addition, PricewaterhouseCoopers LLP, an independent examiner engaged by NSF, verified and validated selected performance information and data.

Outcome Goals: We were successful for four of our five outcome goals (80%) related to:

- Developing "a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens" (PEOPLE);
- Providing intensive professional development programs for at least 65,000 K-12 teachers (PEOPLE);
- Enabling "discovery across the frontier of science and engineering, connected to learning, innovation and service to society" (IDEAS); and,
- Providing "broadly accessible, state-of-the-art and shared research and education tools." (TOOLS)

We were not successful in achieving the goal involving systemic reform in K-12 schools. While we accomplished two of the three indicators required for successful attainment of this goal, we did not accomplish the third.

Examples of accomplishments achieved during this reporting period:

- New planets were discovered in orbit around far-off stars, in a quest to find planetary systems similar to Earth.
- Computer scientists created what may be the most intrusion-proof system invented so far. It has successfully

repelled more than 13,000 hacker attacks from around the world.

- Researchers designed the first autonomous vehicle to work under the Arctic ice.
- Robotics advanced in numerous ways, with robot scouts used to search for victims at the World Trade Center site.
- The "Deep Green" project revealed major discoveries about the history of plant life on Earth.
- Climate researchers uncovered an apparent self-regulating feedback relationship between sea-surface temperature and cloud formation that could prompt drastic changes in the way scientists model climate.
- The Macrogalleria, a pioneering educational polymer web site, is continuing to garner broad recognition. The worldwide popularity is so high it has already been translated into Afrikaans, French, and Spanish, and is being translated into Italian and Portuguese.
- *Sounds of the Sea* is an NSF informal science education project that serves diverse students and engages diverse communities directly in the scientific enterprise. It created a national model for engaging blind and visually impaired students and adults in experiencing hands-on science.
- The new Terascale Computing System (TCS) has begun operation well ahead of schedule and is exceeding performance. The combined peak power of the full computer system will be 6 Teraflops, making it the most powerful computer available to academic scientists and engineers in the U.S.
- A Lightning Mapping Array (LMA) has been developed that provides added lead-time for use in forecasting the onset of lightning strokes hitting the ground (one of the deadliest weather phenomena occurring today).

Additional 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 four of our five goals (80%) in this area: We were able to:

- Ensure that at least 95% of full proposals are submitted electronically through the computer-based "FastLane" system. In fact, more than 99% were submitted electronically;
- Increase the total number of science and engineering hires at NSF from under-represented groups, as judged against an FY 1997 baseline. NSF achieved a 138% increase in female hires and a 47% increase in minority hires;
- Increase usage of a broad range of video-conferencing/long distance communications technology by 100 percent over the FY 1999 level. The increase achieved was 184%; and
- Meet the goal of having the technological capability to move competitive proposals submitted electronically through the entire review process without generating paperwork. A pilot project involving 10 programs was successful.

We were not successful in meeting a management goal related to distributing a survey to help establish baselines to enable us to better assess the quality of the work environment. A survey will be administered in FY 2002.

Investment Process Goals: We achieved 7 of 13 (54%) of these goals. These are:

- Allocating at least 85% of funds to projects reviewed by external peer groups and selected through merit-based competition.
- Ensuring that 95% of program announcements and solicitations are available at least three months prior to proposal deadlines. We achieved 100%.

- Increasing our average annualized award size for research projects to $110,000. We exceeded our goal, achieving an average annualized award size of $113,000.
- Developing the capability and implementing electronic approaches that request voluntary demographic data from all reviewers to determine participation levels of members of underrepresented groups in the NSF reviewer pool.
- Ensuring that NSF Program Officers address both generic review criteria when making award decisions.
- Keeping annual construction and upgrades expenditures at 90% of our facilities within 110% of estimates. Ninety-six percent of the projects were within 110%.
- Keeping total cost of construction and upgrade projects initiated after 1996 within 110% of estimates made at the initiation of construction. One project was completed and its actual cost was equal to the total estimated cost.

We were not successful for six of our investment process goals. These were:

- Awarding at least 30% of competitive research grants to new investigators. We awarded 28%, and will continue our efforts in reaching out to new investigators to promote awareness of funding opportunities and to encourage new investigators to submit proposals.
- Ensuring that external merit reviewers take *both* NSF criteria into account when evaluating proposals. The two generic criteria are intrinsic merit and broader impacts of the proposed activity. We have taken several steps, including revising the Grant Proposal Guide, to ensure that both the proposer and reviewer communities are aware of the importance we attach to both criteria.
- Processing 70% of our proposals processed within six months of receipt. Although we did not achieve our goal, we showed significant improvement, rising from 54% in FY 2000 to 62% in FY 2001. This improvement took place even though the number of proposals received in FY 2001 represented an 8.5% increase over FY 2000 and was the largest annual percentage increase in over a decade.
- Increasing the average duration of awards for research projects to at least three years. Sufficient resources were not available to achieve both the average annualized award size and the average duration goals. We focused on increasing our average annualized award size. We will continue to focus on increasing both award size and duration.
- Having 90% of our facilities meet all annual schedule milestones by the end of the reporting period. Of 25 construction and upgrade projects supported by NSF, 21 (or 84%) met this goal (compared with 64% achieving the goal in FY 2000).
- Holding operating time lost due to unscheduled downtime at 90% of NSF-funded facilities to less than 10% of total scheduled operating time. Of 29 reporting facilities, 25 (86%) met the goal

Management Challenges: The NSF Office of the Inspector General listed 10 major management challenges for FY 2001:

- FastLane
- GPRA Data Quality
- Merit Review
- Cost Sharing
- Award Administration
- Management of Large Infrastructure Projects
- Management of U.S. Antarctic Program
- Work Force Planning and Training
- Fostering a Diverse Scientific Workforce
- Data Security

Our responses and focused NSF activities in these areas are provided within the report.

I. ABOUT NSF

Who we are

On May 10, 1950, President Harry S. Truman signed Public Law 810-507, creating NSF and setting forth our mission:

"To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."

Our authorizing legislation directs us to initiate and support basic scientific and engineering research; to support programs to strengthen scientific and engineering research potential; to support education programs at all levels in all fields of science and engineering research and education, and to establish an information base for science and engineering appropriate for development of national and international policy. Since the passage of that legislation 50 years ago, we have endeavored to maintain American leadership in scientific and engineering discovery, learning and innovation.

In contrast to other federal agencies that have research objectives such as energy, biomedicine, or space, we stand alone as the only federal agency charged with supporting and strengthening all disciplines across the science and engineering frontier. The Internet, plant genomics, nanotechnology and biocomplexity are but a handful of examples of NSF-supported research outcomes that have revolutionized, or have promise to revolutionize, how we live, work, and play.

America's science and engineering enterprise is unparalleled in scope and quality and has enabled the United States to become one of the most productive nations in the world. The return on investments in science and engineering has been enormous and has directly contributed to the nation's economic growth and to the health and welfare of its people. It is estimated that as much as one-half of the nation's economic productivity can be attributed to technological innovation and the science and engineering that supports it. Science and technology have contributed to an increased standard of living in most of the world's modern industrial societies, and have had enormous impact on health care, agriculture, environmental protection and national defense.

What we do

Our role is to fund the best ideas and most capable people exploring science, mathematics, and engineering research and education. We award grants, contracts and cooperative agreements to approximately 2,000 colleges, universities, schools, academic consortia, nonprofit institutions and small businesses throughout the United States. We also maintain partnerships with international organizations around the world. Investments promote the emergence of new disciplines, fields, and technologies that enable and enhance our nation's capacity for sustained growth and prosperity.

While our budget accounts for only about four percent of the total federal expenditure on research, we provide about one-fifth of the federal support to academic institutions for basic research. Each year our programs involve nearly 200,000 scientists, engineers, mathematicians, teachers and students.

How we do it

We receive about 30,000 proposals a year from the science and engineering community. In determining which of these proposals to invest in, we use external experts to advise us on the merit of the proposed activities, and how they compare to other proposals. Only about one in three proposals is selected for award. We consider the merit review process critical to our efforts to foster the highest standards of excellence and accountability. Each year, thousands of experts volunteer their time to evaluate proposals sent to NSF. We ask them to use two criteria in evaluating proposals—the intellectual merit of the proposed activity *and* its broader impacts.

NUMBER OF PEOPLE INVOLVED IN NSF ACTIVITIES	
	FY 2001
Senior Researchers	27,601
Other Professionals	9,904
Postdoctoral Associates	5,608
Graduate Students	25,461
Undergraduate Students	31,044
K-12 Students	11,335
K-12 Teachers	83,401
Total Number of People	194,354

What we fund

We play a unique role in the federal investment portfolio in that in our funded activities we integrate research and education activities. We support individual investigators and small groups engaged in research and education in traditional fields at about 2,000 colleges and universities, K-12 school districts, academic consortia, nonprofit institutions, small businesses and other research and education institutions throughout the nation. We provide support for U.S. participation in international state-of-the art research facilities such as the National Astronomy Centers, oceanographic research ships, and Antarctic research stations. Research facilities provide scientists, mathematicians and engineers access to state-of-the-art capabilities that enable research and education at the cutting-edge. We support research centers that address complex scientific and engineering questions through multi-disciplinary, long-term, coordinated efforts of many researchers and educators.

Our education and training investments support work at all levels, from pre-kindergarten through career development, across the U.S. These activities promote public science literacy and help to ensure that our nation maintains world-class scientists, engineers and mathematicians. We focus on programs that encourage the participation and achievement of groups underrepresented in science and engineering. We emphasize K-12 education through the support of partnerships that unite local school districts, colleges and universities and other stakeholders such as state and tribal entities. We believe that treating whole systems is the most effective way to make improvements in science and mathematics education.

How we are organized

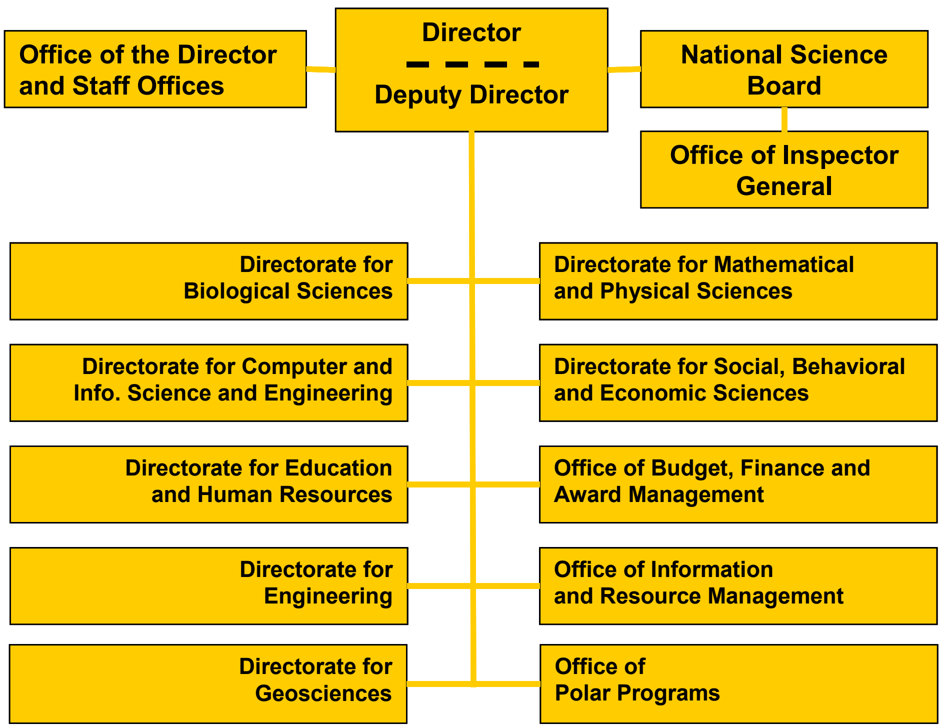
The President appoints, with the consent of the U.S. Senate, the NSF Director to serve a six-year term. Our current director, Dr. Rita R. Colwell, became NSF's eleventh director in 1998.

The National Science Board (NSB) establishes our policies. The Board consists of 24 members representing a cross-section of American leadership in science and engineering research and education. Presidentially-appointed NSB members are selected solely on the basis of established records of distinguished accomplishments. They serve six-year terms, with one-third of the Board's membership appointed and approved every two years. The NSF Director is a member *ex officio* of the Board. The NSB also serves the President and the Congress as an independent advisory body on policies affecting the health of U.S. science and engineering research and education.

NSF is structured much like an academic institution, with divisions organized by disciplines and fields of science and engineering, and for science, mathematics, engineering, and technology education. We have seven directorates, an Office of Polar Programs and two management offices.

Some statistics

In FY 2001, approximately 93% of our $4.5 billion budget supported research and education activities carried out by awardees. These programs and activities directly engaged nearly 200,000 people[1], including researchers, educators, students, and other professionals. Approximately three percent ($119 million) of the budget was devoted to major research equipment and construction. The remaining five percent was devoted to conducting the administrative work of the agency.
We employ a scientific and engineering staff of approximately 600 permanent and visiting scientists and engineers (approximately 65% of the agency's scientists and



[1] Source: NSF FY 2003 Budget Request to Congress, p. 43.

engineers are permanent government employees), 450 business and operations personnel, and 350 program support personnel. Our staff manage our investment portfolio: they do not conduct research nor do they operate laboratories supported by NSF awards. In FY 2001 staff processed more than 200,000 merit-based reviews and made funding decisions on nearly 32,000 competitive proposals. About 10,000 new awards were made. During 2001, about 45,000 reviewers were sent one or more proposals for mail review and about 10,000 reviewers served as panelists. About 9,000 of these reviewers had never reviewed an NSF proposal before.

FY 2001 BUDGET / PERFORMANCE ALIGNMENT
(Millions of Dollars)

	STRATEGIC OUTCOMES				
Account	PEOPLE	IDEAS	TOOLS	A&M	TOTAL
R&RA*	283	2,153	911	26	3,372
EHR	612	144	25	15	795
MRE	0	0	119	0	119
S&E	0	0	0	166	166
OIG	0	0	0	7	7
Total	$894	$2,297	$1,055	$214	$4,460

*R&RA = Research and Related Activities
EHR = Education and Human Resources
MRE = Major Research Equipment
S&E = Salaries and Expenses
OIG = Office of Inspector General

II. SOME NSF ACHIEVEMENTS

NOBEL PRIZES FOR 2001: Of the eleven 2001 Nobel Prize winners in the sciences, eight[2] have been previously funded by NSF (http://www.nobel.se).

The 2001 Nobel Prize in Chemistry was awarded to William S. Knowles, Ryoji Noyori and K. Barry Sharpless, for their development of catalytic techniques for asymmetric chemical synthesis. In nature, many molecules are found in mirror image, right-handed or left-handed, forms. Often only one of these asymmetric forms is biologically active. Sharpless developed highly efficient catalytic synthetic techniques to selectively produce only one of these mirror image forms. These techniques have allowed pharmaceutical companies to synthesize only the mirror image form that they need. The catalytic techniques developed as a result of this discovery are now used by pharmaceutical companies to produce, for example, beta-blocker medication to control blood pressure.

The 2001 Nobel Prize in Economics was awarded to three NSF-supported economists, George A. Akerlof, A. Michael Spence, and Joseph E. Stiglitz, for their fundamental contributions to our understanding of asymmetric markets – markets in which one side has more information than the other. More recent research by economists following up on the earlier theoretical work has shown that job candidates can signal to prospective employers their motivation, ability and training through the wage their current employer is willing to pay or the type of contract they will accept. "Signaling theory" has been widely applied, most notably to understanding the Internet and e-commerce.

The 2001 Nobel Prize in Physics was awarded to three researchers – Eric A. Cornell, Wolfgang Ketterle, and Carl E. Wieman – for their achievement of Bose-Einstein condensation in dilute gases of alkali atoms and for early fundamental studies of the properties of the condensates. The Bose-Einstein Condensate is regarded as a new state of matter in which all the constituents, by virtue of their near-absolute zero low temperature, are in the same quantum state. For this new state of matter the corresponding atom waves are coherent. Current speculation suggests that this new level of "control" of matter is going to bring revolutionary applications in such fields as precision measurement and nanotechnology.

Louis Stokes Alliances for Minority Participation: A variety of current initiatives are directed toward broadening participation of underrepresented minorities in science, technology, engineering, and mathematics. A principal one, the Louis Stokes Alliances for Minority Participation (LSAMP), shows increasingly positive results with growing numbers of students in this program entering these fields and a higher percentage earning degrees, including advanced degrees, in these disciplines. Particularly noteworthy are the increased graduation rates (from 48% to 62% in science and from 53% to 76% in engineering over a five-year period) at Puerto Rico LSAMP institutions.

Aging: A new model system was developed to study telomeres, structures that seal the ends of chromosomes in plants and animals much like the plastic tips on shoelaces, and which wear out, allowing the "lace" to fray. Telomeres break down in most cells in the

[2] George A. Akerlof, Eric A. Cornell , Wolfgang Ketterle, William S. Knowles, K. Barry Sharpless, A. Michael Spence, Joseph E. Stiglitz, Carl E. Wieman.

human body over time and have been implicated in aging. By exploiting the completed genome sequence of *Arabidopsis*, it is possible to uncover the contributions of the DNA damage surveillance machinery in identifying dysfunctional telomeres (http://www.nsf.gov/od/lpa/news/press/01/pr0115.htm).

Deep Green: The "Deep Green" project has made radical new discoveries about the history of plant life on earth. The findings significantly rearranged the "family tree" of green plants since it was learned that ferns and horsetail are not, as was previously believed, transitional between mosses and flowering plants. They are, in fact, the closest living relatives to seed plants. Ramifications of these findings span practical areas ranging from agriculture to economics (http://www.nsf.gov/od/lpa/news/press/01/pr0109.htm).

Extra-solar planets: A major impetus to the observational and theoretical studies of the formation of stars and their planetary disks was provided in the last few years by the discovery of extra-solar planets. The most recent discovery finds a planet three-quarters the mass of Jupiter in a circular orbit around the solar-like star 47 Ursa Majoris. Although more than 70 extra-solar planets have been found thus far, this is the first system with two planets in circular orbits, and at distances that make the planetary system similar to our own.

The oldest material: Reports of the Hadean detrital zircons from Western Australia include the discovery of one that is approximately 4.4 billion years old. This tiny crystal formed within 160 million years of the formation of Earth and is the only sample known from the earliest history of Earth. The zircons also indicate that there was liquid water, and perhaps even oceans, i.e. a cool early earth, at a time when many have hypothesized the existence of magma oceans.

Clouds and climate models: One of the most uncertain aspects of climate models is the treatment of clouds. Recent work has led to a discovery with potentially significant implications for global climate change scenarios. An analysis of the distribution of upper-level cirrus clouds and sea surface temperatures (SSTs) shows a strong inverse relation between cirrus cloud area and the underlying surface temperatures. The finding suggests that the earth has a natural adaptive infrared 'iris' that opens and closes the upper dry regions in order to control the heat radiated by the Earth in response to SST changes, in a manner similar to how a human iris reacts to changing light levels. If confirmed, this could significantly affect current global climate models.

Intelligent robots used at World Trade Center: Intelligent Autonomous Marsupial Robots, prototyped with NSF funds, were used for search and rescue at the World Trade Center (WTC) during the disaster recovery efforts following the September 11, 2001 attack. Just as kangaroos carry their young in a pouch, these "marsupial" robots possess unique characteristics: the "mother" robot carries smaller ones in its "pouch" into the site as far as it can maneuver and it then releases and provides power as the "babies" descend from it to perform their search – negotiating smaller crevices and hidden spaces. Equipped to maintain balance on rough terrain, the robot "mother" and its "children" can reach, sense, and report on spaces that are too small and/or too dangerous for human rescue workers to approach or enter. The robots located five victims and a set of remains, and surveyed three buildings and two voids in the debris. As a result of watching the robotic creatures in action, the Federal Emergency Management Agency (FEMA) Task Force has ordered various small and semi-autonomous robots for future use (http://www.nsf.gov/od/lpa/news/press/01/pr0178.htm).

Newly discovered animals in hydrothermal vents: In the spring of 2001, an interdisciplinary team of scientists and engineers explored a newly discovered hydrothermal vent field in the Indian Ocean. They collected biological samples, samples of vent and smoker fluid and plumes, rocks and sediment samples from the seafloor, and precisely mapped the area. Newly discovered animals living in the hydrothermal vent system as well as ancient bacteria found at the site may help scientists better explain how and whether the fauna living at hydrothermal vents in the Atlantic and Pacific Oceans are genetically related. The research expedition was fully integrated with an educational component entitled "Dive and Discover," co-funded with the Woods Hole Oceanographic Institution and Ohio's Center of Science and Industry. "Dive and Discover" involved live webcasts, interactions between students and researchers, and companion materials that assisted teachers in explaining the science and technology behind the expedition (http://www.nsf.gov/od/lpa/news/press/01/pr0136.htm).

Learning technologies: Just as human teachers need to listen as well as speak, some researchers believe that learning technologies should observe and react to students' needs, not just present material in an informative and appealing way. Researchers supported by NSF are opening up new avenues of education research. Here are several examples:

- A series of participatory simulations has been developed by which middle and high school students, using handheld and networked devices, each become independent agents in simulations of system dynamics. These simulations may be as varied as chemical molecule collisions or automotive traffic. They all yield entirely different kinds of content-rich experiences.

- Tracking devices that examine students' eye movements as they interact with a computerized algebra tutor have already proven effective as an instructional agent. Eye movements may be indicative of changing cognitive states on a fine time scale. When the tutor's feedback was contingent on eye movement data, students learned 20% faster (preliminary unpublished results).

Wisdom of practice: Findings from NSF supported research on learning are directly applicable to the classroom and help to identify the most effective types of interventions or instructional approaches. A commonly held "wisdom of practice" is that one of the best means to learn a subject is to teach it. Research has documented this phenomenon and has used it to design agent-based technology by which mathematics and science students have to master disciplinary content at a sufficient level to "teach" computer agents. Programs were developed that enable analysis not only of progress in writing proficiency but also in evolution of content knowledge. Research of this type supports the conclusion that children learn better if they are put into the position of reconstructing or explaining newly learned scientific material to others. Work in the Detroit Public Schools suggests that youngsters as young as sixth grade can build and analyze models of complex systems that without technology would require use of undergraduate mathematics.

Underwater robots: The first autonomous underwater vehicle with the endurance to work under ice in the Arctic was developed. This is part of a continuing effort to obtain better all-season ocean data. Strategically related efforts continue to develop robotic samplers for the atmosphere (aerosondes) and to develop an autonomous, under-ice ocean bottom seismometer.

Modeling contamination events: Newly developed computer models enable modeling of the flow of water in shallow basins. These models include factors such as river inflow and standard tidal flow, and allow for the presence of contaminants being transported by the flow. These computational methods have been used in the development of a complex shallow water simulator, called UTBEST (University of Texas Bays and Estuaries Model). It has also been possible to model a simulated contamination event in the Houston Ship Channel with the domain modeled being all of Galveston Bay.

Cyber-terrorism: A computer system was built that is capable of identifying and stopping intrusive behavior on the system it is protecting. The technology can identify assaults in progress, stop the offending process, and disable the IP address of the culprit. As a proof of concept, the team that developed the system placed a highly vulnerable version of the Linux system (no security patches) on the net as a web server and invited hackers throughout the world to root the machine. There were over 13,000 attacks on this box and not one successful intrusion.

Lost City: Hydrothermal vent structures, dubbed the "Lost City," were discovered in December 2000 in the mid-Atlantic Ocean. These vent structures, including a massive 18-story vent, taller by far than any seen before, are very different from all others discovered across the world since the 1970s (http://www.nsf.gov/od/lpa/news/press/01/pr0156.htm).

Antifreeze proteins in fish living in extreme environments: The question of how cold-blooded creatures such as fish survive in the frigid waters off Antarctica is being investigated by studying the role of antifreeze glycopeptides, antifreeze proteins of Antarctic fishes involved in freezing avoidance. We anticipate that the results will lead to major advances in understanding molecular biology and evolution of antifreeze systems and will be applicable to a wide range of disciplines.

Researchers on another project, also focused on Antarctic fishes, seek to determine at the molecular level those adaptations that enhance the assembly and movement of microtubules and the expression of related genes. In the broadest sense, this research program should advance the molecular understanding of the survival of cold-blooded organisms.

Another project is a phylogenetic study of Antarctic microorganisms to understand the unique adaptations required for survival. The application of DNA microarray technology to studies of life in extreme environments offers an outstanding opportunity for identifying new genes for biotechnological use. Discovering specific adaptations to extreme environments by detecting genes that are uniquely expressed in the natural environment is an ultimate goal of this research.

Sounds of the Sea: An NSF informal science education project that serves diverse students and engages diverse communities directly in the scientific enterprise is *Sounds of the Sea.* This project empowers a generation of students and teachers to explore scientific concepts and engage in understanding an array of scientific professions that are not a traditional part of the K-12 experience. It created a national model for engaging blind and visually impaired students and adults in experiencing hands-on science. The program provided curricula to urban school districts that will reach 15,000 teachers annually through the Teacher Resource Center. The program will remain in use beyond the grant period. A legacy of the project is a four-page "advanced organizer," as well as in-home, in-school, and after-school activity guides distributed to over 10,000 educators to facilitate students' exploration in marine science.

Replacing chlorine-based processes: Catalysts for the activation of hydrogen peroxide in water for green oxidation processes have been developed. They may replace environmentally harmful chlorine-based processes used in the textile, paper and laundry industries.

Astroflow: The activities of faculty members who are active in bringing their research results to the public are well illustrated by work taking place in Rochester, NY. A research group is making the results of their research directly available to the public through a variety of venues including programs at local grade, middle and high schools. A program called Astroflow is a suite of software tools allowing users to interactively control, visualize, and explore realistic simulations of cosmic events: exploding stars, comets diving into planetary atmospheres, jets of hypersonic gas driving through interstellar clouds, and more. Astroflow gives students and non-scientists the opportunity to learn by experimentation and exploration. Currently Astroflow is installed in a specially designed kiosk at the Strasenburgh Planetarium in Rochester, NY. The technology behind Astroflow has been successfully commercialized.

The **Macrogalleria,** a pioneering educational polymer web site, is continuing to garner broad recognition. NSF Director Rita Colwell described it in these terms in one of her speeches: "Many of you have seen the wonderful Web Site called 'Macrogalleria.' It is set up like a shopping mall. The site bills itself as 'the Internet mall where you net surfers can learn all kinds of nifty stuff about polymers and polymer science.' The student or the Internet surfer clicks on the shops and learns that polymers are everywhere. As he or she ascends to the different levels of the mall, more complex concepts are conveyed." The Macrogalleria was recently selected by *Scientific American*[3] as one of its "50 Top Websites." This follows many other distinctions, such as the Education Index Top Site and the Top 5% of Chemistry Sites. The worldwide popularity of the Macrogalleria is so high that it has already been translated into Afrikaans, French, and Spanish, and is being translated into Italian and Portuguese.

VORTEX – Predicting tornadoes: The benefits of education and research within the atmospheric sciences are extremely visible to the public at large. The importance of the daily weather to individuals is self-evident. Severe weather prediction is of paramount importance. The Verification of Origins of Rotation in Tornadoes Experiment (VORTEX) used airborne and surface mobile Doppler radars and other mobile sensors to map in detail the structure of tornadoes and their near environment. The modeling and observations indicated that a localized downdraft is an important ingredient in the final stages of the formation of a tornado. This knowledge was directly translated to more accurate tornado forecasts (tornado watches) being issued by the National Weather Service.

Hazard loss: A major research project on "2nd National Assessment of Research and Applications on Natural Hazards" involved over 130 national experts in hazards and disasters from all fields of science, engineering, policy, and practice. The results of this effort greatly influenced policies for and approach to hazard loss mitigation in the Federal Emergency Management Agency's (FEMA) Project Impact. The objectives of Project Impact are to establish a national risk assessment, meet the need for computer-aided systems to inform local hazard decision-making [e.g., FEMA's Natural Hazard Loss Estimation Methodology (HAZUS)], and assist local efforts to design safer communities, such as efforts underway in Berkeley, California and Tulsa, Oklahoma. A summary brochure of the assessment was distributed to every member of the U.S. House of Representatives. The document was subsequently used internationally. It provided the basis for redrafting New Zealand's environmental and hazards legislation to link sustainable development with environmental management and hazards mitigation.

3 http://www.scientificamerican.com/explorations/2001/051401top50/#ScientificAmerican

COPLINK: A collaboration between a university artificial intelligence laboratory and a local police department has led to development of an integrated justice information database available over a secure intranet. COPLINK is still in the deployment phase with 32 law enforcement professionals currently using this system. Plans are being developed to deploy COPLINK in other areas of the U.S. COPLINK is an excellent example of multi-agency partnerships supported under the Digital Government program. NSF and the Defense Advanced Research Projects Agency (DARPA) supported the fundamental research that led to COPLINK under the Digital Library 1 initiative.

Astro coalitions: This project links amateur and professional astronomers, school children, their teachers, and families around a variety of activities, such as creation of scientific records, production of student research journals, and collaborative investigation of astrophysical phenomena. In addition to having formed partnerships that connect groups who have never worked together before, this project has created a system that has engendered new coalitions beyond those targeted in the funding cycle. The project has launched a new idea for public collaboration in science that is regenerating itself in a variety of forms across the nation.

Wavelets and their uses: The theory of wavelets has had a profound impact on data compression, signal analysis, scientific calculation, medical imaging and radar detection. In one application wavelets are used to identify the key features of an image and allow reconstruction of the image with only a tiny amount of information about the original object.

Environmental changes in Antarctica: The Cape Roberts Project is a major international drilling program involving more than 50 people from seven countries. Researchers have collected more than 1,700 m of sediment core that is providing a record of environmental changes extending back more than 30 million years. These cores reveal periods of high frequency instabilities in the Antarctic climate during the Miocene (e.g., 24 million years ago) age. A detailed record of environmental changes extending back this far has not been available previously; the new discoveries from the cores are expected to make significant contributions to many areas of Antarctic geosciences.

III. SUMMARY OF PERFORMANCE RESULTS

Overall, we were successful in achieving 65% – 15 of 23 – of our performance goals.

RESULTS FOR OUTCOME GOALS: This is the first year we are reporting on the new outcome goals of People, Ideas, and Tools. We achieved four of our five outcome goals (80%) in FY 2001. We failed to achieve our goal involving schools participating in systemic initiative programs.

Management Goals	**4 of 5 (80%)**
Outcome Goals	**4 of 5 (80%)**
Investment Process Goals	**7 of 13 (54%)**
TOTAL	**15 of 23 (65%)**

In assessing our results for People, Ideas, and Tools, external experts noted significant achievement in diversity and broadening participation. However, participation of underrepresented groups remains lower than desired. It was also noted that there was limited involvement of agency programs other than Science Resources Statistics in the development of information fundamental to national policy debates. A complete discussion of our outcome goal results is provided in Section IV.

RESULTS FOR MANAGEMENT GOALS: We achieved four of our five management goals (80%) in FY 2001. We are particularly pleased to have demonstrated the feasibility of implementing a paperless proposal review environment at NSF. Ten programs participated in a pilot program in electronic proposal review in FY 2001, and the pilot program was a success. The one goal we did not achieve involved distribution of an employee survey to our staff. Our management goals discussion is in Section V.

RESULTS FOR INVESTMENT PROCESS GOALS: We achieved seven of our thirteen investment process goals in FY 2001. Areas identified as needing improvement include: the use of the generic merit review criteria by reviewers, decreasing the time to decision, increasing the percentage of awards to new investigators, and keeping operating time lost at facilities due to unscheduled downtime to less than 10% of the total scheduled operating time. Discussion of these goals and how NSF is addressing issues is provided in Section VI.

The following Table provides a summary of the results for NSF's FY 2001 GPRA reporting.

III. – Summary of Performance Results

ANNUAL PERFORMANCE GOALS FOR NSF'S STRATEGIC OUTCOMES

Strategic Outcome	FY 2001 Annual Performance Goal	Results for National Science Foundation
People Strategic Outcome **Outcome Goal III-1:** Development of "a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens."	***<u>Performance Goal III-1a:</u>*** **NSF is successful when, in the aggregate, results reported in the period demonstrate significant achievement in one or more of the following indicators:** • Improved mathematics, science, and technology skills for U.S. students at the K-12 level, and for citizens of all ages, so that they can be competitive in a technological society. • A science and technology and instructional workforce that reflects America's diversity. • Globally engaged science and engineering professionals who are among the best in the world. • A public that is provided access to the benefits of science and engineering research and education. <u>FY 2001 Result:</u> Reports prepared by external experts during FY 2001 GPRA reporting provide assessments and retrospective examples of NSF-supported projects that document significant achievement. *A number of these assessments were emphatic that NSF must continue and increase its efforts related to diversity.	New goal in FY 2001 **FY 2001: NSF is successful for goal III-1a.** • Demonstrated significant achievement • Demonstrated significant achievement* • Demonstrated significant achievement • Demonstrated significant achievement
	<u>Performance Goal III-1b:</u> Over 80 percent of schools participating in systemic initiative programs will (1) implement a standard-based curriculum in science and mathematics; (2) further professional development of the instructional workforce; and (3) improve student achievement on a selected battery of tests, after three years of NSF support. <u>FY 2001 Result**:</u> The curriculum, instructional workforce, and improved achievement in science components of the goal were successful. However, less than 80% of schools met the goal of improved student achievement in mathematics. In FY 2002, appropriate technical assistance will be provided to schools not meeting the goal.	**FY 1999:** NSF successful **FY 2000:** NSF successful **FY 2001: NSF is not successful for goal III-1b**.**
	<u>Performance Goal III-1c:</u> Through systemic initiatives and related teacher enhancement programs, NSF will provide intensive professional development experiences for at least 65,000 pre-college teachers. <u>FY 2001 Result</u>: In school year 1999-2000, EHR awards provided intensive professional development (60 hours or more) to a total of 79,000 teachers, exceeding substantially the GPRA goal of 65,000.	**FY 1999:** NSF successful **FY 2000:** NSF successful **FY 2001: NSF is successful for goal III-1c.**

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

Strategic Outcome	FY 2001 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 is successful when, in the aggregate, results reported in the period demonstrate significant achievement in one or more of the following indicators:** • A robust and growing fundamental knowledge base that enhances progress in all science and engineering areas including the science of learning. • Discoveries that advance the frontiers of science, engineering and technology. • Partnerships connecting discovery to innovation, learning, and societal advancement. • Research and education processes that are synergistic. <u>FY 2001 Result:</u> Reports prepared by external experts during FY 2001 GPRA reporting provide assessments and retrospective examples of NSF-supported projects that document significant achievement.	New goal in FY 2001 **FY 2001: NSF is successful for goal III-2.** • Demonstrated significant achievement • Demonstrated significant achievement • Demonstrated significant achievement • Demonstrated significant achievement
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 is successful when, in the aggregate, results reported in the period demonstrate significant achievement in one or more of the following indicators:** • Shared use platforms, facilities, instruments, and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce. • Networking and connectivity that take full advantage of the Internet and make SMET information available to all citizens. • Information and policy analyses that contribute to the effective use of science and engineering resources. <u>FY 2001 Result:</u> Reports prepared by external experts during FY 2001 GPRA reporting provide assessments and retrospective examples of NSF-supported projects that document significant achievement. *There are very limited contributions and limited involvement of agency programs other than Science Resources Statistics (SRS) in developing information and other materials fundamental to national policy debates.	New goal in FY 2001 **FY 2001: NSF is successful for goal III-3.** • Demonstrated significant achievement • Demonstrated significant achievement • Demonstrated significant achievement*

III. – Summary of Performance Results

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
NSF Business Practices		
Electronic Proposal Submission	***Performance Goal IV-1:*** Ninety-five percent of full proposals will be received electronically through FastLane. FY 1998 Baseline 17% FY 1999 Result 44% FY 2000 Goal 60% FY 2000 Result 81% FY 2001 Goal 95% FY 2001 Result 99%	**FY 1999:** NSF successful **FY 2000:** NSF successful **FY 2001: NSF is successful for goal IV-1.**
Electronic Proposal Processing	***Performance Goal IV-2:*** In FY 2001, NSF will conduct ten pilot paperless projects that manage the competitive review process in an electronic environment. FY 2001 Result: Ten pilot paperless projects were completed.	New goal in FY 2001 **FY 2001: NSF is successful for goal IV-2.**
Video-Conference/Long-Distance Communications	***Performance Goal IV-3:*** By the end of FY 2001, NSF will increase usage of a broad range of video-conferencing / long distance communications technology by 100 percent over the FY 1999 level. FY 2001 Result: 142 video-conferences were conducted, an increase of 184 percent over the 1999 level.	New goal in FY 2001 **FY 2001: NSF is successful for goal IV-3.**
NSF Staff		
Diversity	***Performance Goal IV-4:*** NSF will show an increase over 1997 in the total number of hires to science and engineering (S&E) positions from underrepresented groups. FY 1997 Baseline: 16 females and 15 members of underrepresented minority groups were hired. 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.	Goal revised in FY 2000 **FY 1999:** NSF successful for related goal **FY 2000:** NSF successful **FY 2001: NSF is successful for goal IV-4.**

ANNUAL PERFORMANCE GOALS FOR NSF'S MANAGEMENT (continued)

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
Work Environment	***Performance Goal IV-5:*** NSF will establish various baselines that will enable management to better assess the quality of worklife and work environment within the Foundation. FY 2001 Result: Development of an employee survey is underway. This survey will provide baseline information on the quality of worklife and work environment at NSF. In FY 2002, the survey will be made available to employees.	New goal in FY 2001 **FY 2001: NSF is not successful for goal IV-5.**

III. – Summary of Performance Results

ANNUAL PERFORMANCE GOALS FOR NSF'S INVESTMENT PROCESS

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
Proposal and Award Processes		
Use of Merit Review	***Performance Goal V-1:*** At least 85 percent of basic and applied research funds will be allocated to projects, which undergo merit review. * FY 2000 Goal 80% FY 2000 Result 87% FY 2001 Goal 85% FY 2001 Result 88% **During FY 2000 OMB redefined what constitutes a merit-reviewed project and established a new target level of 70-90%.*	Goal revised in FY 2000 **FY 1999:** NSF successful for related goal **FY 2000:** NSF successful **FY 2001: NSF is successful for goal V-1.**
Implementation of Merit Review Criteria – Reviewers	***Performance Goal V-2:*** NSF performance in implementation of the merit review criteria is successful when reviewers address the elements of both generic review criteria. FY 2001 Result: Program reports prepared by external experts during FY 2001 GPRA reporting provide assessment of implementation of merit review criteria for reviewers. In FY 1998 – FY 2000, reviewers did not consistently address the broader impacts criterion. In FY 2001, NSF added separate review screens to FastLane to enable reviewers to address each merit-review criterion separately. NSF also established an internal task force to examine strategies to improve both proposer and reviewer attention to the broader impacts criterion. A number of FY 2001 reports note that reviewers are making significant progress in utilizing both merit review criteria. In FY 2002, NSF will continue to develop and apply recommendations that focus on strategies which stress the importance of using both criteria. It will also collect and make available examples of broader impacts and develop a plan to disseminate them.	Goal revised in FY 2001 **FY 2001: NSF is not successful for goal V-2**.
Implementation of Merit Review Criteria – Program Officers	***Performance Goal V-3:*** NSF performance in implementation of the merit review criteria is successful when program officers address the elements of both generic review criteria when making their award decisions. FY 2001 Result: Program reports prepared by external experts during FY 2001 GPRA reporting result in an assessment of successful for the foundation in implementation of both merit review criteria for program managers.	Goal revised in FY 2001 **FY 2001: NSF is successful for goal V-3.**

ANNUAL PERFORMANCE GOALS FOR NSF'S INVESTMENT PROCESS (continued)

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
Customer Service: Time to Prepare Proposals	***Performance Goal V-4:*** 95 percent of program announcements will be available to relevant individuals and organizations 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 1999:** NSF not successful **FY 2000:** NSF not successful **FY 2001: NSF is successful for goal V-4.**
Customer Service: Time to Decision	***Performance Goal V-5:*** For 70 percent of proposals, be able to tell 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 2001 Result: In FY 2001, 62% of proposals were processed within 6 months of receipt. In FY 2002, NSF will continue to focus on improving the efficiency of proposal processing, including the dissemination of best practices to program staff.	**FY 1999:** NSF not successful **FY 2000:** NSF not successful **FY 2001: NSF is not successful for goal V-5.**
Award Size	***Performance Goal V-6a:*** NSF will increase the average annualized award size for research projects to $110,000. 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	New goal in FY 2001 **FY 2001: NSF is successful for goal V-6a**.

ANNUAL PERFORMANCE GOALS FOR NSF'S INVESTMENT PROCESS (continued)

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
Award Duration	***Performance Goal V-6b:*** NSF will increase the average duration of awards for research projects to at least three years. 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 2001 Result: Resource limitations impacted NSF's ability to achieve both the award size and award duration goals. NSF focused its efforts on increasing average annualized award size. In FY 2002, 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:** Not applicable **FY 2001: NSF is not successful for goal V-6b**.
Maintaining Openness in the System	***Performance Goal V-7:*** NSF will award 30 percent of its research grants to new investigators. FY 1997 Baseline 27% FY 1998 27% FY 1999 Goal 30% FY 1999 Result 27% FY 2000 Goal 30% FY 2000 Result 28% FY 2001 Goal 30% FY 2001 Result 28% In FY 2002, NSF will continue its outreach to new investigators to promote awareness of research funding and to encourage new investigators to submit proposals.	**FY 1999:** NSF not successful **FY 2000:** NSF not successful **FY 2001: NSF is not successful for goal V-7.**

ANNUAL PERFORMANCE GOALS FOR NSF'S INVESTMENT PROCESS (continued)

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
Broadening Participation		
Reviewer Pool	***Performance Goal V-8:*** NSF will begin to request voluntary demographic data electronically from all reviewers to determine participation levels of members of underrepresented groups in the NSF reviewer pool. FY 2001 Result: The reviewer system in FastLane was revised to gather voluntary demographic data.	New goal in FY 2001. **FY 2001:** NSF is successful for goal V- 8.
Facilities Oversight		
Construction and Upgrade	***Performance Goal V-9a:*** For 90 percent of facilities, keep construction and upgrades within annual expenditure plan, not to exceed 110 percent of estimates. FY 1999 Result: Majority of facilities within 110 percent of annual spending estimates. FY 2000 Result: Of the 11 construction and upgrade projects, all were within annual expenditure plans; most were under budget. FY 2001 Result: Of 25 construction and upgrade projects, 24 (96 percent) were within 110 percent of annual expenditure plans.	Goal revised in FY 2001 **FY 1999:** NSF successful for related goal **FY 2000:** NSF successful **FY 2001: NSF is successful for goal V-9a.**

ANNUAL PERFORMANCE GOALS FOR NSF'S INVESTMENT PROCESS (continued)

Performance Area	FY 2001 Annual Performance Goal	Results for National Science Foundation
Construction and Upgrade	***Performance Goal V-9b:*** Ninety percent of facilities will meet all annual schedule milestones by the end of the reporting period. FY 1999 Result: Majority of facilities on schedule. FY 2000 Result: Majority (7 of 11) of construction/upgrade projects within the annual schedule goal. FY 2001 Result: Of the 25 construction and upgrade projects, 21 (84 percent) met all annual schedule milestones by the end of the reporting period. Project delays were caused in part by circumstances beyond the control of the facility, technical problems and personnel issues. In FY 2002, NSF will work with awardees to identify obstacles to successful performance and implement plans to avoid or mitigate their consequences in the future.	Goal revised in FY 2001 **FY 1999:** NSF successful for related goal **FY 2000:** NSF not successful for related goal **FY 2001: NSF is not successful for goal V-9b.**
Construction and Upgrade	***Performance Goal V-9c:*** For all construction and upgrade projects initiated after 1996, keep total cost within 110 percent of estimates made at the initiation of construction. FY 2001 Result: One project was completed. The actual total cost was equal to the estimated total cost.	**FY 1999 and FY 2000:** There were no projects completed, therefore this goal did not apply. **FY 2001: NSF is successful for goal V-9c.**
Operations and Management of Facilities	***Performance Goal V-10:*** 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. Some causes of failure were outside the control of the facility or were related to technical problems. In FY 2002, NSF will continue to work with awardees to identify obstacles to successful performance and develop plans to avoid or mitigate their consequences in the future.	Goal revised in FY 2001 **FY 1999:** Inconclusive for related goal **FY 2000:** NSF not successful for related goal **FY 2001: NSF is not successful for goal V-10.**

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 the OMB Circular No. A-11 Part 2, Section 230, dated July, 2001, pp. 539-541, each report must include the following elements[4]:

- *"A comparison of your actual performance with the projected levels of performance as set out in the performance goals in your annual performance plan (see section 232.4);*
- *An explanation, where a performance goal was not achieved, for why the goal was not met (see section 232.6);*
- *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 the goal (see section 232.7);*
- *An evaluation of your performance plan for the current fiscal year, taking into account the actual performance achieved in the fiscal year covered by your report (see section 232.8);*
- *Eventually, actual performance information for at least four fiscal years (see section 232.9); and*
- *An assessment of the reliability and completeness of the performance data included in the report (see section 232.10)."*

Other features as they apply to the agency[5]:

- Program evaluations;
- Information on use of non-Federal parties;
- Classified appendices not available to the public;
- Description of the quality of the reported performance information;
- Budget information;
- Analysis of tax expenditures; and
- Waivers of administrative requirements.

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[4] The first five of these elements are provided with each goal discussed in our report. The last element is discussed in Section VIII.

[5] Information on program evaluations is given in Appendices I. and II. Quality of reported performance information is discussed in Section VIII. The other features are discussed in Section XI.

OUTCOME GOALS

IV. NSF OUTCOME GOALS

A. PEOPLE

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

PERFORMANCE OUTCOME GOAL III-1a: Development of "a diverse, internationally competitive and globally engaged workforce of scientists and engineers, and well-prepared citizens."

✓ 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 must serve as a catalyst and a test bed for a gradual change in the process and philosophy of educating the workforce. This is particularly true of science education at K-12 level, given the small fraction of total resources in K-12 education represented by NSF funding.

Goal III-1a is a new performance goal for us. Our performance for this goal is successful if *assessments from external evaluators* find that results we reported for the period FY 2001 demonstrate significant achievement for one or more of the following indicators:

- Improved mathematics, science, and technology skills for U.S. students at the K-12 level, and for citizens of all ages, so that they can be competitive in a technological society;
- A science and technology and instructional workforce that reflects America's diversity;
- Globally engaged science and engineering professionals who are among the best in the world; and
- A public that is provided access to the benefits of science and engineering research and education.

RESULT FOR PERFORMANCE GOAL III-1a: Reports prepared by external experts provided examples of significant achievement in reports they developed during FY 2001 reporting. A number of reports indicate that further improvement is needed in activities related to diversity.

Implications for the FY 2002 Performance Plan: This goal will be continued in FY 2002. The set of performance indicators related to the People goal has been expanded and modified to appropriately reflect the breadth of NSF activities (See Section X. for details).

INDICATOR 1: Improved mathematics, science, and technology skills for U.S. students at the K-12 level, and for citizens of all ages, so that they can be competitive in a technological society.

RESULT: ***Demonstrated significant achievement. Examples follow.***

SYSTEMIC ACTIVITIES

Systemic Reform: This combination of programs [Statewide Systemic Initiatives (SSI), Rural Systemic Initiatives (RSI), Comprehensive Partnerships for Mathematics and Science Achievement (CPMSA)] address state, region, and school district science, mathematics, engineering, and technology (SMET)[6] education. While it is difficult, if not impossible, to directly attribute the changes in U.S. SMET education solely to the Educational System Reform (ESR) programs, the ESR programs clearly contributed to these changes. First, the notion of systemic reform now permeates SMET education, and education in general. Prior to the SSI, RSI, and the CPMSA programs, improving SMET education was not characterized as a systemic problem. These programs were the first to recognize that the typical strategies used by school districts or state departments of education to increase SMET achievement were not sufficient to produce high-quality SMET education for all students. Second, these programs made improvement of mathematics and science education a priority issue for K-12 education. This combination of programs focused the attention of school districts, states, and other institutions on improvement of mathematics and science education and prompted these institutions to allocate resources to this issue. Third, these programs made serving all students a national mandate. The importance of SMET education for all students, including those from groups traditionally underrepresented in SMET jobs and careers, is now widely recognized. Though bridging the achievement gap between students from traditionally underrepresented groups and other students remains a significant challenge, the importance of addressing this problem is firmly established.

In the following paragraphs we highlight statements and quotations taken directly from reports of the FY 2001 COVs (Committees of Visitors) on NSF systemic programs.

Student Achievement:

The vast majority of the USI/CPMSA programs has shown significant increases in the number of students participating and succeeding in gatekeeper courses. In mathematics over the period 1993-1998 the average annual increase for students enrolling in these courses is about 9% and the annual increase of successful mathematics completions during this time was about 7%. In science during the same period enrollment increased about 7% annually and completions increased by 8% annually, which is excellent.

Except for Cohort I, the RSI have not been in effect long enough for program-wide evidence of substantial student achievement gains to materialize. The RSI program has made significant progress in building the capacity and infrastructure of rural districts to

[6] In our report one will find the acronyms SMET (Science, Mathematics, Engineering, and Technology) and STEM (Science, Technology, Engineering and Mathematics). The two acronyms are equivalent. External experts used one or the other of these terms.

understand, initiate and sustain mathematics and science reform. This action should result in increased student achievement. Given the initial state of RSI districts—poor rural districts with few resources to initiate and support reform efforts or to provide challenging educational opportunities to students—the focus on building infrastructure and capacity is the appropriate starting point for reform efforts.

Of particular note are the achievement gains made in the Puerto Rico SSI, the Louisiana SSI, and the Massachusetts SSI…For the Massachusetts SSI, we find that over the last three years, the trend has been of increased enrollment in all AP classes among all populations. About 79% of the more than 12,000 students taking AP courses also took the Advanced Placement (AP) exam, of which over 71% achieved a score of 3 or better on the exam. The Calculus enrollment (both AB and BC) has received the more robust raises with more than a 50% increase in the African American population and a third in the Hispanic population. The passing rates among students taking Calculus are also superior (ca. 73% for the first course and 90% for the second course).

Curriculum Implementation:

Five RSI projects have been in effect for three of more years (Alaska RSI, Appalachian RSI, Delta RSI, Tribal Colleges RSI, Navajo Nation RSI). Some evidence of improvement in mathematics and science achievement is beginning to emerge from these RSI projects. For example, the SAT9 test scores of Arkansas students in schools in which the Delta RSI has worked intensely have increased substantially compared to those in other Delta districts and the state overall (DRSI 2000 Annual Report). Similarly, 94% of the Appalachia RSI (ARSI) “Catalyst Schools” are showing improvements in state assessment results relative to comparison schools in non-participating districts (ARSI 2000 Annual Report). And the Alaska RSI (AKRSI) reported increases in college enrollment (from 36 students in 1994 to 70 students in 1998) by Alaskan Native students from AKRSI districts

“The RSI have been particularly effective in the area of standards and curricula. All RSI have increased awareness of national mathematics and science standards; most have played key roles in state and district standards development. For example, the Alaska RSI (AKRSI) was responsible for the development of state science as well as mathematics standards as well as providing professional development about these standards. (Initially, the state department intended to create only mathematics standards.) … Most notably, RSI working with indigenous populations (AKRSI, Navajo Nation RSI) have developed culturally sensitive instructional materials that integrate the knowledge base of indigenous peoples with western science.”

The RSI have focused their limited resources to develop the knowledge base and leadership capacity of teacher leaders and district administrators, and have worked intensively with a subset of "catalyst schools," schools that, for a variety of factors, were most poised to implement standards-based mathematics and science programs. The most recent annual reports of the five RSI indicate the increased capacity of teacher leaders and teachers in “catalysts schools” to implement standards-based mathematics and science instruction. For example, ARSI reported substantial increases in the percentage of “catalyst schools” with standards-based mathematics and science curricula (from 29% pre-ARSI to 79% in 1999), with instructional materials aligned to curricula (from 31% pre-ARSI to 86% in 1999) and extent of implementing inquiry-based teaching (10% pre-ARSI to 75% in 1999).

A key element to the success of the CPMSA investment is geared toward the partnerships that have been established. These relationships not only provide support for students and teachers but also increase community awareness of the efforts of the CPMSA and its influence on science and mathematics teaching and learning. Eligible activities under this initiative include research-based professional development for teachers; summer institutes for teachers; research-based internships and/or mentorships for students; and tutorial programs involving graduate/undergraduate students. In one site, the Partners in Education/Adopt A School Project has attracted 250 volunteers to assist with mentoring students. CPMSA sites are all involved in developing standards-based curricula. Progress in this area varies from the developmental phase to clearly defined time schedules. There is indication that these efforts incorporate National Council of Teachers of Mathematics (NCTM) standards; National Research Council (NRC) National Science Education Standards; and state Mathematics and Science Frameworks. The sites appear to be demonstrating more progress toward implementation at the lower grades than at the higher grades.

NON-SYSTEMIC ACTIVITIES

The **Show-Me** Center, the Implementation and Dissemination Site for middle-school mathematics curriculum: (a) has had approximately 35,000 hits on its Website (http://showmecenter.missouri.edu) that is estimated to reach approximately 250 new users each week; (b) conducted a Leadership Conference attended by nearly 400 state and national leaders in mathematics education seeking information on the curricula; and (c) gives presentations at local, state, and national teacher and professional society conferences.

The Leadership and Assistance for Science Education Reform Center (**LASER**), the dissemination site for K-8 science curriculum, exceeded its five-year goal within its first 3.5 years of operation. It has disseminated and helped to implement NSF-supported curriculum materials in over 300 school districts, serving some 1,000,000 K-8 students nationwide.

The Teachers Experiencing Antarctica and the Arctic (TEA): K-12 teachers who join a research team in Antarctica or the Arctic post daily electronic journals for their students and develop teaching materials for classroom use. Fifteen teachers participated in the program in the year 2001. NSF also supported a program for K-12 Teacher Training in Arctic Science. A partnership between the University of Texas at Austin Marine Science Institute and the Port Arkansas Independent School District provided training for K-12 teachers on Arctic science, including topics such as climate, sea ice, ozone depletion, and human adaptations.

IRIS Education: The Education & Outreach (E&O) Program of the IRIS Consortium runs one-day workshops that train both pre-service and in-service K-12 teachers. IRIS uses a two-pronged approach to reach the K-12 teacher population: directly through workshops held at national professional scientific and education meetings, and by training seismologists in the research community to run teacher workshops and then providing these seismologists with the resources to run a workshop locally. The IRIS E&O Program has placed high priority on development of educational materials that can be used at all levels. One-page handouts and posters have been distributed to a wide audience worldwide that includes research scientists, college and K-12 educators and their students, and the public. Over the past two years, more than 15,000 handouts and posters have been distributed nationally and internationally upon request, with a similar number distributed at national and regional scientific and educational meetings. Both English and Spanish versions of the one-pagers have been developed (http://www.iris.washington.edu/EandO/onepager.html).

INDICATOR 2: A science and technology and instructional workforce that reflects America's diversity.

RESULT: ***Demonstrated significant achievement. Examples follow.***

Distributed Mentor Project: The primary goal of this project is to increase the number of women entering graduate school in Computer Science and Engineering (CS&E) by involving them in research at a university with a female mentor. Each year, approximately twenty undergraduate women have participated in the research and mentoring activities of the Distributed Mentor Project (DMP). The students are involved in research, learn how a research university operates, meet graduate students and professors, and get a chance to observe a successful female researcher first hand. A longitudinal evaluation study of the project is being conducted by the Learning through Evaluation, Adaptation, and Dissemination (LEAD) Center of the University of Wisconsin[7].

The longitudinal evaluation shows the DMP project to be spectacularly successful at meeting its goal of increasing the number of women entering graduate school in CS&E. Using a Baccalaureate & Beyond study conducted in 1994 as a comparison, the best male CS&E graduates were 10 time more likely to enter graduate or professional school within one year of graduation than the best female CS&E graduates; the figure for men being 29.19% of graduates, for women being 2.53% of graduates[8]. Of the DMP participants, over 50% were enrolled in graduate or professional school the year following their graduation. In both cases the surveys considered only graduates with Grade Point Averages (GPA) greater than or equal to 3.5.

One successful program that provides a “pipeline" to bring ethnically diverse undergraduates into careers in the atmospheric and related sciences **Significant Opportunities in Atmospheric Research and Science (SOARS):** SOARS resides at the National Center for Atmospheric Research (NCAR) and identifies, recruits, and provides students attending colleges/universities in the U.S. and Puerto Rico with multi-summer research experiences, year-round guidance, counseling, and mentoring, and up to two years of graduate school support. SOARS boasts an 82% retention rate. Since its 1996 inception, 62 students/protégés have participated. Forty-two are current participants, nine are alumni and 11 have left the program. To date 38 have completed bachelor's degrees in a science field, 17 are enrolled in atmospheric or related science graduate programs, three are American Mathematical Society (AMS) graduate fellows, nine have completed master's degree programs, and three are Ph.D. candidates. No protégé has left college/university without completing an undergraduate degree in science, mathematics or engineering. Seven protégés have co-authored nine papers published in refereed journals. Many protégés have presented papers and posters of their summer research results at numerous regional, national, and international professional conferences; two papers received best presentation awards, one paper received an honorable mention; one poster was awarded best poster in atmospheric science. Six alumni are in the scientific workforce; three are enrolled in Ph.D. programs.

Louis Stokes Alliances for Minority Participation (LSAMP): Increased efforts are underway to keep more of the Science, Technology, Engineering and Mathematics (STEM) graduates

[7] “*Distributed Mentor Project: Comprehensive Participant Survey Analyses for 1994-1999*”, The LEAD Center, University of Wisconsin-Madison, Preliminary Report, March 2000.
[8] “*Baccalaureate and Beyond; Longitudinal Study*”, National Center for Educational Statistics, 1994.

from LSAMP institutions in the graduate school pipeline. There is a Bachelor of Science/Master of Science (BS/MS) program involving several institutions in the Atlanta area: Emory University, Georgia Institute of Technology, Georgia State University, Morehouse School of Medicine, and the colleges of the Atlanta University Center. Other initiatives focus on providing better linkage of the NSF-funded undergraduate programs with NSF-funded graduate programs. Attention to making the early STEM curriculum more student-friendly is underway in programs at several universities including the one at North Carolina A & T State University in Greensboro, NC, which focuses on tackling the three introductory "killer courses" in chemistry, mathematics, and physics. Other initiatives are taking place in the Historically Black Colleges and Universities Undergraduate Program and include one at Jackson State University to revise the teaching of calculus to include technology and laboratory experiences. At Morgan State University the initiative emphasizes research experiences for the STEM students.

The **Advanced Technological Education (ATE)** program contributes to broadened participation by under-represented minorities, as well as general improvement of technological education, through its focus on community colleges. Community colleges are where a large fraction of minority students begin their higher education. For example, the American Association of Community Colleges is conducting a series of activities designed to advance community colleges' leadership in STEM education. These activities include organizing an annual conference for ATE Principal Investigators; organizing a "Summit on Technological Education" that will bring community college and business representatives together to develop strategies to strengthen the nation's technical workforce and faculty pipeline; and continuing a successful mentoring program that helps community colleges establish new programs in STEM by pairing them with colleges that have already developed exemplary programs.

"Team-Mentoring: Catapulting Women through the **Glass Ceiling**" refers to an innovative and very successful mentoring conference for 40 junior women economists supported by NSF. The conference accomplished its goal of improving the research, grant writing, networking, and life balancing skills of the 40 junior women economists. It also produced conference plans, supporting materials and a video that so far have been used to hold four more mentoring conferences for women in economics. The American Economic Association Summer Training Program is an intensive eight and one-half week program designed to encourage and prepare talented undergraduates for success in economics doctoral programs. This is combined with a Scholarship Program that recruits, selects and funds under-represented minority (Black, Hispanic and Native American) participants who are U.S. citizens or permanent residents. Recent statistics show that the Summer program has been very successful in raising the numbers of minority students in strong graduate programs.

The **Gateway Coalition** alters engineering education from a focus on course content to the development of human resources and the broader experience in which individual curriculum parts are connected and integrated. The scope of the program includes four major parts: curriculum structure, human potential development, instructional technology and methodology, and evaluation measures. Gateway efforts aim at increasing the numbers of women, underrepresented minorities and the disabled participating in engineering; and drawing engineering faculty to a dedicated investment in the teaching of undergraduate students. During the period in which the Gateway Coalition was established, the retention of African American engineering students from the freshman to the sophomore year in the Gateway Coalition universities increased from 67% in 1992 to 87% in the year 2000. For women students, this retention increased from 75% to 90%, and for all engineering students retention increased from 79% to 86%.

INDICATOR 3: Globally engaged science and engineering professionals who are among the best in the world.

RESULT: ***Demonstrated significant achievement. Examples follow.***

Costa Rican Biodiversity Laboratory: A collaborative project involving the ALAS (Arthropods of La Selva) research team, the Organization for Tropical Studies (OTS), and the Instituto Nacional de Biodiversidad (INBio, Costa Rica) has produced an inventory of tropical rainforest insects at the La Selva Biological Station, Costa Rica, (a biodiversity laboratory) and trained a staff of parataxonomists drawn from local citizens, who conduct research and give tours. ALAS is highly visible to the public. The ALAS lab is a magnet for La Selva visitors, including local school children, U.S. senators, and Latin American decision-makers. ALAS was the subject of a New York Times ('Science Times') article (Yoon 1995), a live telecast from La Selva by Turner Educational Services, and a Nova-like segment on the Japanese Television Workshop. ALAS has been featured in Costa Rican television programs and newspapers.

International Geotechnical Activities: In addition to promoting the internationally-linked engineering research activities, NSF has been proactive in fostering international initiatives and collaborations-at-a distance. An example is the geotechnical reconnaissance report on Hyogoken-Nanbu earthquake. Eighteen U.S., Japanese, and Canadian researchers were rapidly deployed in the area affected by the Hyogoken-Nanbu earthquake to prepare a document that was of substantial value to U.S. practitioners and researchers. The report was available on the Web shortly after the earthquake. The work represented exceptional international collaboration and provided invaluable reconnaissance training for young researchers. They have become leaders of the reconnaissance efforts that took place following major earthquakes in Turkey, Taiwan, and Washington State.

David Dobson of Texas A & M University received the first **Felix Klein prize** awarded by the European Mathematical Union. The award, made in June 2000, recognized Dobson for his work to design light-diffracting structures for use in devices such as laser instrumentation and optical communications equipment. The early part of this work was supported by an Industrial Postdoctoral Fellowship and by a Mathematical Sciences Postdoctoral Research Fellowship, both funded by NSF.

NSF supports very high quality, field programs in **global meteorology**. The Dynamics and Chemistry of Marine Stratocumulus (DYCOMS) program was a study of cloud microphysics, boundary-layer entrainment, and evaluation of the applicability of large-eddy simulation modeling of the coastal marine boundary layer. In addition to the US participants, DYCOMS included researchers from France and Poland. The Physical Meteorology (PMET) also contributed to support of the Cooperative Atmosphere-Surface Exchange Study-1999 (CASES-99) observational program, led by the Army Research Office and conducted in Kansas. CASES-99 sought to provide a testbed for obtaining high quality, comprehensive boundary layer and hydrological measurements in a small watershed in order to probe the structure of the nocturnal boundary layer and to seek to close the water balance in a small watershed. In addition to numerous US investigators, CASES-99 also involved European scientists from Scandinavia, Spain and the Netherlands.

International Plant Genome Collaboration: One investigator was involved in establishing workshops at the International Triticeae Mapping Initiative, involving a variety of genome and Expressed Sequence Tags (EST) projects related to the cereal crops, especially projects in Europe and Australia. Two others have collaborations with the International Rice Research Institute in the Philippines, and one of these also has formal collaborations with groups in Japan and Brazil. Another investigator heads up a project that has become the hub for research on the model legume system Medicago truncatula. This activity includes collaborations at the Centre National de Recherche Scientifique/Institut National de la Recherche Agronomique (CNRS/INRA) in France, the Agricultural University of Wageningen, the Netherlands. Another investigator has active collaboration with scientists at the Friedrich Miescher Institute in Basel, Switzerland.

Frederick Brooks of the University of North Carolina (http://www.cs.unc.edu/~brooks/) received the **Turing award**, the highest honor in computer science, in February 2000 for “landmark contributions to computer architecture, operating systems, and software engineering.” Dr. Brooks is now working primarily in the areas of computer graphics and supported in part by an NSF grant. This enables him to work on “Real-Time Walkthroughs of Serious Synthetic Environments” (http://www.cs.unc.edu/~walk/). The goal of this project is to create interactive computer graphics systems that enable a viewer to experience an architectural model by simulating a walk through of the model. While Dr. Brooks supplies much expertise for the integration of the system, other team members have made fundamental advances in computer graphics. This includes collision detection – for which Dinesh Manocha of the University of North Carolina (http://www.cs.unc.edu/~dm/) won the Best Paper award at Eurographics in 1999 – simplification of models for visualization, and image-based rendering.

INDICATOR 4: A public that is provided access to the benefits of science and engineering research and education.

RESULT: ***Demonstrated significant achievement. Examples follow.***

Explore the Universe: NSF is supporting the creation and installation of a major new permanent exhibit, *Explore the Universe*, in the Smithsonian Institution's National Air and Space Museum. This exhibit, opened in September 2001, provide the 9 million annual visitors to the Air and Space Museum with a perspective on how our understanding of the Universe has changed over time as the tools we use to study it have evolved. The exhibition makes use of a selection of artifacts, working models, images, interactive videos and computer programs, hands-on exhibits, and live demonstrations to explore scientists' view of the Universe as well as how they use ground- and space-based technology to study it.

Nanoworld 'Picture Books': To bring the nanoworld to everyone, the University of Wisconsin Materials Research Science and Engineering Center has developed a series of short web-based 'picture books' accompanied by hands-on demonstrations that illustrate nanoscale materials and devices. This work is the basis for a lead article in the Smithsonian's *Muse* magazine Spring 2001 issue dedicated to nanotechnology.

The American Association for Microbiology's Microbial Literacy Collaborative produced a four-part TV series that was viewed by 1.6 million households each week. As of June 2000, twenty thousand copies of this project's publication of hands-on activities, "**Meet the Microbe**," had been distributed nationwide (over half to individuals and organization upon specific request), and an additional 17,000 activities were downloaded from the www.microbeworld.org web site. This Website received 689,620 hits and recorded visits by nearly 29,800 individuals during its first month, and received over 3 million hits in its first year.

For the last fifteen years, the NSF and the United States Geological Survey (USGS), along with private foundations and universities, have made significant investments in development of the Global Seismographic Network (GSN) and its associated data collection facilities. **The Incorporated Research Institutions for Seismology (IRIS)** Consortium, in collaboration with the USGS, has begun to exploit this scientific resource for educational purposes, by making data from the GSN accessible to the general public through museum displays. By bringing live research-quality seismic data over the Internet and broadcasting it in museums, IRIS provides visitors with evidence that Earth's surface is in motion. Accompanying handouts and classroom exercises provide the visitor with follow-up educational materials. Currently, the IRIS Education and Outreach Program has museum exhibits at the American Museum of Natural History (NY), the Carnegie Museum of Natural History (PA), the New Mexico Museum of Natural History (NM), and an exhibit on tour with the Franklin Institute as part of their "Powers of Nature" exhibit. Together, these exhibits reach approximately 9 million visitors each year.

The **Thomas Edison Paper Project**, which NSF supported in the 1980s and early 1990s, has pursued the development of extensive materials accessible through the web. The Edison site now has more than a million pages on-line (http://edison.rutgers.edu/). NSF also continues to support the editing, annotating, and publishing of the ***Collected Papers of Albert Einstein***, of which Volume 8 was published in January 2002. The other large-scale, long-running infrastructure project supported by NSF is the publication of the **letters of Charles Darwin**. In 2001 the project released Volume 12 of the letters, covering 1864.

NSF **Informal Science Education (ISE)** programs are directed at improving science, mathematics, and technical skills for citizens of all ages by addressing how families learn in informal settings and by involving parents as participants in children’s science and math education. Projects targeting early childhood learners also demonstrate achievement of this indicator. ZOOM, a WGBH Educational Foundation media project and BUSYTOWN, an Oregon Museum of Science and Industry museum project, are examples of early childhood projects in science and mathematics programs supported by NSF.

National Virtual Observatory: FY 2001 saw the beginning of coordinated efforts to realize the National Virtual Observatory (NVO). This project, which received a strong recommendation from the recent National Academy of Sciences Decadal Survey, will federate astronomical data sets and establish them as a common resource for both researchers and the public. The project will focus not only on the archives, but also on establishing the protocols, standards, and tools that will permit the large astronomical datasets of the future to be fully utilized. Coordinated efforts are also underway at collaborating institutions to develop archives, visualization tools, and related resources. The first concept was developed with the help of an NSF Small Grant for Exploratory Research (SGER) award. NASA and NSF will be cooperating in this activity.

Area of Emphasis 1: Investments in K-12 systemic activities

The report ***Academic Excellence for Urban Students: Their Accomplishments in Science and Mathematics*** (Kim, 2001), an evaluative study of 22 of the Urban Systemic Initiative districts funded between 1994-1999, indicated that the urban program has been a catalyst for large-scale systemic change directed towards improving the science and mathematics achievement of all students. Further, the report presented evidence that the greatest gains were in districts that had participated in the Urban Systemic Initiative (USI) program for the longest period of time. Assessment results showed that USI students made gains in science and mathematics achievement, while reducing achievement gaps among racial/ethnic groups. Moreover, students in these districts substantially improved their enrollment rates in advanced science and mathematics courses. Additionally underrepresented minority students made even greater gains than their peers during the same period, resulting in reduced enrollment disparities in advanced courses. The study provides credible evidence that the implementation of a standards-based curriculum and instruction, aligned assessment practices, and appropriate professional development are key to an increase in student achievement. In addition, the results show that the convergence of resources, a strong leadership structure, and effective partners were also critical to the improvement in student performance. The study also concludes that it takes 7-10 years to bring about substantial improvement in systemic reform that may lead to the gains cited in the report.

The **Statewide Systemic Initiatives (SSI) Program** created “extraordinary activity in terms of very large statewide professional development efforts” and statewide curricular standards focused on more ambitious teaching and learning for children. In particular, there is evidence that infrastructures were created in state-level organizations to support this teaching and learning as well. The presence of such an infrastructure increases the likelihood that gains in student achievement will continue.

Area of Emphasis 2: Investments in enhancing instructional workforce (Centers for Learning and Teaching; Graduate Teaching Fellows in K-12 (GK-12) Education).

The **Centers for Learning and Teaching (CLT) Program** contributes in a significant way to the NSF's "enhancing instructional workforce" emphasis area. These centers offer a new approach to teacher education that responds to needs for increasing the ability of practicing teachers to deliver standards-based instruction; rebuilding and diversifying the national infrastructure for science, mathematics, and technology education; facilitating workforce induction/retention during initial years of service; and strengthening linkages between pre-/in-service teacher education. These large-scale projects are closely linked to K-12 school districts and required to build on shared expertise of local education agencies, institutions of higher education, and the informal science community. They link K-12, higher education, and/or informal science education performers to provide a systemic, K-graduate school approach for educating the instructional workforce in an environment of research and practice.

Two prototype centers were funded in FY 2000 and five additional full centers were funded in FY 2001. In addition, six Developmental grants were funded to build related institutional infrastructures.

The **NSF Graduate Teaching Fellows in K-12 Education Program** places graduate and advanced undergraduate students in K-12 schools to serve as science and mathematics content resources for teachers. The program supports the fellowships and appropriate training necessary for these fellows to enter the schools, but it is *not* a teacher preparation program. The primary objective of the program is to provide fellowships to highly qualified graduate and advanced undergraduate students in science, mathematics, and engineering and technology disciplines to achieve advanced degrees, *and* to contribute toward the improvement of the nation's schools, while introducing K-12 students and teachers to active researchers. This is part of a comprehensive approach to workforce development that reaches from grade school through graduate school. The expected outcomes of this initiative are: 1) improved communication and instructional skills for the Fellows; 2) professional development opportunities and content gain for K-12 teachers; 3) enriched learning by K-12 students; and 4) strengthened partnerships between institutions of higher education and local school districts. The GK-12 program seeks, in the words of one observer, to create "citizen scientists" for the 21st Century.

The AMANDA/IceCube project supported by the Graduate Teaching Fellows in K-12 Education Program (GK-12) is an exciting example of bringing scientific inquiry into the classroom. AMANDA (Antarctic Muon and Neutrino Detection Array) observatory located at the South Pole helps researchers track sub-atomic particles (neutrinos) as they pass by this array located 1500 meters below the polar ice cap. One of the teams supported by the GK-12 project integrates middle and high school education with the astrophysical research community involved with AMANDA. Graduate students, researchers, and teachers team up to develop a curriculum utilizing information generated by AMANDA. Through the "Astronomy in the Ice" course, teachers receive the astrophysical background they need to teach their students about AMANDA and related physical sciences. Throughout the year, graduate students serve as resource persons to schools while they establish communication networks with teachers and researchers. The GK-12 project couples education with the excitement of discovery and the understanding of science generated by the AMANDA/IceCube project.

Area of Emphasis 3: Investments in broadening participation (Tribal Colleges, Partnerships for Innovation).

The NSF initiative for *Tribal Colleges and Universities Program*[9] encourages Native Americans to pursue information technology and other science and technology fields of study, as well as increase the capacity of tribal colleges to offer relevant science and technology courses and enhance K-12 education in feeder school systems.

The project "Sustained Economic Growth of the **Oglala Lakota Nation** through Development of the Technological Infrastructure" is a multifaceted approach to developing the technological infrastructure of the institution and the reservation as a whole. Collaborations with several federal and state certified labs will provide the capacity to conduct research while strengthening curricula and developing new laboratory classes in several areas.

Programs are in place to foster gender-equity in the STEM disciplines such as the one at Arizona State University which involves guidance counselors who work with "**talented at-risk girls**" to improve self confidence and encourage them to enter the STEM fields. This program reached over 400 students at forty-eight schools including more than 100 Native Americans and 130 Mexican Americans.

The Rural Systemic Initiatives (RSI) Program has explicitly addressed the needs of **Native Americans** through the funding of several initiatives. An excellent example is the reconfiguration of the collaborative High Plains RSI into several individually funded RSI Tribal Colleges. By reallocating resources amongst the tribal colleges, the RSI has increased support to the rural systemic infrastructure serving Native American populations in the high plains. Another example would be the spin-off of the Navajo Nations RSI from the Utah-Colorado-Arizona-New Mexico (UCAN) RSI.

Two workshops brought together **Native experts** on sea-ice conditions that have affected whale hunting in the Arctic and scientists with their instrumental data, anthropological records, and sea-ice models. The symposia revealed a wealth of knowledge from both the scientific approach and Traditional Ecological Knowledge (TEK) that, when utilized together, enhance understanding of the impacts of environmental change on subsistence and cultural hunting practices.

NSF continuous its efforts to broaden community and public access to the benefits of scientific research. Several activities supported in 2001 were aimed directly at documenting **traditional indigenous knowledge**, cultural heritage, craft and subsistence practices for its sharing with and modern use by polar residents. Scientific knowledge collected by researchers and shared with communities increases awareness of modern economic, occupational, and social challenges, advances the ability to support public and educational initiatives, and improves potential responses in case of natural catastrophes and/or social losses.

[9] http://www.nsf.gov/pubs/2002/nsf02072/nsf02072.pdf, http://www.nsf.gov/od/lpa/news/press/00/pr0084.htm

NSF statistics show that large fractions of the students involved in the Engineering Research Centers (ERC) for FY 2000 were female and **underrepresented minorities** (URM). The 600 pre-college students included 48% female and 36% URM students; the 4000 undergraduate students included 29% female and 12% URM students; the 2200 graduate students included 22% female and 5% URM students; and the 344 Research Experiences for Undergraduate (REU) students included 39% female and 35% URM students.

With support from two NSF awards, researchers are addressing retention and participation of **traditionally underrepresented groups** in computing. Developing a framework involving undergraduate and graduate students in research, they have created laboratories to support research in neuro-fuzzy systems, parallel and distributed systems, signal processing and communication systems, software engineering, and theoretical applications. Students involved in this study include 73 graduate students (12 Ph.D. students); 102 undergraduate students; 136 students from underrepresented groups (38 female). To date 61 students graduated with BS; 38 students graduated with MS; two students graduated with a Ph.D. and 31 undergraduate students continued to graduate school. The distribution of publications, talks, and awards over the five years is as follows: over 150 research publications; over 100 research publications (journal and conferences) with students as co-authors; 23 publications and talks on the Affinity model; 66 student presentations at student conferences; 25 student awards and recognition.

The **Partnerships for Innovation (PFI) Program** focuses on connections between new knowledge created in the discovery process to learning and innovation. The goals of the program are: (1) to stimulate the transformation of knowledge created by the national research and education enterprise into innovations that create new wealth, build strong local, regional and national economies and improve the national well-being; (2) to broaden the participation of all types of academic institutions and all citizens in NSF activities to more fully meet the broad workforce needs of the national innovation enterprise; and (3) to create the enabling infrastructure necessary to foster and sustain innovation in the long term.

The $14 million in grants awarded in FY 2000 have been supplemented with over $7 million for 12 new grants[10] in FY 2001 to cover projects in 11 states involving more than 150 partner organizations. The lead institutions are selected to act as catalysts in helping their surrounding communities transform research-based knowledge into innovations that create opportunities for new wealth and a broader economic base that benefit communities and the nation at large. Examples of innovation that the grants are meant to foster might involve development of advanced new technologies to boost local economic growth. A university may serve as the research base, then incorporate its results into the corporate arena through knowledge and technology transfer. Corporate partners may develop the industrial processes for the innovation or product. Local governments or other non-profit activities may become a third leg in the partnership process by creating the climate for new businesses or funding the marketing of the product or innovation. Concurrently, a science and engineering workforce focused on innovation is created.

[10] http://www.nsf.gov/od/lpa/news/press/01/pr0188.htm#attachment

Area of Emphasis 4: Investments in addressing near-term workforce needs (Advanced Technological Education).

Advanced Technological Education (ATE) Centers of Excellence focus on systemic approaches to technician education, usually within a specific discipline. ATE Articulation Partnerships bring two-year colleges and four-year colleges and universities together to enhance two-year college programs for prospective K-12 teachers and for students who continue their education in four-year degree programs in science, mathematics, engineering, or technology. Fifteen Centers were active during FY 2001. In FY 2001 the ATE program supported 65 new projects and over 140 projects that were begun in previous years remained active. Cooperative efforts among ATE participants assure that the programs have a national impact. For example, the extensive collaborations of ATE projects with private industry have resulted in "skill standards" for technicians in particular fields and have enabled projects to develop real-world, workplace relevant educational materials and programs. In FY 2001 the program introduced two new emphases: (1) regional centers for information technology or manufacturing education to strengthen the workforce in the areas critical to the US economy and (2) "articulation partnerships" to facilitate the transition from two-year to four-year colleges for students preparing for technology careers or to become K-12 teachers.

The **Northwest Center for Emerging Technologies**, an ATE Center of Excellence at Bellevue Community College (Bellevue, Washington) is developing and refining industry-validated skill standards and associated curricula for information technology. The center's strategic partners include Microsoft, Boeing, and CompTIA (the Computing Technology Industry Association). In 1999–2000, those skill standards influenced or informed the education of approximately 78,000 students nationwide. In the same period, over 500 students took classes using courseware that the center developed in partnership with Dryden Online, and the center sold or licensed over 1,000 copies of its internally developed curricular products, which were used in the instruction of over 50,000 students. Microsoft recently produced a video profiling how the center stays on the cutting edge of information technology (IT) education.

The goal of "**Digital Arts and Sciences**" at the University of Florida is to train students to acquire a hybrid-knowledge of computer engineering and the arts, enabling them to understand the formalism of visualization and the practicality of human communications that deal with aesthetic interpretation. This enables students to work effectively in production-oriented teams focused on education, interactive games, scientific and engineering visualization, software engineering, and video production. Research is integrated in an Aesthetic Computing course and a series of Digital World Production Studio courses to the curriculum. Fine arts as well as computer science and engineering students will take these courses. "Aesthetic Computing" uses genres and styles in fine art as metaphors for formal and diagrammatically rendered model structures commonly found in computing, including automata, data flow graphs, data models, and the comprehensive Unified Modeling Language (UML). This work involves areas generally regarded outside the sphere of computer science, including semiotics, linguistics, analogy, metaphor, and the arts.

PERFORMANCE GOAL III-1b: Over 80 percent of schools participating in systemic initiative programs will (1) implement a standards-based curriculum in science and mathematics; (2) further professional development of the instructional workforce; and (3) improve student achievement on a selected battery of tests, after three years of NSF support.

✕ Goal Not Achieved

NSF manages a portfolio of programs that encourages and facilitates coordinated approaches to systemic, standards-based reform of science, mathematics, and technology (SMET) education. Systemic reform relies on partnerships to identify needs, articulate visions, and develop goals, strategies, and activities for improvement of targeted areas. Although each systemic initiative is unique in its approach, all must begin as a collaborative effort among individuals and organizations that are committed to requiring high expectations for all students through challenging educational opportunities. Systemic initiatives cultivate coordination within cities, states, rural areas, school systems, and other organizations involved with education.

RESULTS: We did not achieve this goal in FY 2001. The curriculum, instructional workforce, and improved achievement in science components of the goal were successful. However, less than 80% of schools met the goal of improved student achievement in mathematics. Forty-seven Systemic Initiative projects implemented mathematics and science standards-based curriculum in 89% of the participating schools and provided professional development for more than 226,900 teachers. The Systemic Initiative projects reported improved student achievement in math in 74% of the 6,255 schools and improved student performance in science in 80% of the 4,082 schools using the same assessments for the last 3 years.

<u>FY 1999 Result:</u> In 1999, 46 NSF-sponsored projects implemented mathematics and science standards-based curricula in over 81% of participating schools, and provided professional development for more than 156,000 teachers. All participating educational systems demonstrated some level of improvement in student achievement in mathematics and science.

<u>FY 2000 Result:</u> In 2000, 47 Systemic Initiative projects implemented mathematics and science standards in over 80% of the participating schools and provided professional development for more than 214,792 teachers. The Systemic Initiative projects reported improved student achievement in math in 81% of the 4,187 schools and improved student performance in science in 86% of the 2,474 schools using the same assessments for the last 3 years.

WHY WE DID NOT ACHIEVE THIS GOAL: No single factor has been identified that explains the drop in performance on student achievement relative to FY 2000 and FY 1999. Fluctuations in performance from year to year are expected, since there are differences in which schools are included within projects, and projects are able to use their own criteria for what constitutes an increase in student achievement. Review of performance data by NSF indicated that the goal for student achievement was not met for mathematics at some sites because, during the year, they adopted a more rigorous definition of increased student achievement.

STEPS WE WILL TAKE IN FY 2002 TO ACHIEVE THIS GOAL: In FY 2002, appropriate technical assistance will be provided to schools not meeting the goal.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be maintained in FY 2002.

Performance Goal III-1c: Through systemic initiatives and related teacher enhancement programs, NSF will provide intensive professional development experiences for at least 65,000 pre-college teachers.

✓ Goal Achieved

Teacher professional development is a core strategy used by EHR-supported projects to promote reform. For example, in the Saint Louis Systemic Initiative schools, more than 75% (1,239 of 1,600) of the science and mathematics teachers received intensive professional development during the 1999-2000 school year.

RESULTS: In school year 1999-2000, EHR awards provided intensive professional development (60 hours or more) to a total of 79,000 teachers, exceeding substantially the GPRA goal of 65,000.

TEACHER PROFESSIONAL DEVELOPMENT

	FY 1999	FY 2000	FY 2001	FY 2002
Goal	>65,000	>65,000	>65,000	N/A
Actual Number of Teachers	82,400	89,700	✓**79,000**[11]	

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This performance goal is not part of our FY 2002 Performance Plan. For FY 2002 NSF has reapportioned a substantial amount of the funds for the Systemic Initiatives to support the new Presidential Math and Science Partnership (MSP) activity. No new competitions or awards are anticipated under the Systemic programs. A goal related to the MSP has been included in the FY 2003 GPRA Performance Plan.

[11] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

NSF OUTCOME GOALS

B. IDEAS

People
Development of 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.

Tools
Providing broadly accessible state-of-the-art and shared research and education tools.

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

✓ 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 promote 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.

This is a new goal in FY 2001. Our performance is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement for one or more of the following indicators:

- A robust and growing fundamental knowledge base that enhances progress in all science and engineering areas including the science of learning;
- Discoveries that advance the frontiers of science, engineering, and technology;
- Partnerships connecting discovery to innovation, learning, and societal advancement;
- Research and education processes that are synergistic.

RESULT: External experts provided examples of significant achievement in reports they developed during FY 2001 reporting. A sample of these is provided for each of the performance indicators and areas of emphasis for this goal.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be continued in FY 2002. The performance indicators related to the Ideas goal have been expanded and modified to appropriately reflect the breadth of NSF activities (see Section X. for details).

INDICATOR 1: A robust and growing fundamental knowledge base that enhances progress in all science and engineering areas including the science of learning.

RESULT: ***Demonstrated significant achievement. Examples follow.***

One study that has captured significant scientific attention, as well as public interest, is the confirmation of viable microorganisms throughout the 4-km long ice column overlying **Lake Vostok**, **Antarctica**. This has implications for the presence of life in the lake itself. NSF supports a diversity of ecological investigations including Arctic bird adaptations, arctic tree growth and needle retention, establishing the metabolic rates of cold-adapted organisms, feedbacks between vegetation and climate change, and the phylogenetic composition of polar bacteria.

The 1987 Whittier Narrows earthquake revealed the need to improve understanding of the **impact of major natural disasters on the business sector**. Most of the existing research had focused on the economic impacts of disasters on households and families. The NSF-supported principal investigators were able to carry out a large-scale survey of businesses in Memphis/Shelby County, TN on business owners' perception of earthquake hazard, on their judgment of vulnerability to and effects of lifeline disruptions, and on their preparedness measures. Similar data was collected from the Northridge earthquake. Another NSF grant extended such studies to Santa Cruz County, CA and Dade County, FL. Overall, these studies have produced data on nearly 5,000 businesses of all sizes and types, comprising the largest database on business disaster readiness and effects in the world.

Advanced techniques have been developed for the communications, coordination, and vision of autonomous **multi-robot systems**. This allows robots to coordinate with each other in varying environments. When obstacles are presented in their path, the multi-robot systems can rearrange themselves to navigate around the object and then return to their original formation. For example, three small robots can coordinate themselves to sense, coordinate, and move a large object that could not be moved by a single robot.

What are the **predictors of children's learning interests** and how does parental involvement influence learning? Findings indicate specific parental traits that influence children's learning: Most importantly, children who develop focused encyclopedic play interests tend to have parents that value family discussions. Why does the value of family discussions predict children's interests? Children cannot easily learn about some domains without adult help; they need parents to talk with them about the domain, to read them relevant books, to participate in their play, and to provide them with relevant resources (toys, models, etc). Preschoolers cannot acquire this kind of knowledge on their own. The impact of **adult investment in child learning** is not insignificant: Children who develop focused encyclopedic play interests are more likely to be boys (by a factor of 5) and to demonstrate higher cognitive skills (particularly verbal).

An NSF-supported project has developed a process for the conversion of silicon carbide (SiC) to crystalline diamond at ambient pressure. This has direct application to the surface science of microelectromechanical systems (**MEMS**). The entire technological field of MEMS represents an area that is gaining momentum with the commercialization of these devices in applications in communications, transportation and aerospace. An article describing this work was published in *Nature* and received substantial attention from the news media.

A suite of investigations has examined the stability of the **West Antarctic Ice Sheet (WAIS)**, a potential contributor to rising sea levels. Results from glaciological modeling and glacial geologic research have highlighted a rapid retreat of the WAIS grounding line in the Ross Sea since the end the last glacial stage. Glacial geologists have developed a history of grounding line retreat for the WAIS. Results concerning the retreat of the WAIS have been of widespread interest, particularly for those who are studying past and present changes in sea level, ocean circulation, and atmospheric circulation.

Predicting the **properties of materials** from first principles (i.e. from the behavior of their atoms and molecules) is an important and challenging field. The challenge comes from the range of scales required - from electrons to clusters large enough to be seen. To span this range, researchers supported by NSF have developed numerical algorithms and a software infrastructure to implement hierarchical and adaptive methods to concentrate the solution on areas of greatest interest. The algorithms include techniques that improved previous techniques by 100-fold in terms of computer time and memory. The software infrastructure included the well-known Kernel Lattice Parallelism (KeLP) system, which manages communications among the memory hierarchies of parallel computers. KeLP is a framework for implementing portable scientific applications on distributed memory parallel computers. It is intended for applications with special needs, in particular, that adapt to data-dependent or hardware dependent conditions at run time. KeLP is currently used in full-scale applications including subsurface modeling, turbulence studies, and first principles simulation of real materials. In addition to materials design, KeLP has been applied to a wide range of partial differential equation solutions.

Neutron stars are born in supernova explosions when approximately one solar mass of burnt nuclear matter in the core collapses from about the size of the Earth to the size of an average city. The collapse of matter into this dense core can leave the **newborn neutron star** spinning extremely rapidly, some 1,000 revolutions per second. NSF-supported researchers have carried out the most detailed computational modeling ever done of the stability of these stars. In addition to surprising new insights into neutron stars, these simulations are yielding a clear “signature” to search for as the new Laser Interferometer Gravitational-Wave Observatory (LIGO) tries to detect gravity waves directly for the first time.

INDICATOR 2: Discoveries that advance the frontiers of science, engineering and technology.

RESULT: ***Demonstrated significant achievement. Examples follow.***

Researchers have, through the use of mathematical modeling, devised a simple and inexpensive method for the prevention of **Chagas disease**. A model predicted how four populations-bugs, chickens, dogs and people-interact with the protozoan parasite *Trypanosoma cruzi* each season in an individual household. The model allowed the researchers to determine that the practice of keeping chickens and dogs inside the house increased the population of blood-feeding bugs called triatomines, also known as the "kissing bug," which in turn increase the parasite population that causes Chagas disease. By excluding infected animals from sleeping areas and spraying insecticides on a predetermined schedule, the people could virtually eliminate transmission of the parasite.

Cloning clock genes: In circadian biology, largely supported and fostered by NSF, "clock" genes have been cloned from several species, and the mechanisms by which circadian rhythms are generated are now being defined. In 1998 a Science magazine cited this research area as one in which major advances were made, and this research has now risen to the public consciousness. These areas, largely initiated by and nurtured by NSF, have become incorporated into the common knowledge base of undergraduate biology and ultimately many of the important advances are incorporated into the public consciousness.

The Arctic Oscillation and global change: The Arctic Oscillation, an annular mode of atmospheric circulation, has been linked in recent years to a variety of issues in the detection and diagnosis of global change. NSF-supported investigators have played leading roles in the study of this annular mode, beginning with Wallace and Thompson's introduction of the term "Arctic Oscillation" (or "AO") in the late 1990s. The AO is strongest in the Atlantic sector of the Northern Hemisphere and has direct effects on the climate of Eurasia, eastern North America, and the Arctic. A large portion of decadal climate variability, including large-scale temperature and precipitation anomalies in the Northern Hemisphere during the 1980s and 1990s, is associated with the AO. There is evidence of a similar mode in the Southern Hemisphere, where this mode appears to have played a role in recent trends in the atmospheric and sea ice conditions. It has been shown that the coherent vertical structure and phasing represents the strongest evidence to data of a dynamical coupling between the upper atmosphere and near-surface climate. There are tantalizing indications that stratospheric variations can precede surface variations, offering potential predictive possibilities for short-term climate variations, although the robustness and physical basis of this linkage require further investigation. In addition, there are suggestions that there may be a linkage between stratospheric chemistry (possibly including decreases of stratospheric ozone) and the troposphere via the stratospheric circulation.

Research groups supported by NSF pioneered the use of high precision measurements of the oxygen/nitrogen (O_2/N_2) ratio in air to study the biogeochemical cycles of carbon and oxygen. The ability to monitor these fluxes in real-time is clearly a critical asset in terms of developing the capability for managing a national or global carbon emission strategy. Using two independent techniques, mass spectrometry and interferometry, they have documented regional and global variations in O_2/N_2 and explored the use of this data to place constraints on the fluxes of carbon dioxide (CO_2) and oxygen between the atmosphere, ocean, and terrestrial biosphere. The combination of atmospheric O_2/N_2 and CO_2 provides **a powerful tool to study the fate of fossil fuel.** This is true of CO_2 because it allows discrimination between uptake via inorganic dissolution in the oceans (which does not release oxygen) and photosynthesis (which does release oxygen). The record to date has revealed significant interannual variability in the magnitude of the terrestrial biospheric sink for CO_2. The ability to detect interannual variability in these fluxes is invaluable in terms of understanding the factors controlling them. For example, 1998 appears to be an anomalous year during which apparently all of the anthropogenically (man-made) emitted CO_2 remained in the atmosphere and O_2 fell abruptly. This suggests that more CO_2 than usual was released by the land biosphere. This line of research has a significant impact on several fields of research, including climate, ecosystem studies, and oceanography.

Environmental factors in human health: The Center for Integrated Studies of the Human Dimensions of Global Change (CIS-HDGC) at Carnegie Mellon University has been exploring the ramifications of a broad range of interactions among human behavior, engineered systems, and natural processes through refinement, adaptation, and expansion of a highly sophisticated, integrated assessment model. In one application designed to better understand the role of environmental factors on human health, CIS-HDGC investigators developed and tested a model for assessing risks associated with *Cryptosporidium*, the water-borne parasite that sickened hundreds of thousands in the Milwaukee area during the early 1990s. The model integrates processes associated with engineering (water treatment technologies), ecology (land-use and land-cover patterns), biology, (proliferation of and testing for parasites), public health (surveillance and notification), and psychology (public perceptions and responses). One analysis using this model demonstrated that under typical conditions in the U.S., traditional responses to *Cryptosporidium* outbreaks calling for the boiling of drinking water are ineffective because most vulnerable people have been exposed before the problem is detected. Analyses designed to assess whether climate changes might increase threats to human populations demonstrated that changes in physical conditions were relatively unimportant as long as effective public health systems and procedures remained in place. As with related analyses of the risks associated with air pollution, the *Cryptosporidium* studies showed the importance of effectively incorporating social institutions into predictive models.

NSF has supported two major surveys of approximately 25,000 Internet users in late 1997 and late 1998 to examine **the sensitivity of Internet commerce to tax rates**. Tax sensitivity is high and is not falling despite the rapidly increasing number of new users because as new users gain experience, particularly young Internet users, their tax sensitivity appears to rise substantially. Internet commerce as a whole continues to be highly sensitive to tax rates and would fall significantly if existing sales taxes were enforced online. This research suggests that applying existing sales taxes to Internet commerce might reduce the number of online buyers by up to 24%. But the data also suggest that the potential sales tax revenue losses from continued exemption of Internet commerce would be quite modest over the next several years. So, taxing Internet commerce would not yield much government revenue and would substantially setback and slow the growth of e-commerce (http://gsbadg.uchicago.edu/).

An innovative proposal supported by NSF deals with the design of **palm size airplanes**, among the world's smallest, using flexible wings made of composite materials. The flight characteristics of these airplanes are similar to biological counterparts. The aircraft can be used in unmanned surveillance and reconnaissance missions.

An NSF award has supported groundbreaking research into the signal transduction pathway controlling responses to the hormone ethylene in plants. This research has used mutational and positional cloning approaches to identify genes that are involved in **ethylene signaling**. Ethylene signaling is now better understood than any other plant hormone signal transduction pathway. Responses to hormones such as ethylene affect plant growth and development, and their ability to adjust to adverse environmental conditions, and by extension to crop quality.

Classroom 2000: How does one substantially reduce the human input for creating and accessing large collections of multimedia, particularly multimedia created by capturing what occurs in an environment? The existing software system used as the starting point for this investigation is **Classroom 2000**, which is designed to capture what happens in classrooms, meetings, and offices. Classroom 2000 integrates and synchronizes multiple streams of captured text, images, handwritten annotations, audio, and video. In a sense, it automates note taking for a lecture or meeting. The research challenge is to make sense of this flood of captured data. The project explores how the output of Classroom 2000 can be automatically structured, segmented, indexed, and linked. Machine learning and statistical approaches to language are employed to understand the captured data. Techniques from computational perception are used to find structure in the captured data. An important component of this research is an experimental analysis of the software system being built. It is expected that this research will have a dramatic impact on how humans work and learn, as the developed technology will aid humans by capturing and making accessible what occurs in an environment.

Most physicists believe that general relativity ceases to provide a good description of the physical reality in the vicinity of the Big Bang. On general physical grounds it is clear that such a theory must incorporate effects not only of general relativity but also of quantum physics. NSF-supported researchers, attempting to unify general relativity and quantum physics, have found that at the tiniest scale conceivable today, called the Planck length (10^{-33} cm), the continuum picture of space breaks down and has to be replaced by a precise 'polymer-like geometry.' While at the laboratory scales (10^{-18} cm and above) this true geometry can be approximated by a continuum, the approximation fails miserably near the Planck scale. As the universe expands, its volume does not change continuously but only in discrete steps. Near the Big Bang one must abandon the use of differential equations on which most of physics is based and replace them by more fundamental difference equations describing the 'true' time-evolution. Once this is done, infinities disappear and regular physics is restored without any ad-hoc assumptions. While general relativity is an excellent approximation for today's universe, **space-time 'dissolves' near the Big Bang**. Einstein's deterministic, geometric universe has to be replaced by a specific, probabilistic universe built from polymer geometry.

INDICATOR 3: Partnerships connecting discovery to innovation, learning, and societal advancement.

RESULT: ***Demonstrated significant achievement. Examples follow.***

NSF's **Children's Research Initiative** (CRI) is providing five years of support for research centers that are developing new thrusts in the field of integrative developmental science. Individually, the centers represent leading edge research about children and media, developmental science, and the integration and dissemination of developmental science to inform both research and policy.

The *Research Center on Children and Media* is a collaboration of five research entities across four universities: Georgetown University, Northwestern University, University of Texas – Austin, and University of California-Los Angeles. The research activities of this center emphasize the types and impacts of emergent digital media on children; interactive media experiences on children's social and academic adjustment; how digital media impact learning; and influences of media on the developing brain.

The *North Carolina Child Development Research Collaborative (CDRC)* builds upon multidisciplinary activities across departments at the University of North Carolina-Chapel Hill, Duke University, University of North Carolina-Greensboro, and North Carolina State University. Investigators from diverse areas of developmental inquiry – health, nursing, social work, education, and developmental psychology – form the CDRC and have a common objective of developing an integrative model of developmental science. Their interdisciplinary approach to human development encompasses the main levels of analysis from the cultural and societal levels studied by anthropologists and sociologists to the neural and genetic levels studied by biologists and neuroscientists.

Development and use of a mixed-lubrication laboratory for **university-industry collaboration** and education has provided work experience for graduate students through partnerships with a major oil company, an automobile firm, a manufacturer, and a federal agency. In addition to enhancing the professional development of the Principal Investigator (PI), one post-doc, three graduate students and four undergraduates were involved in this project. There was interaction with NASA Marshall Space Flight Center, Mobil Technology Company, Ford Motor Company, Ilmor Engineering, Ltd and The Timken Company. These industrial partners provided the matching funds, enabling the PI and his students to leverage the NSF-supported research. Experiments were conducted in the university laboratory and at some of the industrial sites. A senior undergraduate/graduate course in tribology (the study of the effects of friction on moving machine parts) was developed and taught several times. Four industry experts were invited to give guest lectures to the class. The NSF funds were used as seed monies to stimulate the university/industry collaborations. Several students designed and built apparatus and computer programs that are now used at some of the industrial laboratories. The research collaborations led to links between theory and practice on how to best balance calculation accuracy and application practicality. Eleven conference and journal papers produced reflect this concept. The benefit of the award goes beyond the project period, since the PI still interacts with some of the industrial partners and is creating relations with new partners. Some of these new relations reflect ideas that were "seeded" during the NSF-funded project but came to fruition after it was completed.

In Antarctica, a recently recovered ice core from Siple Dome reveals a record of **rapid climate change** that appears to be correlated strongly with northern hemisphere changes. These data strongly suggest global links in the climate system. These data are also crucial for assessments of the state of the climate system, such as the recent Intergovernmental Panel on Climate Change (IPCC) 2001 Report, that provide information for policy-makers.

Icing models for aircraft: An NSF-supported Engineering Research Center at Mississippi State University working in collaboration with the Centers for Research Excellence in Science and Technology (CREST) project at Tennessee State University is engaged in the development, application, and evaluation of one-dimensional icing models with important implications for the safe operation of commercial aircraft.

NSF supports many atmospheric research programs that involve large numbers of partnerships – both among multi-disciplinary groups and among international researchers and institutions. The **U.S. Weather Research Program** (USWRP) is one such program. NSF, the National Oceanic and Atmospheric Administration (NOAA), the Federal Aviation Administration (FAA), and the Naval Research Laboratory (NRL) jointly support the USWRP. Its overarching objective is to conduct fundamental and applied research that will lead to improvements in various aspects of weather forecasting, such as hurricane landfall and quantitative precipitation prediction. The USWRP supports research in two categories--physical scientific research and identification of the societal needs for forecast information. The latter seeks to identify societal impacts of weather and weather information, determine the types of weather products that users require, and better understand how these products are or might be used. This, in turn, provides input and direction to the scope and focus of certain of the physical research studies.

A strong emphasis in the Experimental Program to Stimulate Competitive Research (EPSCoR) is the development of partnerships connecting discovery to innovation, learning, and societal advancement. A major concern of EPSCoR states is **economic development** and many EPSCoR projects produce results that are quickly transferred to industrial partners or result in new small businesses. One example involves the University of Alabama - Huntsville, where a team is developing an integrated research environment for intermeshed optoelectronics, thus allowing the study of systems in which optical and electronic elements are intermeshed in close physical proximity. Through the acquisition of a field emission scanning electron microscope the microfabrication facility is being expanded into a nanofabrication facility. The research and facilities supported by this project have resulted in over $1 million in fabrication contracts and $2 million in private cash donations for expansion of the cleanroom facility and purchase of additional equipment to expand nano- and microfabrication capabilities.

INDICATOR 4: Research and education processes that are synergistic.

RESULT: ***Demonstrated significant achievement. Examples follow.***

NSF supports a number of **Collaboratives to Integrate Research and Education (CIRE)**. These Collaboratives are designed to establish long-term research and education relationships between minority-serving institutions and NSF-supported facilities and centers by using both the human and practical resources of the facilities and centers to establish joint research programs and sponsor summer exchange programs. For example, the University of Puerto Rico at Humacao, and the Materials Research Science and Engineering Center (MRSEC) at the University of Pennsylvania are such a collaborative. A new Masters program in materials physics, the first graduate program at UPR-Humacao, has been developed through the collaboration. The annual University of Pennsylvania-UPR CIRE meeting was held in Puerto Rico in October 2000[12]. The meeting featured Alan MacDiarmid who gave an inspirational talk to over 400 undergraduate and high school students in Humacao. This was the first meeting MacDiarmid attended after he was recognized with the 2000 Nobel Prize in Chemistry earlier that month.

In 2001 NSF offered its third **Biology Training Course in Antarctica**. This past year an international graduate-level training course entitled "Integrative Biology and Adaptation of Antarctic Marine Organisms" was offered. Taught in Antarctica for one month during the austral summer, the participants included 22 individuals from six countries (18 graduate students and 4 postdoctoral researchers). The goals for the course were to introduce students to the diversity of organisms in Antarctica, to study the unique aspects of biology that permit life in such an extreme environment, and to give students firsthand experience in dealing with the unique problems inherent to Antarctic field sampling. The research emphasis of the course was on experimental Antarctic biology, allowing a number of aspects of evolution, physiology and ecology to be considered. These included investigations on bacteria, algae, invertebrates and fish that addressed molecular phylogeny, ultraviolet radiation effects, energy metabolism and biochemical adaptations to cold temperature. The course attracted an extremely competitive group of young scientists, introduced new researchers to Antarctica, and provided participants the opportunity to use the most modern research methods to study mechanisms that are unique to polar biology. The course also fostered collaborations between participants that will further influence their future research activities.

Research Experiences for Undergraduates (REU) Sites: This program introduces undergraduate students to meaningful science and engineering research, and in many cases, motivates them to continue studies for an advanced degree in the science and engineering disciplines. A hallmark of the REU program is diversity, not only in terms of the participating students, but also in the geographic locations, participating institutions, and available research areas. REU sites are located across the country. At all REU sites participating students choose research projects from a spectrum of both traditional and interdisciplinary topics. Some activities allow students to participate in international research collaborations. For example:

- The Division of Chemistry (CHE) has one of the largest investments in REU sites in the National Science Foundation. Support is provided for 64 sites in 32 states where more than

[12] http://www.lrsm.upenn.edu/lrsm/outr.html#CIRE

600 students conduct research each summer. Half the participants are female, and 23% are from underrepresented ethnic or racial groups.

- The REU sites supported in the Division of Astronomical Sciences play a crucial role in providing a science and technology workforce that reflects America's diversity. For example, of the 125 undergraduates supported in FY 2001, fully 50% of them were women and 15% were from members of underrepresented minority groups.
- The Division of Mathematical Sciences supported 243 undergraduates on research awards and an additional 296 undergraduates at 29 Research Experiences for Undergraduates (REU) sites.
- The Division of Physics supported 55 REU sites in 2001, providing undergraduate research opportunities for approximately 700 students. Eight of the physics REU sites also include Research Experiences for Teachers (RET) programs to bring high school teachers into the research experience.
- The Division of Materials Research supported the research efforts of well over 1,000 undergraduates in FY 2001, including 760 at REU Sites, Materials Research Science and Engineering Centers (MRSECs) and other national facilities, and several hundred more through individual-investigator awards. About 350 students participated in summer research experiences at 36 locations established through the annual NSF-wide REU site competition. In addition, 23 MRSECs supported by DMR in FY 2001 incorporated REU Sites as an integral part of the MRSEC efforts; about 380 students participated. DMR user facilities including the National High Magnetic Field Laboratory and the Synchrotron Radiation Center also supported REU Sites involving 30 students[13].
- The Cross-Directorate Activities Program (CDA) in the Directorate for Social and Behavioral Sciences supported 24 REU sites in FY 2001. Forty percent of the Principal Investigators for these sites are female and 13% are underrepresented minorities. Almost 50% of the nearly 200 students participating in these sites are underrepresented minorities and two-thirds are female.
- One additional example comes from the **Oklahoma Weather Center (OWC)** REU activity. It is bringing 30 undergraduate students, over a three-year period, to Norman, Oklahoma to participate in the OWC program. Each student: 1) was matched with an atmospheric scientist based upon his/her interest and ability to conduct research; 2) attended atmospheric science lectures; 3) participated in workshops on topics such as technical writing, numerical modeling, meteorological tools, graduate school preparation; 4) participated in field trips to regional sites; 5) tried various research methods, 6) collected and analyzed data; and 7) presented his or her research results in an formal presentation and a written paper. The NSF REU program was leveraged by incorporating students participating in similar programs sponsored by NSF's CIRE (Collaboratives for Integration of Research and Education) and the Department of Energy's ORISE (Oak Ridge Institute for Science and Education) programs.

[13] http://www.nsf.gov/mps/divisions/dmr/research/c_reusites.htm

Area of Emphasis 1: Appropriate balance of high risk, multidisciplinary or innovative research across all NSF programs.

Maintaining a diverse, balanced portfolio is an essential aspect of any investment strategy, and this holds true for investments we make 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.

Our external reviewers assessed our investment portfolio for FY 1998, FY 1999 and FY 2000 with respect to this area. There were numerous comments on this area of emphasis, and the vast majority of these comments indicated that investments made by the Directorates contained an appropriate balance of high-risk, multidisciplinary or innovative activities. Some of our COVs felt, however, that NSF needed to support more high-risk activities. Some comments from our Advisory Committees and COVs:

- "In FY 2001, the Directorate funded $28.14 million in awards for the Network for Earthquake Engineering Simulation (NEES)—a high risk program to shift the emphasis of earthquake engineering research from physical testing to integrated experimentation, computation, theory, databases, and model-based simulation."

- "The Engineering Directorate invests heavily in high-risk research and education activities in Nanoscale Science and Engineering."

- "In addition to the single investigator grants, the directorate places a high priority on multidisciplinary work and on partnerships. Within MPS, the Office of Multidisciplinary Activities serves as a catalyst in emerging areas of research and education at disciplinary boundaries."

- "The balance of high-risk, multi-disciplinary or innovative research was cited as a particular success; the examples give ample evidence of success; the awards in the ITR program position CISE for continued success in this area of emphasis."

- "The OAC noted that the mix of research activities OPP sponsors cuts across the spectrum from high risk to high innovation. In supporting research that is considered on the "cutting-edge," OPP makes investments that require taking risks."

- "The COV generally felt there was a good balance to the portfolio but more high-risk projects should be considered …."

- "All projects, because of the nature of the program, systemic focus in extremely complex organizations that serve urban, diverse, low-socio-economic districts, are high-risk. In this area, balance of the portfolio is especially important."

- "Using data compiled by the Division for its various component programs, it is clear that funded proposals generally display a high degree of novelty and disciplinary impact with a medium (theory) to medium high (experimental) level of risk. There was no evidence of bias against proposals, which were of high risk, multidisciplinary, and innovative. There was appropriate evidence of bias against proposals that were not innovative. In two cases, one could interpret the unsuccessful outcome of the proposals as being due to an insufficient level of risk."

- "The division seems to have an appropriate balance of high risk and multidisciplinary projects."

Examples of high-risk, innovative, or multidisciplinary awards include support to:

- Determine whether electrical stimulation can control neural cell behavior as well as chemicals;
- Explore the use of nanotechnology techniques for DNA sequencing, based on a pioneering technology that combines the fields of nanotechnology, new fractionation science, and single-molecule molecular biology. This technology could become the basis for the development of a "biology laboratory on a chip."
- Develop novel experimental techniques that will make it easier to study chemical reactions at the atomic scale. The results will pave the way for the design of catalyst nanoparticles to enhance the performance of methanol fuel cells.
- Develop a multidisciplinary bioprocessing curriculum that integrates expertise from biochemistry, microbiology, chemistry, botany, and chemical engineering. This effort has led to a new multidisciplinary graduate training program in "technologies for a bio-based economy."
- Investigate the feasibility of creating sophisticated folded structures from metal and polymer sheets for applications requiring light but stiff structures;
- Work with automotive engine designers to cut down vibration and shake in combustion engines. Researchers are exploring an approach similar to that used in skyscrapers.
- Develop computational and statistical methods to evaluate comparative genetic map data;
- Test a novel expression vector system developed to directly rescue open reading frames (ORFs) from genomic DNA;
- Collect large amounts of expressed sequence information for floral structures across the angiosperms and gymnosperms, and use the information to determine which genes are required for floral organ development. This represents the first of a new kind of Virtual Center funded in FY 2001. Its focus is "evolutionary genomics".
- Determine the presence or absence of biological signatures in Antarctic meteorites;
- Use high-resolution satellite imagery to census Emperor penguin colonies;
- Develop new sampling and measurement methods and tools to explore under the Arctic Ocean ice cap in the Gakkel Ridge region;
- Develop autonomous underwater vehicles (AUVs) designed to explore and collect samples from underneath Arctic sea ice or Antarctic ice shelves;
- Study biology on surfaces. This is an example of research at the interface between the physical sciences of surfaces and the life sciences of biological organisms.
- Have a highly multidisciplinary team of scientists look at environmental catalysis and environmental interfacial characterization.

Area of Emphasis 2: Investments in three initiatives [Information Technology Research (ITR), Nanoscale Science and Engineering, Biocomplexity in the Environment (BE)].

Examples follow.

A number of multidisciplinary areas of research and education are identified as being of particular importance for their potential connections to use in service to society. These fit within the Foundation's broad emphasis areas of ITR, BE, and Nanoscale Science and Engineering. The amounts invested in FY 2001 are given in the following Table:

FY 2001 INITIATIVES (MILLIONS OF DOLLARS)	
Information Technology Research	$216.27
Nanoscale Science and Engineering	$149.68
Biocomplexity in the Environment	$54.88

***Information Technology Research* (ITR):** We have been designated as lead agency for a multi-agency *Information Technology Research* initiative begun in FY 2000. In supporting research and education in the ITR area, we work in partnership with other agencies.

Advanced information technology has expanded the scope of science and engineering – from the subatomic level to the cosmos – by adding the computer as a third partner to the time-tested methods of theory and experimentation. This new, virtual mode of inquiry is where much of today's most important fundamental research is happening. Virtually every field of science and engineering now benefits from – and in many cases relies heavily on – the use of information technology (IT)

IT research and education has also fundamentally changed almost every sector of our **society and economy**. Economists, including Federal Reserve Bank chairman Alan Greenspan, agree that advances in IT have dramatically boosted productivity of the U.S. workforce. To quote Mr. Greenspan:

> "When historians look back at the latter half of the 1990s a decade or two hence, I suspect that they will conclude we are now living through a pivotal period in American economic history….It is the growing use of information technology throughout the economy that makes the current period unique[14]."

While development of commercial products is not the point of basic IT research, the field has recently yielded spectacular results. In the early 1990s, for example, students working under the direction of senior researchers at an NSF supercomputing center helped create Mosaic, the **web browser** that helped trigger a new era of electronic commerce. Other prior successes of NSF-funded IT research and education activities include the vast expansion and privatization of

[14] Speech to the Boston College Conference on the New Economy, March 6, 2000

Internet infrastructure in the mid-1990s, and projects that led to many of today's leading commercial web search engines such as Lycos, Google and Inktomi.

- **Intelligent radar sensors:** NSF supported an ITR award for the development and deployment of intelligent radar sensors for measuring key glaciological parameters. Radar instrumentation will consist of a synthetic aperture radar (SAR) that can operate in bistatic or monostatic mode. A tracked vehicle and an automated snowmobile will be used to test and demonstrate the utility of an intelligent radar in glaciological investigations. This project involves innovative research in intelligent systems, sounding radars and ice-sheet modeling. In addition it has a very strong public outreach and education program that includes near-real-time image broadcasts via the World Wide Web.

- NSF is supporting a project to make computers more proactive in their interactions with people. In **human interaction**, someone who waits for each command before making any communication attempt would be regarded as uncooperative and unhelpful. In order for a computer to bear its part of the burden in initiating interactions, it must first have much more real-time information about its user, and second, algorithms that select actions based on this information, in addition to user commands. The computer needs information about the user's current and past emotional, motivational and cognitive state, as well as the state of the task at hand. Research and education activities will include development of methods to sense user postures, movements, expressions and speech; fusion of this information to track user states; creating means for effective communication, human-centered action decisions, and a corpus of emotion- and action-labeled videotapes for use with computer learning; and finally, evaluation of computer pro-action on human behavior and response.

Nanoscale Science and Engineering **(NSE)** represents a new focused investment opportunity in FY 2001. Support for nanoscale research and education is motivated by the impressive potential for economic return and social benefit. The initiative will lead to potential breakthroughs in areas such as materials and manufacturing, nanoelectronics, healthcare, environment and energy, chemical and pharmaceutical industries, biotechnology and agriculture, computation and information technology, and national security.

Areas of emphasis include biosystems at the nanoscale, nanoscale structures and novel phenomena, device and system architecture, nanoscale processes in the environment, multi-scale and multi-phenomena modeling and simulation. NSF supports a wide range of research and education activities in this priority area, including approximately 15 nanotechnology research and education centers, which focus on electronics, biology, optoelectronics, advanced materials and engineering. Examples of collaborations with other agencies and private sector include: quantum computing with DARPA; Materials Research Science and Engineering Centers (MRSEC) with the Department of Defense (DOD); Semiconductor Industry Association and Engineering Research Centers (ERC); Grant Opportunities for Academic Liaisons with Industry (GOALI) awards (collaboration with private sector); and cofunding two new Nanoscale Science and Engineering Centers (NSEC) with the DOD.

- **Societal implications of nanotechnology:** On September 28-29, 2000, a workshop was held at NSF on "The Societal Implications of Nanoscience and Nanotechnology." The aim was to: (1) survey current studies on the societal implications of nanotechnology (educational, technological, economic, medical, environmental, ethical, legal, etc.); (2) identify investigative and assessment methods for future studies of societal implications; and (3) propose a vision for accomplishing nanotechnology's promise while minimizing undesirable consequences. The extensive report of this workshop has been published both on the web and in book form and has also been distributed to all agencies and to the President's National Science and Technology Council. A second workshop was held December 3-4, 2001, to address how cognitive science can be integrated with nanotechnology, biotechnology and information technology to enhance human performance.

- **Manipulating Matter at the Nanoscale:** Manipulating matter on the nanometer scale is important for many electronic, chemical and biological advances. Available solid-state fabrication methods do not reproducibly achieve nanometer-scale dimensional control. However, an ion beam can be used to poke holes in thin films to produce structures that are used to manipulate nanoscale matter. The method can fabricate a molecular scale hole, or nanopore, in a thin insulating solid-state membrane. Nanopores localize molecular scale junctions and switches and act as masks to create other small structures. Nanopores also function as membrane channels in all living systems, where they are extremely sensitive electromechanical devices that regulate electric potential, ionic flow and molecular transport across cellular membranes. "Ion beam sculpting" has been used to fabricate a robust electronic detector capable of registering single DNA molecules in aqueous solution. Such detectors may find utility in extremely rapid sequencing of DNA for medical diagnostics of genetic diseases and rapid drug design for large populations.

Biocomplexity in the Environment **(BE)** became an area of focus in FY 1999, beginning with a special competition on the "Interrelationships between Microorganisms and Biological, Chemical, Geological, Physical, and Social Environments." In FY 2000, NSF sponsored a $50 million initiative – *Integrated Research to Understand and Model Complexity Among Biological, Physical, and Social Systems*. In FY 2001 and FY 2002 the Biocomplexity in the Environment competitions focused on Integrated Research and Education in Environmental Systems.

Understanding the dynamics of biological complexity and its role in environmental systems is critical to knowledge of living organisms and of the vital natural resources biological systems provide (e.g., food, fiber) and upon which humans depend. Advancing our understanding of the nature and role of biological complexity demands increased attention and new collaborations of scientists and engineers from a broad spectrum of fields – biology, physics, chemistry, geology, hydrology, statistics, engineering, computation, social sciences. Such collaborations can capitalize on powerful new emerging technologies – including genome sequencing, new computational algorithms and mathematical methods, sensors and monitoring devices, and remote sensing – that have greatly enhanced our ability to understand ecosystem complexity and dynamics.

- *Organohalide Pollutants***.** Organohalides pose serious threats to air and water quality. They are among the most widely used industrial chemicals, with applications in such familiar processes as dry cleaning and air conditioning. Of the top 25 organic contaminants found in ground water in U.S. urban cities, 17 are organohalides. Investigators and their collaborators from national laboratories and industry are studying ways to break down organohalides into less toxic substances. They hope to develop new techniques for detecting environmental organohalides, predicting and monitoring their rates of natural attenuation, and, wherever practical, decontaminating sites where organohalides are found.

Area of Emphasis 3: Investments in non-initiative fundamental research (Mathematical Sciences Research, Functional Genomics, Cognitive Neuroscience).

Examples follow.

Mathematical Sciences Research:

- **The Simplex algorithm:** Two NSF-supported investigators have solved a long-standing open question in mathematical programming, optimization, and theoretical computer science, proving that the Simplex Method for Linear Programming usually takes a polynomial number of steps. They developed a new algorithm-analysis framework, called smoothed analysis, which can help explain the success of many algorithms and heuristics that traditional algorithm-analysis frameworks, such as worse-case and average-case analysis, cannot. The simplex algorithm is a classic example of an algorithm known to perform well in practice yet it consumes exponential time in the worst case. It has been an active subject for mathematical and experimental studies for more than 50 years.

Functional Genomics:

- The research project, "The Role of Gamma Aminobutyric Acid (GABA) in Plant Growth and Productivity," awarded to Sun Dance Genetics, Durham, NC has added to understanding of the role of GABA in plant growth. Commercial application of formulations containing GABA is found throughout the world. Agriculture, horticulture, floriculture, and **turf grass** industries are now benefiting from a product that increases plant growth and productivity while reducing the amount of fertilizer needed for optimal plant productivity. The results of this NSF-supported research have established the efficacy of the company's formulations for increasing plant growth and productivity and reducing a plant's fertilizer requirements, and demonstrate their commercial utility. The company estimates the total U.S. market opportunity for such products to be approximately $3.0 billion per year.

- ***Arabidopsis thaliana*:** DNA sequence data is an essential tool but is not enough to tell us everything about how an organism develops and functions. Building on the large and growing store of information amassed in the international sequence databases, biologists are now able to tackle the next frontier in biology, functional genomics, which uses genome sequence information in combination with data from other biological research to study what genes do – that is, how patterns of sequence are related to patterns of function. Functional genomics offers unprecedented opportunity to understand living systems through use of large-scale, genome-derived information. NSF's first major program in functional genomics, the "2010 Project," began in FY 2001, and will continue through the year 2010. Its goal is to determine the functions of the 25,000 genes of the flowering plant, *Arabidopsis thaliana*.

- **How insects develop immunity to plant toxins:** *Bacillus thurnigiensis* (Bt) is a bacterium that produces toxins with insecticidal activities. One of the early success stories of genetic engineering of plants was the introduction of the gene encoding the toxin into agriculturally important crops, such as cotton. These plants produced their own pesticide thereby reducing the need for chemical pesticides. Unfortunately, insects can "learn" (evolve mechanisms) to escape this clever trap, and develop resistance to the toxin but the molecular basis for resistance was unknown. In 2001, two independent groups focusing on the molecular mechanism of Bt toxin resistance in two plant pests produced important results that were reported in back-to-back papers that appeared in *Science*, August 2001 and were highlighted by a "news and views" report.

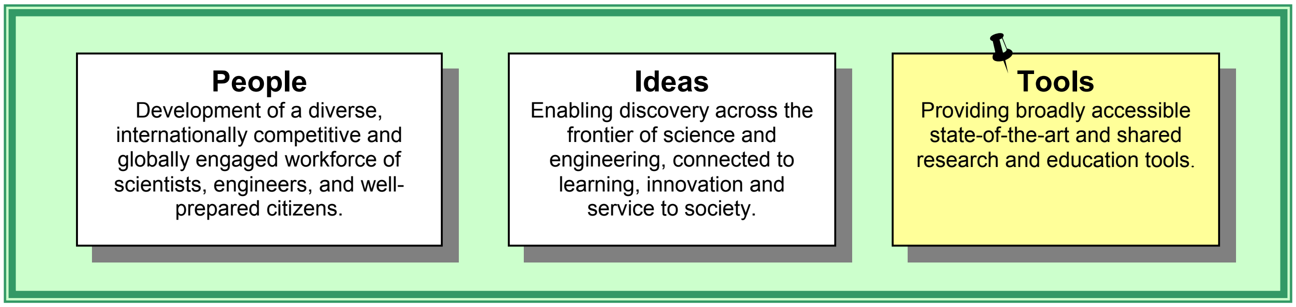
Cognitive neurosciences:

- **How bees learn:** Studies of the neuroanatomical basis of hormone-mediated behavioral development in the honeybee have shown that such bees learn olfactory associations as they emerge from the hive to forage for flower nectar. These studies are the first to use a social insect as a model system to assess the effects of a hormone on cognition, and provide a new perspective for understanding bee foraging behavior. They could also have substantial impact on agriculture. There has been a large response in the popular press to this work, with coverage from the New York Times, National Public Radio, the BBC and many other European news organizations.

- **Mapping brain function:** A conformal map of one region to another preserves angles between intersecting curves, a property that is especially valuable in the study of regions such as the visual cortex of the brain. Conformal geometry is being used to map brain function using conformal mapping algorithms and other geometric ideas. These efforts at brain mapping have been described in several widely-read accounts, such as an article in the August 2001 issue of *Scientific American*.

NSF OUTCOME GOALS

C. TOOLS



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

✓ 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.

This is a new goal. Our performance is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement for one or more of the following indicators:

- Shared use platforms, facilities, instruments, and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce;
- Networking and connectivity that take full advantage of the Internet and make SMET information available to all citizens;
- Information and policy analyses that contribute to the effective use of science and engineering resources.

RESULT: Reports prepared by external experts during FY 2001 GPRA reporting provided assessments and retrospective examples of NSF-supported projects that document significant achievement. A sample of these is provided for each of the performance indicators and areas of emphasis for this goal.

There are very limited contributions and limited involvement of agency programs, other than Science Resources Statistics (SRS), in developing information and other materials fundamental to national policy debates.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be continued in FY 2002. The performance indicators related to the Tools goal has been expanded and modified to appropriately reflect the breadth of NSF activities (see Section X. for details).

INDICATOR 1: Shared-use platforms, facilities, instruments, and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce.

RESULT: ***Demonstrated significant achievement. Examples follow.***

The **Incorporated Research Institutions for Seismology** (IRIS) seeks to image, at high-resolution, the structure and composition of the entire Earth. This image will form the basis for a new, physics-based description of the dynamics of the whole Earth. Moreover, using Internet technology, the data management program will make these state-of-the-art data available to anyone in the world, promoting a powerful synergy of research and education. The scale of the facility, like the scale of the problem, is large, encompassing a partnership of 96 institutions and hundreds of individual researchers and research projects.

The **national astronomy facilities,** consisting of the National Radio Astronomy Observatory, the National Optical Astronomy Observatory, the National Solar Observatory, the National Astronomy and Ionosphere Center and Gemini Observatories, provide access to a broad scientific community on the basis of scientific merit review. Each facility provides unique capabilities to over 2,400 scientists and their students of whom over half were pursuing their doctorates. The Atacama Large Millimeter Array (ALMA), which will bring aperture synthesis techniques to radio astronomy, is in the last year of design and development prior to project construction involving an equal U.S.-European partnership.

Materials Research Facilities: The major-shared facilities include the National High Magnetic Field Laboratory (NHMFL), the Center for High Resolution Neutron Scattering (CHRNS), the Cornell High Energy Synchrotron Source (CHESS), the Synchrotron Radiation Center (SRC), and the National Nanofabrication Users Network (NNUN). Each of these facilities operates to enhance the productivity and effectiveness of scientists and engineers in a wide range of disciplines. For example, the NHMFL is operated by a consortium composed of the University of Florida, Florida State University and Los Alamos National Laboratory and NHMFL and has established itself as the world's leading center for multidisciplinary research and education using high magnetic fields.

Polar Facilities: NSF manages and operates the three permanent U.S. stations in Antarctica (South Pole, McMurdo and Palmer). These stations provide the facilities for U.S. scientists, including those from other federal agencies, to conduct research in Antarctica in widely divergent disciplines. NSF also supports both permanent and seasonal stations in the Arctic. In the past two years the Summit Station (Greenland) has operated year-round to support winter observations with a particular emphasis on atmospheric chemistry.

Forecasting Lightning Strikes: A Lightning Mapping Array (LMA) has been developed and uses very accurate Global Positioning System (GPS) timing capabilities to measure the time of arrival of electrical discharges at a dense array of receivers to provide a very accurate three-dimensional map of the structure and evolution of cloud-to-ground (CG) and intra-cloud (IC) lightning. Because IC discharges typically occur about 15 minutes before the onset of CG strokes, the LMA provides added lead time for use in forecasting the onset of lightning strokes hitting the ground (one of the deadliest weather phenomena occurring today). It also provides a natural complement to weather radar, and together they offer the promise for improvements in the accuracy and timeliness of short-term forecasts of severe convective weather.

Gemini and Laser Guide Stars: NSF serves as the executive agency for the Gemini Observatories, an international project with seven partner nations (the U.S., the United Kingdom, Canada, Australia, Chile, Brazil and Argentina). The Gemini Observatories consist of two 8-meter telescopes, one located in the southern hemisphere in Chile, and one located in the northern hemisphere in Hawaii. NSF provides 50% of the funding, enabling merit-based access to both telescopes for the U.S. national community. The project has also played a pivotal role in sodium laser tests sponsored by Gemini, the Cerro Tololo Inter-American Observatories, and the European Southern Observatory.

NSF is the major source of support for the **Panel Study of Income Dynamics (PSID)**, a survey of a nationally representative sample of U.S. individuals and the family units in which they reside and was initiated in 1968. The major objective of the panel is to provide shared-use databases, research platforms and educational tools on cyclical, intergenerational and life-course measures of economic and social behavior. The PSID's innovative design and long-term panel have been central to the fundamental understanding of key social science issues with substantial broad impacts on society: income, poverty and wealth; cyclical behavior of wages, labor supply and consumption; savings, wealth accumulation and transfers; demographic events; labor market behavior; and the effects of neighborhoods.

PSID data transformed research on poverty from a static view of poor and rich to a dynamic one in which families experience episodes of poverty or affluence. PSID results have been replicated and validated. The enormous usefulness of decades of data on the sample families has made the PSID one of the most widely used social science data sets in the world. The project currently delivers more than 10,000 customized data sets a year to researchers via its Internet Data Center. Since 1968, over 2,000 journal articles, books and chapters, dissertations and other works have been based on PSID data. More information on the PSID is available at http://www.isr.umich.edu/src/psid.

The NSF-funded **General Social Survey** (GSS) has been monitoring social change in the United States, examining sub-groups in society, and studying social processes since 1972. Over this period, 23 cross-sectional surveys of the U.S. adult household population have been completed, involving face-to-face interviews with approximately 41,000 respondents. Surveys document fundamental social change in areas such as uses of technology, social and cultural capital, neighborhoods and communities, social networks, and racial and gender attitudes. The GSS is widely used by the academic research community and scholars at research centers, foundations, and in government. For example, as of April 2000, there were 5,430 documented uses of the GSS data, including 2,676 journal articles, 1,201 books, 959 scholarly papers and 153 dissertations and theses. The GSS is used extensively in teaching, with GSS having been utilized in 226 textbooks and contained in course materials on 224 websites. The cumulative GSS data files are used in the Inter-University Consortium for Political and Social Research (ICPSR) Summer Program, which is annually attended by 150 scholars representing over 100 colleges in the United States and Canada.

The World Data Center for Paleoclimatology (WDCP) is housed at the National Oceanic and Atmospheric Administration's (NOAA) National Geophysical Data Center at Boulder, Colorado. Data sets include tree-rings, lake core records, ice core records, ocean sediment records and corals, developed in part by NSF-supported researchers.

INDICATOR 2: Networking and connectivity that take full advantage of the Internet and make science, mathematics, engineering and technology (SMET) information available to all citizens.

RESULT: ***Demonstrated significant achievement. Examples follow.***

The objective of the National Science, Mathematics, Engineering and Technology (SMET) Education **Digital Library** (NSDL) is to catalyze and support significant advances in the quality of SMET education at all levels by providing broad access to the rich collections of teaching and learning resources of the nation in a distributed, digital environment. The NSDL aims to create, organize and install high-quality education resources onto the Internet. The program may strongly affect K-12 and undergraduate educational by providing anytime, anywhere access to a rich array of authoritative and reliable interactive materials and environments. Some of the newly funded projects focus on gathering and organizing content in areas such as geosciences, life sciences, engineering and mathematics. Others will develop the processes to manage and coordinate that content in the library's core collections, and develop services for users and collection providers. The program continues ongoing efforts of the national, multi-agency Digital Libraries Initiative begun in 1994, which has involved NSF, the Defense Advanced Research Projects Agency, the National Aeronautics and Space Administration, and other federal agencies.

The **Performance Assessment Links in Science** (PALS) project has created an on-line web-based assessment resource for teachers and test developers. The teacher site includes science performance tasks, with information on which national science standards are addressed, its psychometric properties, scoring rubric, and examples of students' work. This rich resource is used by teachers nationally, including Chicago, Los Angeles, San Mateo (CA), and the Spring Independent School District (TX). PALS also is used in several NSF-supported Urban Systemic Initiative sites to help document program effectiveness through improved student achievement.

The Space Science Institute has developed the **Space Weather Center web site** as part of the National Space Weather Program (NSWP). The web page can be viewed at http://www.spacescience.org/. It serves as a central outlet for public information on space weather by providing a collection of resources of interest to educators, the media, and the general public. The web site includes introductory information on space weather, an image archive of the best images from space weather research programs, brief reports written by space weather researchers, links to current solar and space weather data, and links to downloadable curricula related to space weather. A new capability installed in the past year allows visitors to the web site to take a virtual tour of any of several space weather museum exhibits the Space Science Institute has developed.

In FY 2001 NSF awarded **high performance network connections** to 19 universities, a research museum, and two research institutes, bringing the total of institutions assisted through such grants to 221. Since 1995 the NSF High Performance Network Connections (HPNC) program has provided scientists and engineers better access to research facilities across the U.S., including those maintained by NSF through its Partnerships for Advanced Computational Infrastructure (PACI) program. The new awardees will join in connecting to a national grid of research networks that operate at speeds up to 2.4 billion bits per second.

Mathematics: Software available through the Internet has been developed for the solution of partial differential equations via numerical analysis or object-oriented code, for the teaching of finite element analysis, and for the solution of linear recurrence equations. In addition, the conservation law package (CLAWPACK) has been freely available on the Internet to researchers using multidimensional high-resolution finite-volume methods for solving hyperbolic partial differential equations. For example, the equations can simulate ultrasound propagation in human tissue, elastic waves in heterogeneous media, and gravitational waves of planetary bodies indicating applicability to biosciences, materials science and astronomy.

Through the **WEB100** project, universities, research centers, and some businesses today have connections capable of transmitting data at 100 megabits per second (Mbps) or higher. Research has shown, however, that users rarely see performance greater than 3 Mbps. New WEB100 software, developed jointly by the National Center for Atmospheric Research (NCAR), the Pittsburgh Supercomputing Center, and the National Center for Supercomputing Applications, with funding from NSF, will allow users to take full advantage of available network bandwidth without the help of a networking expert. WEB100 researchers traced the problem of poor performance to software that governs the Transmission Control Protocol (TCP). Networking experts are able to overcome this limit by fine-tuning connections with adjustments to TCP. This type of "middleware" can help us use existing resources more efficiently.

The **HomeNetToo** project focuses on the home Internet use of low-income families, many of whom are first-time computer users. Internet use is automatically computer-logged and surveys are administered at five times over an 18-month period to address the antecedents and consequences of Internet use. Preliminary findings indicate that cognitive style is related to Internet use and influences the relationship between race and use (as does socioeconomic status, i.e., education and income). Subsequent analyses will identify additional culturally-based factors that influence this relationship. Twenty-three undergraduates served as technology facilitators during the project's first year, nearly half (10) of whom were members of underserved minority groups (nine African-Americans, one Hispanic-American). Almost half (11) were female. All are majoring in Computer Science. The graduate student who served as Project Director in the first year is an African-American male, majoring in educational technology.

Digital archives: Two important NSF-supported tools projects are already available on the web. The first catalogs the development of sanitary technologies for New York during the 19th century in a digital archive of documents, reports, and illustrations. With NSF assistance, the Center for the History & Ethics of Public Health in the Department of Sociomedical Sciences in the Mailman School of Public Health at Columbia University has assembled *The Living City* (http://156.145.78.54/htm/home.htm), which includes among other things, an annotated timeline for New York from the 1860s through the 1920s. This project could become an essential reference tool for historians and students interested in sanitation, technology, urban history, and New York City history.

The other accomplishment is the *Perseus Digital Library* at Tufts University devoted to ancient Greece (http://www.perseus.tufts.edu/). The Perseus project is widely regarded as a model for digital archives.

INDICATOR 3: Information and policy analyses that contribute to the effective use of science and engineering resources.

RESULT: ***Demonstrated significant achievement. Examples follow.***

The Division of Science Resources Statistics (SRS) is the unit within NSF charged with collecting, analyzing and disseminating information on the S&E enterprise. These activities fulfill the legislative mandate of the National Science Foundation Act to "provide a central clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering resources, and to provide a source of information for policy formulation by other agencies of the Federal Government."

To carry out this mandate, SRS designs, supports, and directs 11 periodic surveys as well as a variety of other data collections and research projects. These activities yield the materials for SRS staff to compile, analyze, and disseminate quantitative information about domestic and international resources devoted to science, engineering, and technology. Each year SRS produces 40 to 50 publications, ranging from short Data Briefs and Issue Briefs highlighting results from recent surveys and analyses to Detailed Statistical Tables (DSTs) containing extensive tabulated data from a particular survey; and large, comprehensive "overview" reports, such as *Science and Engineering Indicators* and *Women, Minorities, and Persons with Disabilities in Science and Engineering.*

All new publications are placed on the SRS website and some material is available only in an electronic format, not in a printed version. Many tables on the web are also available in a spreadsheet format so they may be downloaded and manipulated by users. The data are also provided to users in a variety of formats, media, and in customized tabulations. In addition, access to much of the data is provided through on-line databases.

SRS has made improving the quality and usefulness of its data a high priority in recent years. In previous years, SRS has had GPRA performance goals related to the timeliness of the release of the data the Division collects and establishment of data quality measures for its surveys. For FY 2001, SRS worked to improve the relevance and quality of the data it collects, the two dimensions rated most important by SRS customers in a 1999 customer survey – accuracy and the ability to find and obtain needed information on S&E personnel and resources.

For FY 2001, SRS identified one or more aspects of each ongoing survey in need of improvement and ways in which such improvement could be pursued. Projects for half the surveys were begun in FY 2001. Choices as to which of the projects to pursue in FY 2001 were based on a variety of factors, including funding, feasibility, favorable timing in terms of the survey cycle, and Division priorities. In nearly every case, these projects will extend into FY 2002 and beyond, and it will be several years before the results of these efforts will be evident in terms of improved data quality. In the meantime, additional projects directed toward improving data quality will be undertaken in FY 2002 and subsequent years.

The projects undertaken in FY 2001 vary considerably in scope, ranging from the complete redesign of the Survey of Scientific and Engineering Research Facilities to review/improvement of questionnaire layout and specific question wording of several surveys to adoption of a standard method of computing response rates in the National Survey of Recent College Graduates. Examples of specific FY 2001 projects include the Facilities Survey, the Federal Funds Survey, the Academic Survey, the Graduate Student Survey (GSS), and the National Survey of Recent College Graduates (NSRCG)

In addition to these projects, all of which had been identified at the beginning of FY 2001, SRS undertook a variety of other activities during the year that will contribute to improved data quality in the future. Several approaches toward improving questionnaire design (paper and electronic) were started, including cognitive interviews with survey respondents and assistance from a nationally recognized expert on questionnaire design. Specifically, with regard to the public attitudes survey, several avenues were explored as alternatives to the historical Random-Digit-Dialing (RDD) telephone survey, about which there are concerns related to both content and response rates. These included placing items on other surveys, and web-based options for collecting information.

SRS also provided data and assistance to a variety of offices throughout the government in support of policy debates about science and technology. For example, SRS continued working with the Immigration and Naturalization Service in efforts to improve the scope of data capture and nature of coding of immigrants' education levels, major fields, and last occupation before entering the U.S.

In addition to conducting surveys and releasing reports/data based on the surveys, SRS prepared and completed external reviews of the Congressionally mandated report, *Women, Minorities and Persons with Disabilities in Science and Engineering: 2002*, a source book of data on the participation of these groups in science and engineering education and employment, widely used by policy makers addressing the problems of underrepresentation of these groups in science and engineering.

SRS released, on the Division of Science Resources Statistics website, the Industrial Research & Development Information System (IRIS) which is an online interface to the new Survey of Industrial Research and Development Historical Database 1953-1998. The database contains all industrial research and development (R&D) data published by NSF for the years between 1953 and 1998 in over 2,500 statistical tables including statistics on the levels of R&D support from company and federal sources and sales and employment of R&D performers.

Area of Emphasis 1: Investments in Major Research Equipment (MRE).

Examples follow.

NSF provides funding for capital expenditures for the construction and acquisition of major research facilities that provide unique transformational capabilities at the cutting-edge of science and engineering. Projects supported capitalize on technological innovation to provide significant new research and education opportunities, frequently in totally new directions. Continuing projects include South Pole Station Modernization (SPSM), Atacama Large Millimeter Array (ALMA) research and development, Network for Earthquake Engineering Simulation (NEES), the Large Hadron Collider, and the Terascale Computing System (highlighted in the next section).

The **Large Hadron Collider** (LHC) will be the frontier particle accelerator in the world when it comes on-line in the second half of this decade. There is now preliminary experimental evidence that the Higgs particle, the key to understanding why everything in the universe has mass, can be detected with the LHC. Recent work at the Brookhaven National Laboratory on the magnetic moment of the muon, (the recently reported results from the "g-2" experiment), provided results not predicted by the Standard Model. Further tests of the Standard Model will be done at the LHC. The U.S. ATLAS and CMS projects continue to meet their goals and are reliable and influential partners in the construction of the two detectors of the LHC machine. The European Organization for Nuclear Research (CERN) expects to complete construction of the LHC and initiate collider commissioning in 2005. The U.S. schedules are consistent with this goal. The institutions developing the two detectors have done an excellent job of meeting cost and schedule goals.

At 10:00 AM, Friday, October 20, 2000, leaders of the **Laser Interferometer Gravitational-wave (LIGO) Observatory** announced that "First Lock" had been achieved with the two-kilometer long interferometer at the Hanford Observatory. This marked achievement of a major LIGO milestone. All mirrors were "locked" into their proper positions to atomic-scale precision using a sophisticated computer-based control system. First lock validated many aspects of the control system design for the initial LIGO detectors, but it had even greater significance – the beginning of the process of tuning the interferometer to its full sensitivity. Most importantly, this achievement brought LIGO closer to its ultimate goal – the first true gravitational-wave observations.

NSF supports two ongoing MRE projects of enormous significance to scientific and engineering research in the Antarctic region: 1) The **South Pole Station Modernization**; and 2) Polar Support Aircraft (LC-130) Upgrades. Both projects represent essential investments in the health and vitality of on-continent and deep-field research in Antarctica.

Areas of Emphasis 2: Continue investments in Terascale Computing System, Major Research Instrumentation, S&E information/reports/databases; New types of scientific databases and tools for using them.

Examples follow.

Terascale Computing System

NSF is continuing development of a *Terascale Computing System* to enable U.S. researchers and educators to gain access to leading edge computational systems.

- **Supporting technologies:** Research performed under past and present NSF support has been incorporated as key components of the Terascale Computing System in the following key technology areas of parallelizing compilers; sequential compilers; numeric libraries; runtime libraries; and parallel software tools, input/output, visualization, and applications.

- **Initial performance:** The new Terascale Computing System (TCS) funded by NSF in fiscal year 2000 has begun operation well ahead of schedule and is exceeding performance expectations. During an acceptance test in which the Pittsburgh Supercomputer Center staff evaluated its performance, TCS consistently surpassed speed expectations and operated virtually without interruption. The combined peak power of the full computer system will be 6 Teraflops, making it the most powerful computer available to academic scientists and engineers in the United States.

The Major Research Instrumentation Program

The Major Research Instrumentation Program (MRI) is designed to improve the condition of scientific and engineering equipment for research and research training in our nation's academic institutions. This program seeks to improve the quality and expand the scope of research and research training in science and engineering, and to foster the integration of research and education by providing instrumentation for research-intensive learning environments.

- The **Electronic Visualization Laboratory's (EVL)** research has focused on developing tools, techniques and hardware to support real-time, highly interactive visualization. Current efforts continue through the development of virtual reality (VR) devices, software libraries/toolkits and applications for collaborative exploration of data over national and global high-speed networks - called "tele-immersion." After building first and second-generation VR devices [the Cave Automatic Virtual Environment (CAVE) in 1991 and the ImmersaDesk in 1995] to support tele-immersion applications, EVL is now conducting research in "third-generation" VR devices to construct variable resolution and desktop/office-sized displays. EVL continues to develop and refine a robust and VR-device-independent software library, as well as the software tools for building tele-immersion applications. This software infrastructure supports collaboration in design, training, scientific visualization, and computational steering in VR. Through advanced networking techniques, researchers can access distributed computing, storage and display resources more efficiently than ever.

S&E informational/reports/databases

- **The General Social Survey:** The General Social Survey (GSS) has been monitoring social change in the United States, examining sub-groups in society, and studying social processes since 1972. Over this period, 23 cross-sectional surveys of the U.S. adult household population have been completed, involving face-to-face interviews with approximately 41,000 respondents. Surveys document fundamental social change in areas such as uses of technology, social and cultural capital, neighborhoods and communities, social networks, and racial and gender attitudes. The GSS is widely used by the academic research community and scholars at research centers, foundations, and in government. For example, as of April 2000, there were 5,430 documented uses of the GSS data, including 2,676 journal articles, 1,201 books, 959 scholarly papers and 153 dissertations and theses. The GSS is used extensively in teaching, with GSS having been utilized in 226 textbooks and contained in course materials on 224 websites. The cumulative GSS data files are used in the Inter-University Consortium for Political and Social Research (ICPSR) Summer Program, which is annually attended by 150 scholars representing over 100 colleges in the United States and Canada. GSS data are made available to researchers and their students. The GSS Data and Information Retrieval System provides facilities for statistical analyses, hypertext viewing, customized extracts from data sets, and File Transfer Protocol for extracted data sets.

- **Climate Change Policy:** NSF supports scientists who are engaged in the Intergovernmental Panel on Climate Change (IPCC) and U.S. National Assessment programs. The results of both of these assessments are used for policy analyses so that there is effective use of scientific resources. Beyond these scientific assessments with their specific policy-informing goal, there are specific examples of studies that provide policy analyses. One particular example involves an analysis of climate-change abatement policies. Most quantitative studies of climate-change policy attempt to predict a greenhouse-gas reduction plan that will have the optimum balance of long-term costs and benefits. However, it was found that large uncertainties associated with the climate-change problem could make the policy prescriptions of this traditional approach unreliable. An adaptive strategy with mid-course corrections was able to avoid significant errors.

New types of scientific databases and tools for using them

- **Government statistical information** is essential in the day-to-day lives of all citizens. The importance of such data is illustrated by the efforts of multiple federal government agencies to create the National Statistical Information Infrastructure. Data from agencies such as Bureau of Labor Statistics, Census Bureau, and Bureau of Economic Analysis determine costs of everything from apples to zinc, the locations of new businesses, and the indexes for all government programs and payments. Web-based technologies offer citizens broader access to the vast array of statistical data so that they may make better personal decisions. Examples include baby-boomers planning for retirement, unemployed or underemployed individuals looking to relocate, and school children exploring careers. For broader segments of the population to take advantage of government statistical information, however, the data must both be easy to find and easy to interpret and use. Ease of search in this setting depends on helping users articulate needs, on distributing these articulations to different datasets across the federal government, unifying the results, and presenting them in forms most useful to user needs. NSF-supported researchers have successfully completed work on graphical representation, manipulation, browsing, and usability over the Web for federal statistical (tabular) data. As the system becomes commercially available to the users of federally collected and archived statistical data, the primary challenge is to ensure it will improve the usefulness of data in establishing, for example, the Consumer Price Index, the unemployment rate, and the determination of federal congressional districts.

- **LAPACK and ScaLAPACK:** The LAPACK and ScaLAPACK libraries are the standard software for solving dense linear equations. With FY 1999 funding NSF-supported release 3.0 of LAPACK, which improves error bound estimates. As important as the LAPACK software is the means by which it is disseminated. NSF has been a long-term supporter of Netlib, the standard Internet repository for numerical software. There have been over 129,000,000 requests from Netlib to date, indicating just how popular it is. Less obvious is the amount of effort that its search capabilities have saved countless investigators in locating the right software for the job. NSF support of Netlib also contributes to full use of the national networks (http://www.netlib.org/lapack/index.html), (http://www.netlib.org/scalapack/index.html).

- This year NSF supported the establishment of the **National Historical Geographic Information System** (NHGIS) to upgrade and enhance U.S. Census databases from 1790 to the present, including the digitization of all census geography so that place-specific information can be readily used in geographic information systems. The NHGIS consists of three major components: (1) The data and documentation component will gather all extant machine-readable census summary data, fill holes in the surviving machine-readable data through data entry of paper census tabulations, harmonize the formats and documentation of all files, and produce standardized electronic documentation according to the recently developed Data Documentation Initiative (DDI) specification. (2) The mapping component will create consistent historical electronic boundary files for tracts, minor civil divisions, counties, and larger geographic units. (3) The data-access component will create a powerful but user-friendly, Web-based browser and extraction system based on the new DDI metadata standard. The system will provide free public access to both documentation and data and will present results in the form of tables or maps. Through these activities, the NHGIS will become a resource that can be used widely for social science training, by the media, for policy research at the state and local levels, by the private sector, and in secondary education.

MANAGEMENT GOALS

V. MANAGEMENT GOALS

Business Practices
- Electronic Proposal Submission
- Electronic Proposal Processing
- Videoconferencing

NSF Staff
- Diversity
- Work Environment

For FY 2001 we emphasized five performance goals (three of them new) related to implementation of information technologies and human resources development. These goals address the incorporation of advanced technology into NSF business operations, and human capital involving diversity and the NSF work environment.

Summary of Results for Management Goals

We achieved four of five management goals in FY 2001. We achieved our goals for electronic proposal submission, electronic proposal processing, videoconferencing, and staff diversity. The one management goal not achieved involved conducting an employee survey on our work environment. As in FY 2000, we engaged an outside firm to verify and validate performance information for most management goals.

We consider four factors to be especially critical to management excellence at NSF:

- Operating a viable, credible, efficient merit review system;
- Exemplary use of and broad access to new and emerging technologies;
- A diverse, capable, motivated staff that operates with integrity; and
- Implementation of mandated performance assessment and management reforms in line with agency needs.

These critical factors were used in our developing annual performance goals. Results for the management goals, most of which have quantitative measures, are prepared and reviewed by NSF staff. For selected goals, the auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used in our assessment.

A. Business Practices

Goal IV-1 – Electronic Proposal Submission
✓ Goal Achieved

Goal IV-1: Ninety-five percent of full proposals will be received electronically through FastLane.

A state-of-the-art communications and technology infrastructure has been essential to our successful management of an increasing workload. This investment also provides incentives for the recruitment and retention of high-quality employees. We continue to experiment with new means to do business electronically.

For example, FastLane, our web-based interface with grantee institutions, was developed in close consultation with the research and education communities. The most complex use of FastLane is for the submission of full technical proposals via the web. NSF is the *only* federal research agency currently receiving proposals electronically on a routine basis.

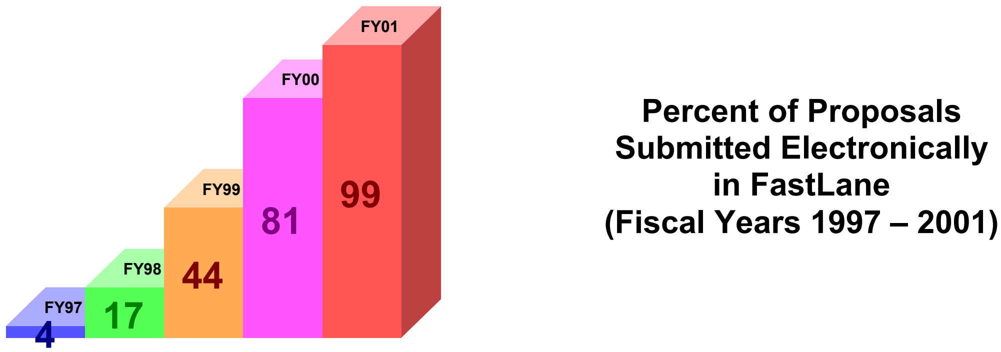
PERCENT OF PROPOSALS SUBMITTED ELECTRONICALLY IN FASTLANE

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001
Baseline	4.4%				
Goal			25%	60%	95%
Actual		17%	44%	81%	**✓99%**[15]

RESULTS: NSF is successful for this goal. Of the 32,141 full proposals that were submitted in FY 2001, only 286 were not submitted through FastLane. *This equates to 99% of full proposal submissions received and processed through FastLane* – well in excess of the 95% goal.

[15] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

The following chart illustrates progress over the past five years:



Outreach: We have continued aggressive outreach to the research and education community to promote the use and advantages of FastLane. We conducted over 30 FastLane presentations and workshops at scientific meetings, research administration conferences and educational institutions, and through videoconferencing.

Customer Service: Throughout FY 2001, our FastLane Helpdesk continued to assist our external customers.

Implementation: In view of our success with electronic submission, in September 2000, we issued Important Notice 126 to Presidents of Universities and Colleges and Heads of other NSF grantee institutions reaffirming that effective October 1, 2000, specified transactions with NSF had to be accomplished electronically via use of the FastLane system[16].

Electronic Signatures: We implemented acceptance of electronic signatures on incoming proposals in June 2001. In the remaining three months of FY 2001, and the first three months of FY 2002,19,982 (97%) of 20,451 submissions were received with electronic signatures.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will not be continued in FY 2002. Electronic submission of proposals via FastLane is now standard operating procedure at NSF.

[16] http://www.nsf.gov/pubs/2000/iin126/iin126.htm.

Goal IV-2 – Electronic Proposal Processing
✓ Goal Achieved

Goal IV-2: In FY 2001 NSF will conduct ten pilot paperless projects that manage the competitive review process in an electronic environment.

This was a new goal in FY 2001, and represented a logical step in our evolution towards a paperless environment. As we noted above, more than 99% of all proposals are now submitted electronically. But once proposals are received, our current processes still involve paper. Ultimately, we want to make our entire proposal and award process an electronic, or paperless, process.

The pilot paperless project goal was intended to develop the technological capability to process electronically submitted proposals through the entire review process *without generating paper within NSF*.

Programs within four of our Directorates participated in the pilot. Successful accomplishment of the pilot project required all of the following tasks to be accomplished for proposals in the program:

- Receipt of all proposals through FastLane
- Electronic capture of proposal data into the Proposal, Principal Investigator and Reviewer System (PARS)
- Assignment of reviewers accomplished in PARS (if using ad hoc reviewers)
- Submission of reviewer requests through PARS (if using ad hoc reviewers)
- Printed proposals not sent to reviewers
- Submission of reviews in FastLane
- Panels, if conducted, utilize the electronic Interactive Panel System
- Funding recommendation by the Program Officer accomplished in PARS

RESULTS: NSF is successful for this goal. All ten participants in the FY 2001 pilot project successfully managed the review process in their programs electronically, demonstrating the capability for a paperless review process within NSF[17].

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: In FY 2002 we will make various enhancements to several modules used in the paperless process. The FY 2002 goal doubles the number of projects, will include more directorates, divisions, and larger programs, and will incorporate the e-signature in the definition of a paperless project. The intent of making the FY 2002 pilots broader and more complex is to further demonstrate the capability and benefits of an internal paperless process, thus encouraging the majority of our programs to transition to paperless processing.

[17] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

Goal IV – Video Conferencing
✓ Goal Achieved

Goal IV-3: By the end of FY 2001 NSF will increase usage of a broad-range of video-conferencing/long distance communications technology by 100% over the FY 1999 level.

This was a new goal in FY 2001 and was designed to illustrate and promote the use of innovative business technologies within NSF. Over the past several years efforts have been underway to increase our ability to collaborate worldwide via videoconference. In FY 1999 we monitored videoconference usage and established a baseline of 50 videoconferences. During FY 2000 we focused efforts on increasing our technical capability in this area and marketing the technology to staff and the communities we serve. For FY 2001 we established a goal of conducting 100 videoconferences–double the FY 1999 baseline.

RESULTS: NSF is successful for this goal. We held a total of 142 videoconferences, a 184% increase over FY 1999, and logged about 342 hours of videoconferencing time (both point-to-point and multi-point) during the course of the year. Staff from six Directorates, seven Staff Offices, and members of the National Science Board conducted videoconferences during the year. Our staff used videoconferencing to hold Advisory Committee meetings, conduct FastLane training sessions for institutions across the country, conduct site visits, meet with PIs, and conduct peer review panels. We also held videoconferences with foreign sites.

NUMBER OF VIDEOCONFERENCES HELD

	FY 1999	FY 2000	FY 2001	FY 2002
Baseline	50			
Goal		N/A	100	N/A
Actual		74	**✓142**[18]	

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: In FY 2001 videoconferencing was viewed as a functioning, rather than experimental, technology. Because videoconferencing is an established practice for us it will not be continued as a goal. We will, however, continue to emphasize this technology for current and emerging business applications. For example, we intend to pilot videoconferencing for telecommuters and facilitate communication between visiting staff scientists and engineers and students and colleagues at their home institutions.

[18] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

MANAGEMENT GOALS

B. NSF Staff

Business Practices
- Electronic Proposal Submission
- Electronic Proposal Processing
- Video Conferencing

NSF Staff
- Diversity
- Work Environment

Goal IV-4 – Staff Diversity
✓ Goal Achieved

Goal IV-4: NSF will show an increase over 1997 in the total number of hires to S&E positions 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.

We continue to make progress in diversifying our NSF workforce.

During FY 2001 we conducted a number of activities to increase the numbers of minorities and underrepresented groups in the S&E staff. These activities included:
- Developing internal and external strategies for recruitment efforts, with direction and focus provided by the NSF Director and Deputy Director.
- Requiring supervisors to implement recruitment and selection plans to address diversity issues specific to their organizations.
- Soliciting input from senior officials regarding best practices and impediments to attracting and maintaining a diverse, professional staff.
- Ensuring diversity goals are reflected in individual performance plans.
- Endorsing comprehensive, nationwide searches for executive positions, as well as for the science and engineering staff.
- Broadening recruitment and outreach efforts through a variety of electronic websites and paid advertisements. Vacancy announcements are now listed on NSF's website and Directorate home pages, the Office of Personnel Management's (OPM) electronic listing, and the Department of Labor's Office of Disability Employment Programs Job link.
- Expanding NSF's mailing list for vacancy announcements to over 1,500 organizations, including Historically Black Colleges and Universities (HBCU), Tribal Affiliations, Hispanic Serving Organizations, and others.

We now encourage our Custom News Service subscribers to access our vacancy announcements and to request e-mail notification of specific vacancies as announcements are posted. These electronic advancements in disseminating information have revolutionized the ability of the Foundation to bring its announcements to the attention of the science and engineering community and the general public.

RESULTS: NSF is successful for this goal. In comparison to the hiring statistics for FY 1997, during FY 2001 we achieved a 138% increase in the number of female hires and a 47% increase in the number of minority hires. FY 2001 is the 2nd year we exceeded our goal.

APPOINTMENTS TO SCIENCE & ENGINEERING POSITIONS FROM UNDERREPRESENTED GROUPS

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
Baseline	16 Female 15 Minority					
Goal			Efforts to attract underrepresented groups	More than 16 Female, 15 Minority	More than 16 Female, 15 Minority	More than 35 Female, 19 Minority
Actual			Achieved[19]	35 Female 19 Minority	✓**38 Female**[20] **22 Minority**[21]	

The success we have achieved over the past several years in the employment of women and minorities is reflected in the total on-board strength in our S&E corps. Women and minorities now comprise 39% and 21%, respectively, of our current S&E workforce, in comparison to 34% and 18% in 1997.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: For FY 2002 we will increase the baseline against which we measure success to reflect more recent hiring practices. In lieu of the 1997 baseline (16 women and 15 minorities) the baseline will become the results achieved in FY 2000 (35 women and 19 minorities). The new goal is much more challenging and will necessitate a more proactive approach in recruiting and retaining individuals from underrepresented groups.

[19] 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."

[20] Includes 1 Female hired by OPP. FY 2001 is the first time OPP data is included.

[21] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

Goal IV-5 – Work Environment
✕ Goal Not Achieved

Goal IV-5: NSF will establish various baselines that will enable management to better assess the quality of worklife and work environment within the Foundation.

Performance Indicator: Development of an employee survey.

This was a new goal for FY 2001. We realized that a systematic method of collecting relevant information on our human capital and work environment was needed in order to promote a more effective and efficient workplace and ensure that the needs of our staff were being addressed. We are committed to enhancing employee potential and promoting higher performance.

Fundamental to achieving this goal was the establishment of an organizational assessment tool (workforce survey) that would be distributed to our staff. We:

- Researched, reviewed and analyzed numerous workforce assessment tools to help identify an appropriate survey that could be administered to staff.
- Selected, after careful and extensive review, an assessment survey prepared by the Office of Personnel Management.
- Established an internal working group to develop an implementation process for this survey within NSF. We also identified employee focus groups to review questions and discuss possible concerns and responses.
- Solicited extensive involvement of all levels of staff to determine whether the survey needed to be adapted to reflect our academic culture and organization. Our senior management provided input regarding the scope of the survey questions and the timing of implementation. We briefed union officers and stewards on the survey process and management's expectations for future actions.

RESULTS: NSF was not successful for this goal. While significant progress was made towards achieving this goal we did not achieve the goal because the survey was not administered.

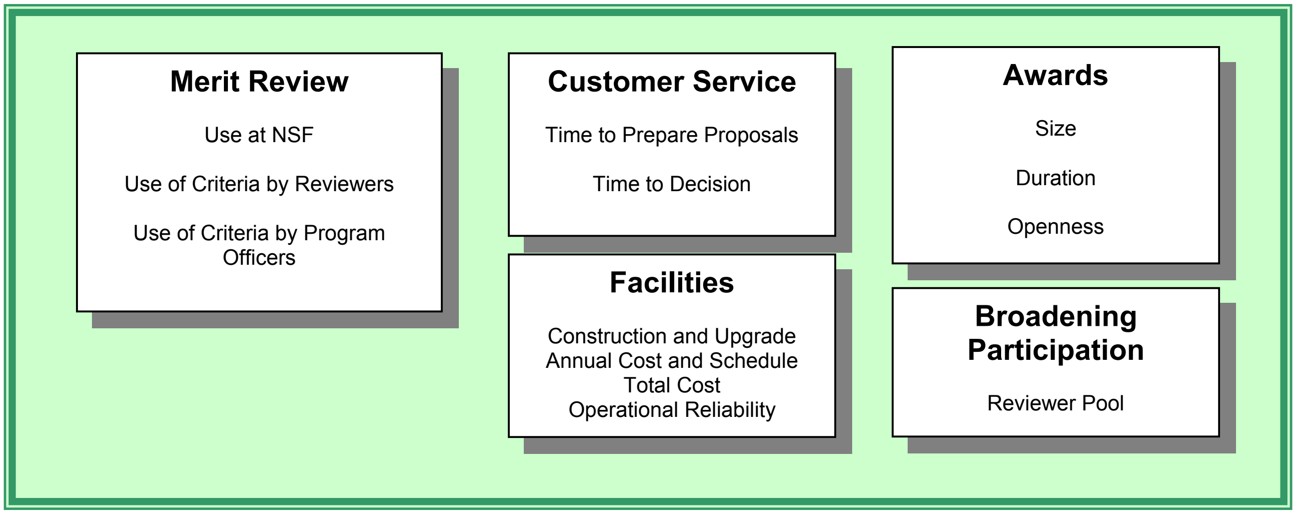
WHY WE DID NOT ACHIEVE THIS GOAL: Implementation of the survey was delayed for several reasons, including an extensive process to identify an appropriate survey instrument, adapting the survey to reflect NSF's culture, and carefully addressing employee, supervisory and policy level input.

STEPS WE WILL TAKE IN FY 2002 TO ACHIEVE THIS GOAL: A survey will be conducted during FY 2002.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal is contained in the FY 2002 Performance Plan. This survey will inform the agency's approach to meeting the standards for success outlined in the Human Capital initiative of the President's Management Agenda.

INVESTMENT PROCESS GOALS

VI. INVESTMENT PROCESS 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 investment process shapes the awards portfolio and supports our outcome goals. Investment process goals focus on means and strategies for successful performance – in merit review and award oversight and management processes, broadening participation, and facilities oversight.

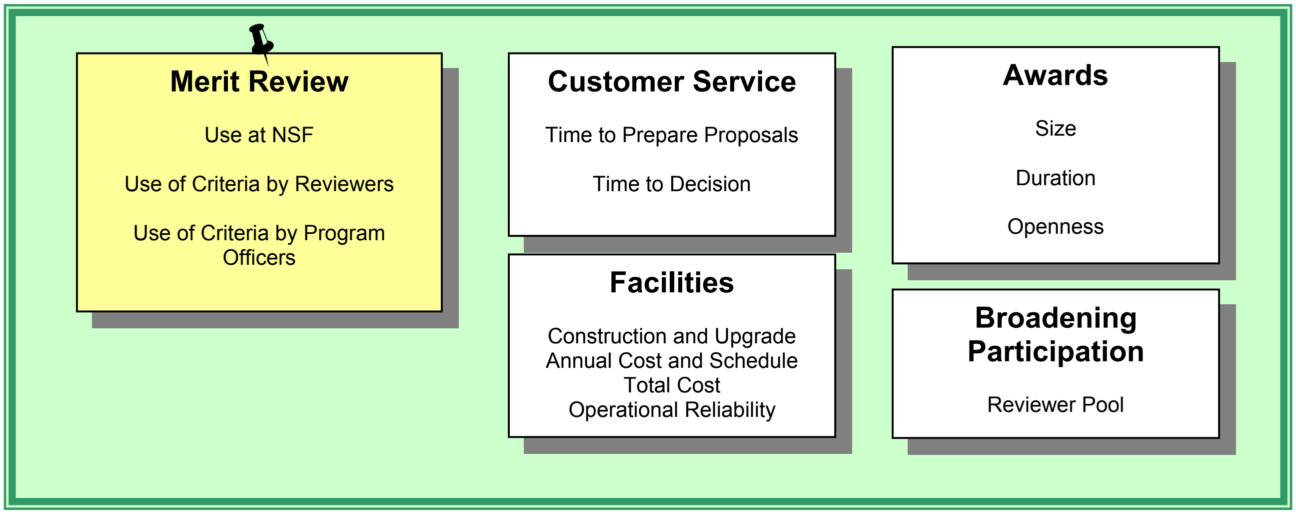
The goals included within this section focus on merit review, customer service, awards managements and oversight, broadening participation of our reviewer pool, and facilities. Success in achieving these goals is dependent upon factors such as high quality merit review, sufficient staff resources and operating expenses, constraints imposed by administrative requirements, and electronic information systems that support the various management processes.

Summary of Results for Investment Process Goals

We achieved seven of our 13 Investment Process Goals in FY 2001. We achieved our goals for allocation of funds to merit-reviewed projects, use of the two merit review criteria by program officers, time for the science and engineering community to prepare proposals, average annualized award size, taking steps to increase the diversity of our reviewer pool, and annual and total cost of construction and upgrade projects. We did not meet our Investment Process Goals for use of the two merit review criteria by reviewers, the time it takes to make a decision on funding a proposal, the average award duration, percent of awards to new investigators, and the annual construction/upgrade schedules and operating efficiency of facilities. As in FY 2000, we engaged an outside accounting firm to verify and validate performance information for most Investment Process goals.

INVESTMENT PROCESS GOALS

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 the broader impacts of the proposed activity.

Evaluations of proposals and funding decisions made through the process of merit review rely on evaluation by experts. Each year, more than 200,000 merit reviews are conducted to help program officers evaluate the proposals submitted for consideration.

The two 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?

A merit-based review involves a scientist, engineer, or educator serving as an NSF Program Officer who reviews all proposals within his/her program, and includes review by three to ten other persons outside NSF who are experts in the particular fields represented by the proposal and are without conflicts of interest. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons who should not review the proposal. These suggestions may serve as an additional source in the reviewer selection process at the Program Officer's discretion. Program Officers may obtain comments from assembled review panels or from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards and declines. When a decision has been made (whether an award or a declination), verbatim copies of reviews, excluding the names of the reviewers, and summaries of review panel deliberations, if any, are provided to the proposer.

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

Goal V-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 few 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.

Data is collected using OMB's government-wide merit-review definition[22] that measures merit-reviewed scientific research as a percentage of basic and applied research[23]. This performance goal applies to federal science, space, and technology agencies. NSF has established the 85% target to be consistent with the OMB recommended range of 70% to 90%.

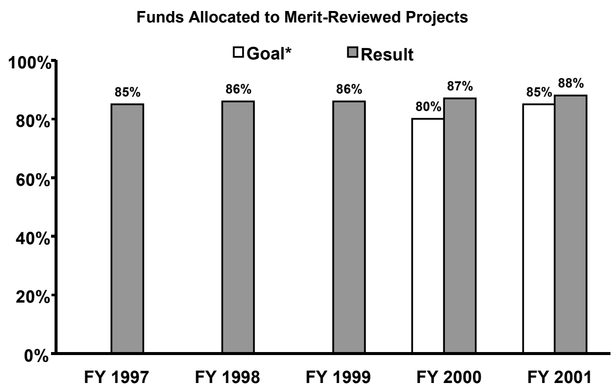
RESULTS: NSF is successful for this goal. In FY 2001 we revised our goal from having 80% of funds allocated to merit-reviewed projects to 85% of funds allocated to merit-reviewed projects. We exceeded that goal by 3%.

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

* 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.

22 *"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."*

23 NSF's original definition included both merit-reviewed projects with competitive selection and external evaluation and projects with limited competitive selection as a percentage of all NSF funding. The revised OMB merit-review definition as of FY 2000 does not include funds for merit-reviewed scientific research with limited competitive selection (*e.g.*, applicants that are limited to organizations that were created to largely serve Federal missions, such as Federally-Funded Research and Development Centers [FFRDCs]). It also does not include merit-reviewed scientific research with competitive selection and internal evaluation (for example, reviews conducted from within the agency program, without additional independent evaluation, such as NSF's Small Grants for Exploratory Research [SGERs]). The revised definition measures merit-reviewed research as a percentage of basic and applied research funds rather than as a percentage of all NSF funding.



IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: An examination of our performance over the last four years shows that we have consistently exceeded our current goal of 85%. Furthermore, we are showing a small increase in the funds allocated to merit-reviewed proposals each year. We will continue to maintain the goal of at least 85% in FY 2002.

* Goal not established for FY 1997 – FY 1999.

Goal V-2 – Reviewer Use of Both Merit Review Criteria
🗝 Goal Not Achieved

Goal V-2: NSF performance in implementation of the merit review criteria is successful when reviewers address the elements of both generic review criteria.

On September 20, 1999, NSF issued Important Notice #125 to Presidents of Universities and Colleges, encouraging Principal Investigators to address the merit review criterion, "the broader impacts of the proposed activity", in their proposals and reviews. This criterion addresses the extent to which proposed activities will: advance discovery and understanding while promoting teaching, training, and learning; broaden participation of underrepresented groups; enhance the infrastructure for research and education; enhance scientific and technological understanding; and benefit society.

RESULTS: This goal was revised for FY 2001[24]. For FY 2001 external groups of experts reviewed 70 NSF programs with respect to this performance goal. In analyzing these reports we concluded we were unsuccessful in achieving this goal[25].

WHY WE DID NOT ACHIEVE THIS GOAL: The two merit review criteria were not implemented until FY 1998. The FY 2001 assessment includes proposals reviewed in FY 1998, FY 1999, and FY 2000, and is the first assessment to review the full implementation of the two criteria.

We believe that a critical factor in our failure to achieve this goal is the time required for our community to become aware of the importance that we assign to discussing both merit review criteria within proposals and within reviews. There are indications that discussion of both criteria by reviewers has increased since the criteria were implemented in FY 1998. During FY 2001 we examined a random sample of FY 2001 reviews to determine the extent of reviewer response to the broader impacts criterion. We found, overall, that approximately 69% of reviews provided evaluative comments on proposer attention to the broader impacts criterion. We expect, therefore, that full usage should become more apparent in the FY 2002 assessments.

STEPS WE WILL TAKE IN FY 2002 TO ACHIEVE THIS GOAL: In response to a directive by the Senate Appropriations Committee that NSF review the procedure and criteria for merit review once the new criteria had been in place for a year, we issued a contract to the National Academy of Public Administration (NAPA) to conduct a study of the impact of the new merit review criteria on the nature of the projects NSF supports. Their key finding was that it is too soon to make valid judgments about the impact and effectiveness of the new criteria. The NAPA report also highlighted the need to improve quantitative measures and performance indicators to track the objectives and implementation of the new criteria.

We are continuing to educate reviewers and proposers on the use of both merit review criteria. We have clarified the meaning of the broader impacts criterion and stressed the importance of

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[24] In FY 1999 and FY 2000 the goal required that both reviewers *and* program officers use both criteria in order for NSF to be successful. In FY 2001 this goal was separated into two distinct goals.
[25] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

using both criteria. We will also collect examples of broader impacts and develop a plan to disseminate them. We have modified program announcements to encourage proposers to provide information on all relevant aspects of the merit review criteria in their proposals.

We have added separate screens in FastLane to enable reviewers to address each merit-review criterion separately. Information for this goal will be collected from the FastLane database. In FY 2002, we expect most reviews to be submitted electronically via FastLane. Since there are separate sections for responses to each of the merit review criteria, we expect to see an increase in the response rate by reviewers to both criteria. This will also significantly increase the ease and reliability with which we will be able to track and count reviews that address both criteria. External expert judgment will also be used to enable assessment of our progress towards achieving this goal.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be modified to reflect our expectation of increasing use of both criteria in FY 2002.

Goal V-3 – Program Officer Use of Merit Review Criteria
✓ Goal Achieved

Goal V-3: NSF performance in implementation of the merit review criteria is successful when Program Officers address the elements of both generic review criteria when making their award decisions.

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 that "*Program Officers must comment on the intellectual merit of the proposed activity and the broader impacts of the proposed activity*."

RESULTS: NSF is successful for this goal. This goal was revised for FY 2001[26]. For FY 2001 external groups of experts reviewed 70 NSF programs with respect to this performance goal. Program reports prepared by external experts during FY 2001 GPRA reporting indicated an assessment of successful for the Foundation in implementation of both merit review criteria by Program Officers.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be continued for FY 2002, and we will take initial steps towards quantifying this goal.

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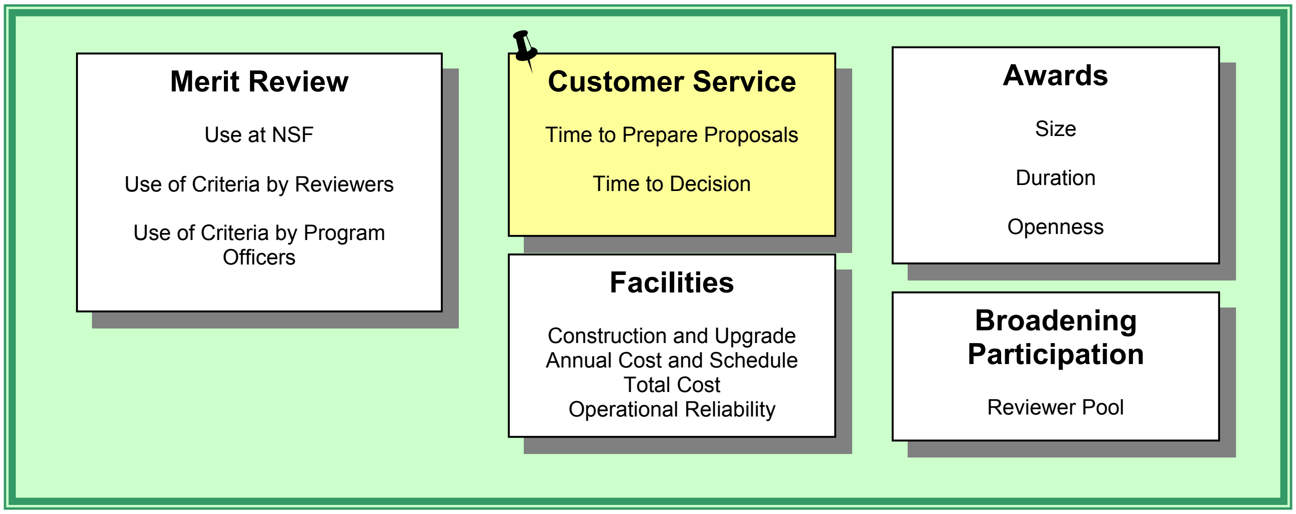
[26] In FY 1999 and FY 2000 the goal required that both reviewers *and* program officers use both criteria in order for NSF to be successful. In FY 2001 this goal was separated into two distinct goals.

Investment Process Goals

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 2001 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 being addressed in internal processes.

Goal V-4: – Time to Prepare Proposals
✓ Goal Achieved

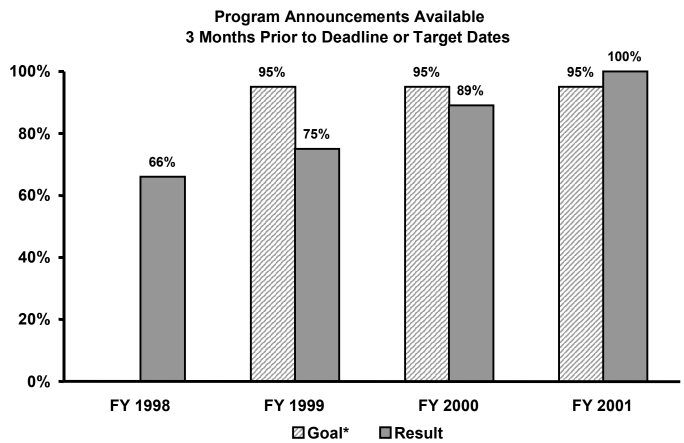
Goal V-4: Ninety-five percent of program announcements will be available to relevant individuals and organizations at least three months prior to the proposal deadline or target date.

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. This goal is identical to the FY 1999 and FY 2000 goals.

RESULTS: NSF is successful for this goal. After two years of failing to achieve this goal, we exceeded our goal. All of our program announcements and solicitations were made available at least 90 days before the proposal deadline[27].

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
Baseline	66%				
Goal		95%	95%	95%	95%
Actual		75%	89%	**✓100%**	



*No goal established for FY 1998

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be maintained in FY 2002.

We are also considering enhancement of one of our corporate systems in order to track data for this goal. The Foundation is developing a Program Information Management System (PIMS), which is a relational database designed to collect information and could be used to track the progress of publications such as program announcements and solicitations.

[27] 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 V-5 – Time to Decision

✕ Goal Not Achieved

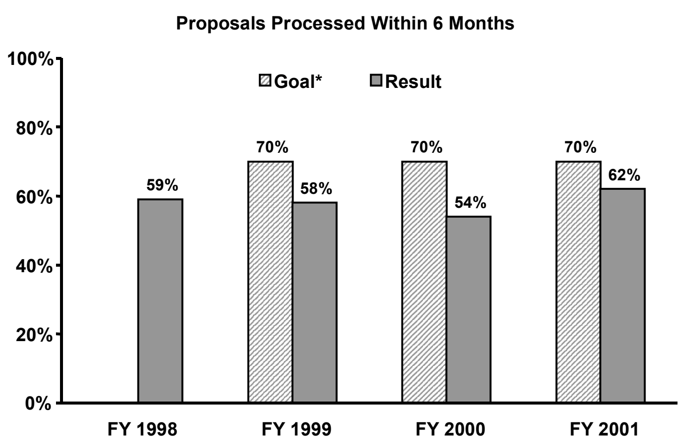
Goal V-5: For 70 percent of proposals, be able to tell applicants whether their proposals have been declined or recommended for funding within six months of receipt.

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, and we are continually reviewing the steps needed to decrease proposal processing time.

RESULTS: We were not successful in achieving this goal. In FY 2001 we processed 62% of all proposals within six months of receipt, a significant improvement over FY 2000. Nevertheless, we fell short of the 70% goal.

PERCENT OF PROPOSALS PROCESSED WITHIN 6 MONTHS OF RECEIPT

	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002
Baseline	61%					
Goal			70%	70%	70%	70%
Actual		59%	58%	54%	**✕62%**[28]	



*No goal established for FY 1998

WHY WE DID NOT ACHIEVE THIS GOAL: One factor leading to delay in processing is that some programs prefer to conduct merit review by mail rather than by convening review panels. Mail reviews often take longer to complete. For example, in FY 2001, 70% of all proposals reviewed by panel-only were processed within six months, compared to 58% for mail-plus-panel review and 52% for mail-only review. Another factor is that some programs tend to hold a few highly rated proposals until the end of the fiscal year, or even into the next fiscal year, in anticipation that more funds might become available.

STEPS WE WILL TAKE IN FY 2002 TO ACHIEVE THIS GOAL: This represents the third consecutive year we have not achieved this goal. However, we are encouraged by the fact that

[28] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

in FY 2001 we processed a greater percentage of our proposals within six months than in each of the preceding three years. Furthermore, a review of our FY 2001 data shows that 77% of our proposals were processed in less than seven months. Thus, an additional 15% of our proposals came within one month of being processed within our goal.

In FY 2002, we will continue to focus on improving the efficiency of proposal processing, including the dissemination of best practices to program staff. We have implemented a series of new electronic processes designed to improve the efficiency and effectiveness of the merit review process. New FastLane modules such as the Interactive Panel System and Electronic Declination, as well as the pilot project to provide proposals to reviewers electronically (with print-on-demand available), are reducing processing time and helping our staff to cope with increasing workloads.

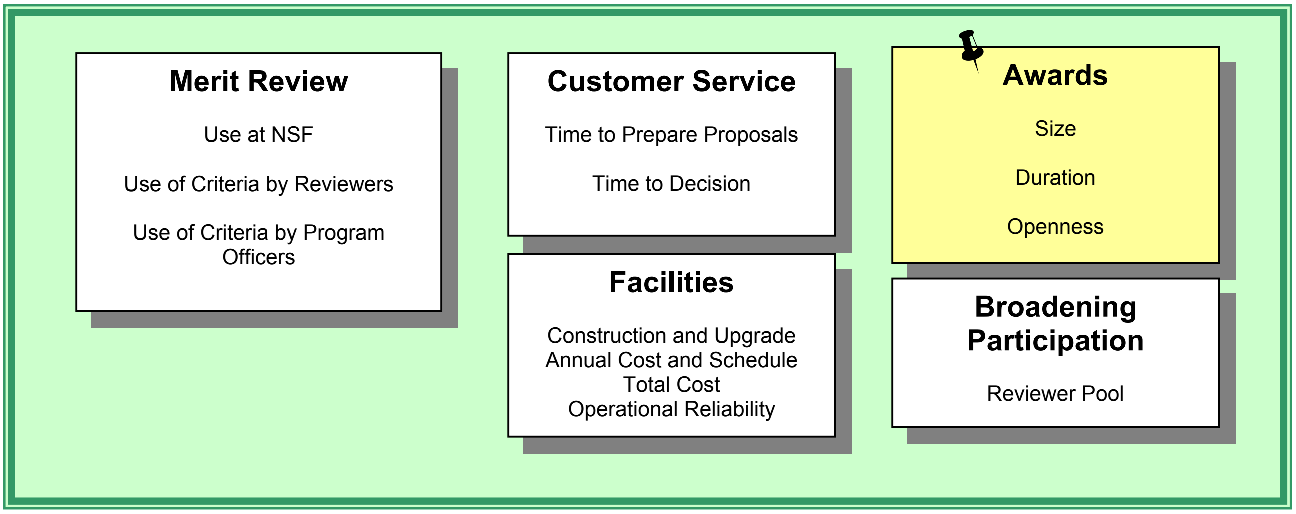
We have sponsored a series of brainstorming sessions for staff at all levels within the organization to discuss issues, concerns, and effective practices related to proposal processing time. The results of these sessions, including effective practices employed by organizations with excellent processing times, have been widely disseminated throughout NSF. The sessions also identified a number of key management issues related to processing time such as the need for timely processing of declinations and better tracking information on proposals in process. We have developed a report that tracks proposals through major processing stages and identifies those that are close to exceeding recommended timeframes for each stage. This report is produced centrally and periodically distributed to division directors throughout NSF.

In FY 2002 NSF staff will work towards shortening the award processing time by making more effective use of electronic mechanisms in conducting the review, working cooperatively to reduce overloads and bottlenecks, and by carefully tracking the stage of processing and receipt date of all proposals. Some internal organizations are considering eliminating the practice of holding over proposals for potential funding until the next fiscal year. Some have added “performance on prompt handling of proposals” to the performance evaluation criteria of their staff.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be maintained in FY 2002. We believe the expanded use of key electronic processes and adoption of effective practices identified in the FY 2001 brainstorming sessions will lead to our meeting or exceeding the 70% goal.

INVESTMENT PROCESS GOALS

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.

In FY 2002, NSF will continue efforts to address Foundation-wide concerns about research and education grant size and duration – this priority is highlighted in NSF's Strategic Plan and is one of the new management reform activities for NSF highlighted by OMB.

Goal V-6a – Increased Average Annualized Award Size
✓ Goal Achieved

Goal V-6a: NSF will increase the average annualized award size for research projects to $110,000.

Increasing award size is a new goal[29]. We want to reach an average annualized award size of $150,000 by FY 2005.

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 and exceeding this goal.

AVERAGE ANNUALIZED AWARD SIZE FOR RESEARCH PROJECTS					
	FY 1998	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**
Baseline	$90,000				
Goal				$110,000	$113,000
Actual		$94,000	$105,800	✓**$113,601**[30]	

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: Our new goal for FY 2002 is based on our performance in FY 2001. Our goal for FY 2002 will be an average annualized award size of $113,000.

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[29] 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).

[30] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used to calculate results for this goal. They concluded that the procedures related to this goal 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 for selected goals were verifiable and the results valid, in Appendix IV.

Goal V-6b – Increased Average Award Duration
✕ Goal Not Achieved

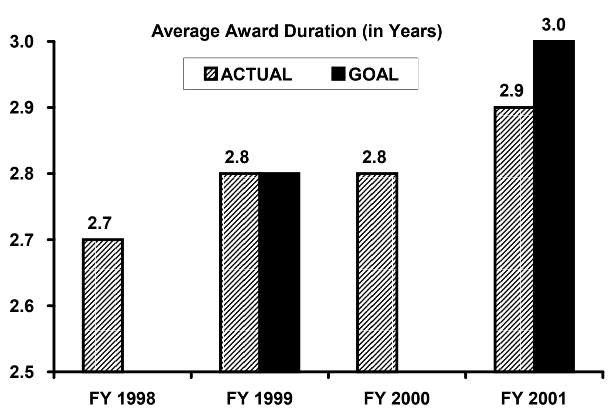
Goal V-6b: NSF will increase the average duration of awards for research projects to at least three years.

Our goal is to reach an average award duration of 4 years by FY 2005[31]. Increasing award duration was a new goal in FY 2001. The award duration goal built on a FY 1999 goal (the duration goal was dropped in FY 2000 and reinstated in FY 2001).

Longer award terms are important in increasing the effectiveness of Principal Investigators and graduate students. Less time is spent preparing proposals, and graduate students are able to have more time to do their thesis work.

RESULTS: We were not successful in achieving this goal.

AVERAGE AWARD DURATION FOR RESEARCH PROJECTS					
	FY 1998	**FY 1999**	**FY 2000**	**FY 2001**	**FY 2002**
Baseline	2.7 years				
Goal		2.8 years	N/A	3.0 years	3.0 years
Actual		2.8 years	2.8 years	✕ **2.9 years**[32]	



WHY WE DID NOT ACHIEVE THIS GOAL: Sufficient resources were not available to achieve both the award size and award duration goals. NSF focused its efforts on increasing average annualized award size and reached its goal for FY 2001.

STEPS WE WILL TAKE IN FY 2002 TO ACHIEVE THIS GOAL: Progress on this goal is budget dependent. Program Directors must balance competing/multiple requirements: increasing award size, increasing duration of awards, or making fewer awards. We will continue to focus on increasing award size and duration in order to improve the efficiency of the research process.

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[31] 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).

[32] The auditing firm of PricewaterhouseCoopers LLP (PwC) reviewed the data collection, maintenance, processing, and reporting procedures used in this goal. They concluded that the procedures related to this goal 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 for selected goals we report were verifiable and the results valid, in Appendix IV.

We have contracted with Mathematica Policy Research, Inc. to assist in the development and administration of two surveys – one for Principal Investigators and one for institutions – on issues related to the appropriate size and duration of awards. The goal of the study is to understand how to improve the overall efficiency of the research process and to understand the impact of NSF research and education awards.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: We will maintain the FY 2001 goal of 3.0 years for the average duration of awards for research and education grants.

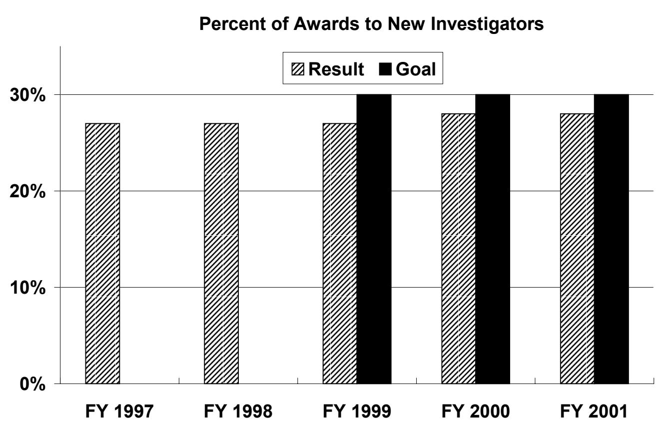
Goal V-7 – Maintaining Openness in the System
🗝 Goal Not Achieved

Goal V-7: NSF will award 30% of its research grants to new investigators.

We believe it is important that the proposal and award process be open to new people and new ideas to help ensure that NSF is supporting research and education at the frontier of science and engineering. We are committed to maintaining openness in the system and will strive to increase the percentage of awards to new investigators.

RESULTS: We were not successful in achieving this goal. The percentage of competitive research and education grants issued to new investigators was 28%, the same as in FY 2000, and one percent higher than in FY 1999.

PERCENTAGE OF COMPETITIVE RESEARCH GRANTS ISSUED TO NEW INVESTIGATORS					
	FY 1997	**FY 1998**	**FY 1999**	**FY 2000**	**FY 2001**
Baseline	27%				
Goal			30%	30%	30%
Actual		27%	27%	28%	🗝 **28%**



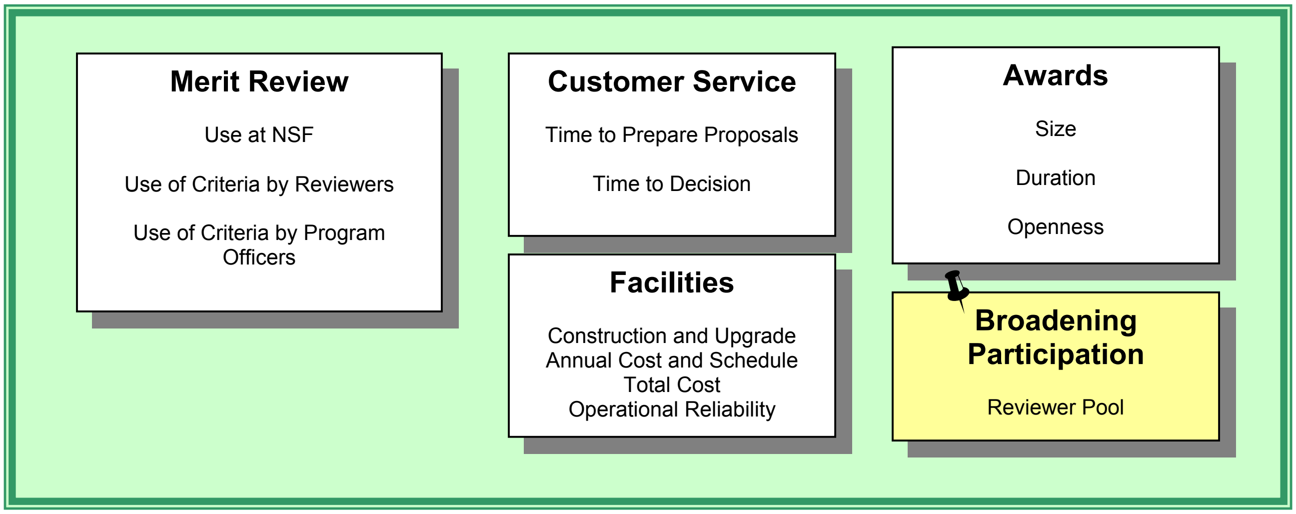
WHY WE DID NOT ACHIEVE THIS GOAL: This has been a difficult and challenging goal for NSF. In spite of our focused efforts, we have been unable to achieve this goal, although we have come close in the past few years. It is not clear why we have not attained the goal, as budgets, quality of proposals, experience of Principal Investigators, and other factors all come into the equation.

WHAT WE WILL CONTINUE TO DO IN FY 2002: We will continue to actively seek creative and innovative proposals from new investigators. We will continue our outreach efforts. Program staff will continue to attend scientific meetings, conferences, and conventions and will conduct site visits to promote awareness of the research opportunities at NSF and to encourage new investigators to submit proposals. We will examine trends, such as whether the pool of new investigators is smaller than in previous years or whether they are submitting fewer proposals.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This openness goal is not included in the FY 2002 Performance Plan because we wish to fully consider whether this goal provides a good measure of openness in the system. Thus, we intend to examine a variety of interrelated parameters that affect it, and on that basis consider another.

INVESTMENT PROCESS GOALS

D. BROADENING PARTICIPATION



We are strongly committed to increasing the participation of science and engineering researchers, educators and students from groups currently underrepresented in the science and engineering enterprise in all NSF activities. Congress has enacted legislation giving NSF explicit responsibility for addressing issues of equal opportunity in science and engineering. This assignment of responsibility reflected the serious underrepresentation of women, minorities, and persons with disabilities in the science and engineering workforce, and, although progress has been made, underrepresentation persists.

Recognizing that progress toward all outcome goals for research and education requires maximum diversity of intellectual thought, NSF is focusing its attention on enhancing the participation of groups currently underrepresented in science and engineering in all its programs. In order to realize this increased participation, and so contribute to the development of a dynamic, diverse, human resource pool in science and engineering over the next decade NSF seeks to:

- Increase the participation of scientists and engineers from underrepresented groups in NSF's merit review process;
- Increase the participation of scientists and engineers from underrepresented groups in NSF's workshops and conferences;
- Increase the number of proposals submitted by and awards made to scientists and engineers from underrepresented groups; and
- Increase the number of scientists and engineers from underrepresented groups appointed by NSF to its staff.

At present we are focusing on the first and fourth of these efforts. NSF is committed to maintaining openness in the system and strives to increase the percentage of awards to new investigators.

Goal V-8 – Broadening Participation: Reviewer Pool Diversity
✓ Goal Achieved

Goal V-8: NSF will begin to request voluntary demographic data electronically from all reviewers to determine participation levels of members of underrepresented groups in the NSF reviewer pool.

NSF is strongly committed to increasing the participation of science and engineering researchers, educators and students from groups currently underrepresented in the science and engineering enterprise in all NSF activities. Congress has enacted legislation giving NSF explicit responsibility for addressing issues of equal opportunity in science and engineering.

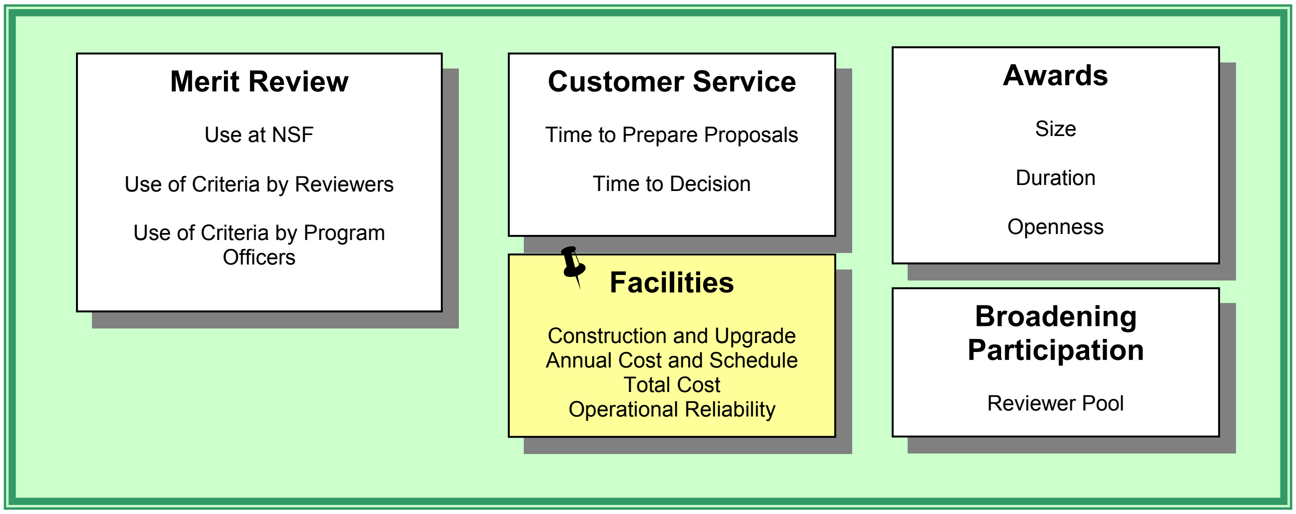
FY 2001 marks the first time we have focused attention on reviewer pool data. To establish the baseline, we have begun to gather the appropriate voluntary data from the reviewers. A baseline for FY 2002 will be derived from this data.

RESULTS: We were successful in achieving this goal. The reviewer system in FastLane was revised to gather voluntary demographic data.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: We will continue a related goal in FY 2002. Our FY 2002 goal is to establish a baseline for participation of members of underrepresented groups in NSF proposal review activities. We will seek voluntary demographic data from all reviewers electronically, and encourage increased participation of members of underrepresented groups in NSF conferences and workshops where they may come into contact with NSF program staff. We will continue to encourage members of underrepresented groups in science and engineering fields to participate in the NSF merit review system as reviewers and widely disseminate information about opportunities to participate in our merit review process as a reviewer or panel member.

INVESTMENT PROCESS GOALS

E. 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.

Every year, in the President's Budget Request, we set out a cost plan and schedule for major construction and upgrade projects currently underway or planned for initiation in the Major Research Equipment and Facilities Construction account. Cost plans and schedules are also developed for other construction and upgrade projects funded through the Research and Related Activities Account. We have established performance goals and measurements with respect to these plans and expect each construction and upgrade activity to meet these performance goals. We consult with other agencies to avoid duplication and to optimize capabilities available to American researchers and educators, and cooperate with other agencies and international partners in construction of facilities where it will facilitate use across broad communities of researchers. We manage facilities in the Antarctic that are used by all federal agencies.

In FY 2001 24% of our budget was allocated to the support of "Tools." Within Tools, FY 2001 funding for the Major Research Equipment (MRE) account was approximately $119 million, an increase of $14 million over FY 2000.

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 new 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.

Further development and implementation of the plan is continuing.

We have established a new position–Deputy, Large Facility Projects–to enable the efficient and effective evolution of our large facility projects from their pre-formulation through operations. This position will be filled in FY 2002.

In order to report on the government performance goals related to Facility Operations and Construction and Upgrades, we initiated, in FY 1999, development of a new 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. As is the case with any new data collection effort, we expect the quality of the information provided to improve as NSF's Program Officers and external facilities managers gain experience with gathering and reporting the required data.

In FY 2001 NSF engaged PricewaterhouseCoopers LLP (PwC) to review the process for collection and reporting of GPRA data for the facilities goals. PwC's recommendations, along with NSF's own review of the facilities goals and associated data collection methods, will be examined in FY 2002. Necessary changes will be identified and an implementation plan for the changes will be developed.

The facility goals that follow are organized in two categories – (1) *Construction and Upgrade of Facilities and (2) Operations and Management of Facilities*. Our goals are based on the general goals for facilities construction and operations outlined in the "General Science, Space and Technology" (Function 250) chapter of the President's FY 2001 Budget Request. These goals apply to the federal science, space and technology agencies (NSF, NASA, DoE).

Goal V-9a – Annual Construction and Upgrade Expenditures
✓ Goal Achieved

Goal V-9a: For 90 percent of facilities, keep construction and upgrades within annual expenditure plan, not to exceed 110 percent of estimates.

This FY 2001 goal was slightly revised from the FY 2000 goal. In FY 2000 one hundred percent of facilities were required to meet the goal for NSF to be considered successful. In FY 2001 the goal was revised so that we were considered successful if at least 90% of facilities kept construction and upgrade expenditures within 110% of their estimates. This change was made because while we place great importance on accurate planning for construction and upgrade of facilities we recognize that the unique, state-of-the-art projects being supported stretch the limits of technological capability. As a result there may be unforeseen expenditures. Nevertheless, we expect that the vast majority of our projects will be within budget. However, we do not believe the agency should be considered unsuccessful overall in this area if a small percentage of facilities are unable to meet the goal. Therefore, to assure that we have realistic and achievable goals, we reestablished the target level of success at 90% of the facilities for FY 2001. We will evaluate this goal over time to determine if 90% is the appropriate level.

RESULTS: We were successful in achieving this goal. Of the twenty-five construction and upgrade projects supported by NSF, twenty-four (96%) were within 110% of annual expenditure plans. The expenditures of nine projects were equal to the planned annual cost, twelve projects' expenditures were less than the estimated cost and three projects had annual costs greater than but within 110% of their estimate.

ANNUAL CONSTRUCTION AND UPGRADE EXPENDITURES				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Goal	Keep within annual expenditure plan, not to exceed 110% of estimates.	Keep within annual expenditure plan, not to exceed 110% of estimates.	For 90% of facilities, keep within annual expenditure plan, not to exceed 110% of estimates.	For 90% of facilities, keep within annual expenditure plan, not to exceed 110% of estimates.
Actual	Majority of projects were within 110% of estimates.	11 of 11 (100%) projects were within 110% of estimates.	**✓24 of 25 (96%) projects were within 110% of estimates**[33].	

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be maintained in FY 2002. We have established a new position–Deputy, Large Facility Projects–to enable the efficient and effective evolution of our large facility projects from their pre-formulation through operations.

[33] In their report of January 2002, the auditing firm of PricewaterhouseCoopers LLP (PwC) stated: "For the four goals related to facilities management, we identified significant data limitations, which impaired our ability to verify the processes. However, we believe that NSF's reported outcomes are consistent with the data they collected." We are in the process of refining the data collection procedures for FY 2002.

Goal V-9b – Meeting Annual Schedule Milestones
✕ Goal Not Achieved

Goal V-9b: Ninety percent of facilities will meet all annual schedule milestones by the end of the reporting period.

The FY 2001 goal is slightly revised from the FY 2000 goal. In FY 2000, for NSF to be considered successful, one hundred percent of facilities were required to meet all annual schedule milestones within 110% of estimates. In FY 2001 we have modified this goal and consider successful achievement to be when at least 90% of facilities meet all major schedule milestones by the end of the reporting period. This change was made because while we place great importance on accurate planning for construction and upgrade of facilities we recognize that the unique, state-of-the-art projects being supported stretch the limits of technological capability and there may be unexpected construction delays. While we expect the vast majority of projects to be on schedule, we do not believe we should be considered unsuccessful overall in this area if a small percentage of facilities are unable to meet the goal. Therefore, to assure that we had realistic and achievable goals, we reestablished the target level of success at 90% of the facilities for FY 2001. We will evaluate this over time to determine if 90% is the appropriate level.

RESULTS: For FY 2001, of the 25 construction and upgrade projects we supported, 21 (84%) met all annual schedule milestones by the end of the reporting period.

ANNUAL SCHEDULE MILESTONES				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Goal	Construction and upgrades within annual schedule, time required for major components within 110% of estimates.	Construction and upgrades within annual schedule, time required for major components within 110% of estimates.	90% of facilities will meet all major annual schedule milestones by the end of the reporting period.	90% of facilities will meet all major annual schedule milestones.
Actual	Majority of projects were within 110% of estimates.	7 of 11 (64%) projects were within 110% of estimates.	**✕21 of 25 (84%) projects met all major annual schedule milestones by the end of the reporting period[34].**	

WHY WE DID NOT ACHIEVE THIS GOAL: In some cases, projects were unable to meet all major annual schedule milestones within the reporting period due to circumstances beyond the control of the facility manager, such as an earthquake. Other examples of why some projects

[34] In their report of January 2002, the auditing firm of PricewaterhouseCoopers LLP (PwC) stated: "For the four goals related to facilities management, we identified significant data limitations, which impaired our ability to verify the processes. However, we believe that NSF's reported outcomes are consistent with the data they collected." We are in the process of refining the data collection procedures for FY 2002.

were not able to meet annual schedule milestones are underestimates of project complexity, technical problems and personnel vacancies.

STEPS WE WILL TAKE IN FY 2002 TO ACHIEVE THIS GOAL: We will continue to work with our awardees to identify obstacles to successful performance and together implement plans to avoid these same obstacles or to mitigate their consequences in the future.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: The FY 2002 goal will be revised because of our experiences during FY 2001. We found that the definition of “reporting period” was somewhat ambiguous. As a result, the goal for FY 2002 has been changed to “Ninety percent of construction/upgrade projects will meet all major annual schedule milestones.” Relevant definitions of terms used in reporting will be clarified.

Goal V-9c – Total Cost
✓ Goal Achieved

Goal V-9c: For all construction and upgrade projects initiated after 1996, when current planning processes were put in place, keep total cost within 110 percent of estimates made at the initiation of construction.

We recognize that construction and upgrade projects may experience both cost and schedule overruns. Our goal, since FY 1999, is that all projects/upgrades will keep within 110% of their initial estimated total costs.

RESULTS: We were successful in achieving this goal. One project was completed in FY 2001. The total cost of the project was equal to the estimated total cost. This goal was not applicable in FY 1999 and FY 2000 since no projects were completed.

CONSTRUCTION AND UPGRADE TOTAL COST				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Goal	For all construction and upgrade projects initiated after 1996, keep total cost within 110% of estimates made at the initiation of construction.	For all construction and upgrade projects initiated after 1996, keep total cost within 110% of estimates made at the initiation of construction.	For all construction and upgrade projects initiated after 1996, keep total cost within 110% of estimates made at the initiation of construction.	For all construction and upgrade projects initiated after 1996, keep total cost within 110% of estimates made at the initiation of construction.
Actual	No projects completed.	No projects completed.	✓ **One project was completed. The actual total cost was equal to the estimated total cost[35].**	

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be maintained in FY 2002. We have established a new position – Deputy, Large Facility Projects – to enable the efficient and effective evolution of our large facility projects from their pre-formulation through operations.

[35] In their report of January 2002, the auditing firm of PricewaterhouseCoopers LLP (PwC) stated: "For the four goals related to facilities management, we identified significant data limitations, which impaired our ability to verify the processes. However, we believe that NSF's reported outcomes are consistent with the data they collected." We are in the process of refining the data collection procedures for FY 2002.

Goal V-10 – Operating Time
✕ Goal Not Achieved

Performance Goal V-10: For 90 percent of facilities, keep operating time lost due to unscheduled downtime to less than 10 percent of the total scheduled operating time.

Our FY 2001 goals are based on government-wide goals established by OMB for science and technology agencies (NSF, NASA and the Department of Energy) that support construction projects and have responsibility for managing facilities.

The "operating time" goal has been revised from 100% of facilities to 90% because we recognize that while some facilities may occasionally have a failure rate greater than 10%, this is balanced overall by facilities that operate more reliably. We expect that the vast majority of facilities will keep operating time lost due to unscheduled downtime to less than 10% of the total operating time. We do not believe the agency should be considered unsuccessful if a small percentage of the facilities are, at times, unable to meet this goal. Therefore, to provide the flexibility necessary for NSF to report realistic goals, we reestablished the level deemed "successful" at 90% of the facilities. This change will be evaluated over time to determine if 90% is the appropriate level for this goal.

RESULTS: We were not successful in achieving this goal. Of the 29 reporting facilities, 25 (86%) met the goal of keeping unscheduled downtime to below 10% of the total scheduled operating time. Four reported unscheduled downtime greater than 10%.

OPERATING TIME				
	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
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.
Actual	Majority of facilities successful.	22 of 26 (85%) reporting facilities met goal.	**✕25 of 29 (86%) reporting facilities met goal[36].**	

WHY WE DID NOT ACHIEVE THIS GOAL: Some causes of unscheduled downtime in excess of 10% of total scheduled operating time were outside the control of the facility manager, such as electric power supply interruption and equipment failure. Other causes ranged from sub-par

[36] In their report of January 2002, the auditing firm of PricewaterhouseCoopers LLP (PwC) stated: "For the four goals related to facilities management, we identified significant data limitations, which impaired our ability to verify the processes. However, we believe that NSF's reported outcomes are consistent with the data they collected." We are in the process of refining the data collection procedures for FY 2002.

performance of new instruments early in their commissioning to unanticipated failure and downtime for repair.

STEPS WE WILL TAKE IN FY 2002 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 2002.

IMPLICATIONS FOR THE FY 2002 PERFORMANCE PLAN: This goal will be maintained in FY 2002. We have established a new position – Deputy, Large Facility Projects – to enable the efficient and effective evolution of our large facility projects from their pre-formulation through operations.

OTHER INFORMATION

VII. 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 outcome goals are generally expressed in a qualitative form, and most management goals and investment process goals are quantitative.

MANAGEMENT AND INVESTMENT PROCESS GOALS

We make use of internal data systems to monitor and report progress in achieving the quantitative management goals and investment process goals. For these goals, performance results are assessed and reviewed by our administrative staff and managers, with selected goals audited by external third parties. The two qualitative investment process goals (Goals V-2 and V-3) are addressed by external experts who participate in COV and AC reviews. 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.

OUTCOME GOALS

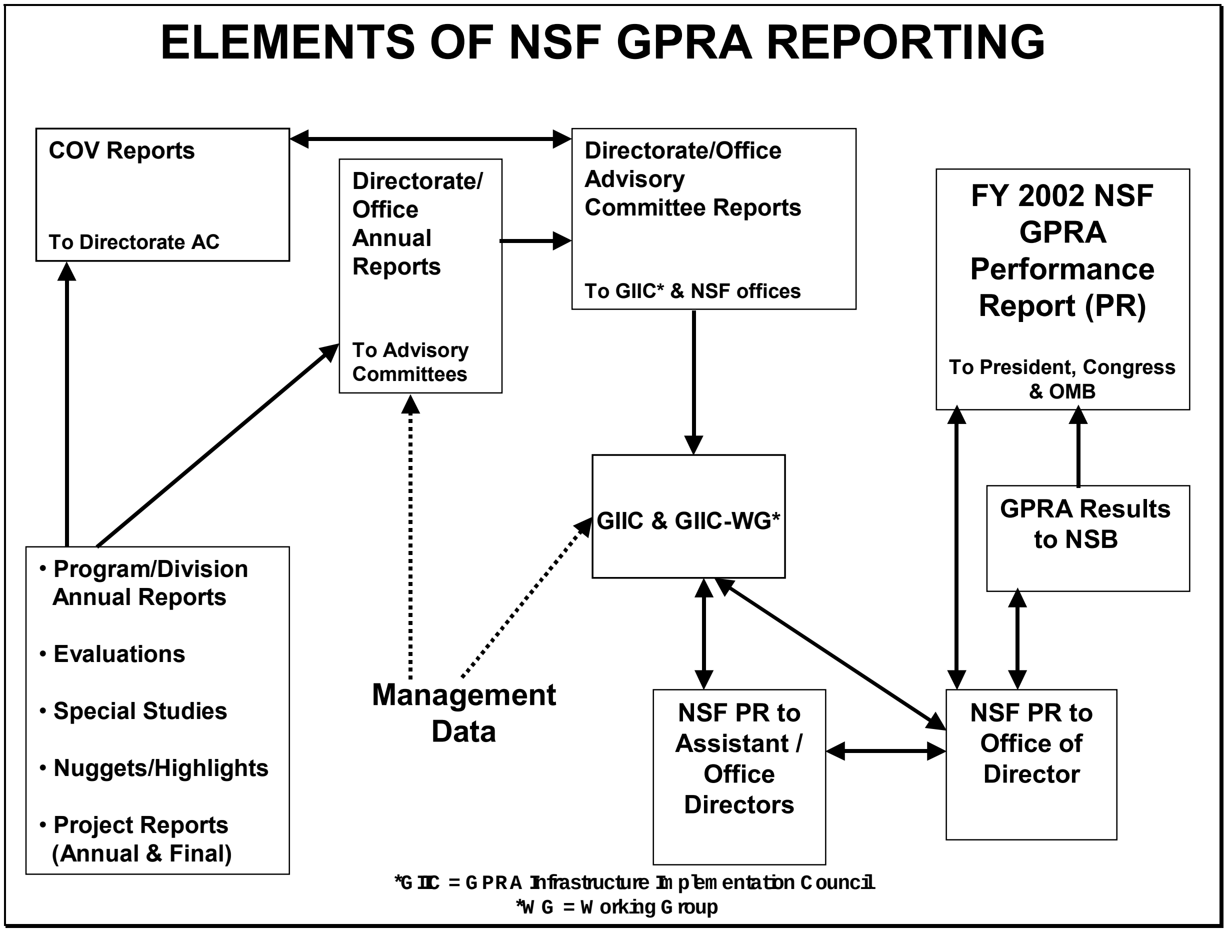
We have traditionally made use of various types of assessments and evaluations to monitor non-quantitative research and education outcomes, the quality of our investments, and the processes we use. Formalized examination takes place during merit review of proposals, COV and AC assessments, and GPRA reporting. 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.

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 ACs) 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, progress achieved in the prior year, 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. Our staff also prepare materials (reports, evaluations, highlights) for use by COVs and ACs 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 our annual GPRA reporting. Included are assessments for outcome goals and for the two qualitative investment process goals dealing with the implementation of the merit review criteria. In the past, COVs have traditionally assessed the integrity and efficiency of the processes for proposal review. With the full implementation of GPRA in FY 1999, we added a retrospective GPRA assessment component (both outputs and outcomes) to their responsibilities.

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.

Each year, COVs assess approximately one-third of our progams, and review their performance over the previous three years. In FY 2001, about 32% of NSF's portfolio of 220 programs was evaluated by COVs for quality of process and progress made in achieving NSF's FY 2001 goals. In FY 2000, about 37% of NSF's portfolio was evaluated by COVs. The remaining portion of NSF's portfolio will be evaluated by COVs in FY 2002 to complete the full three-year cycle of assessment of NSF programs.

In FY 2001, approximately 250 COV members participated in program review and performance assessment. The 19 COV reports generated covered 70 of our approximately 220 programs (see Appendix II for a schedule of program evaluations). Typically, there are fewer COV reports than programs because some reports evaluate multiple programs.

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. In determining whether there has been significant achievement with respect to the prescribed performance indicators, COV members use their collective experienced-based norms.

The FY 2001 COVs were asked to judge whether our programs were successful or not in achieving Outcome Goals III-1a, III-2, and III-3, and in implementing the merit review criteria (Investment Process Goals V-2 and V-3). COVs are asked to justify their judgements and provide supporting examples or statements illustrating success and progress toward GPRA goals.

COVs are generally 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. The reports are also reviewed by NSF staff.

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, review COV reports and directorate responses to COV recommendations, and assess directorate progress in achieving NSF-wide GPRA goals.

The ACs have full access to all available data sources to carry out their assessments. Their review and assessment process culminates with an AC report that incorporates the results of all external COV and directorate reporting and highlights the annual progress of the directorate toward achieving NSF's qualitative goals.

At the close of the fiscal year, each directorate submits all GPRA-related materials (COV and AC reports, directorate annual reports, and responses to recommendations made by COVs) to agency senior management, including the Office of the Director. Simultaneously, quantitative data relevant to the management goals and investment process goals are finalized by our staff and submitted to senior management, including the Office of the Director.

Agency GPRA Reporting

The COV and AC 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-2 and III-3.) These reports also contain discussions of investment process goals related to use of merit review criteria by reviewers (Goal V-2) and Program Officers (Goal V-3). Both are stated in the alternative form. Two quantitative goals (Goals III-1b and III-1c) associated with the People outcome goal are evaluated using relevant quantitative data.

The criterion for success for each of the People, Ideas, and Tools outcome goals can be stated:

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

This criterion is utilized for judgements about both program and agency success for GPRA P-I-T outcome goals. For program assessment, only relevant goals and indicators are used. For agency assessment, all goals and indicators are relevant and all are used in determining agency success. The agency decision for NSF is based on analysis of the successful/not successful judgements contained within the AC and COV reports. Each successful rating requires supporting evidence or retrospective examples supporting such a judgement.

NSF staff examine individual ratings (Successful or Not Successful) included in COV and AC reports to ensure that ratings for the qualititave outcome goals and indicators are justified. Each rating assigned by the committees is evaluated by NSF staff utilizing well-defined, internally developed criteria. In order to verify and validate staff judgements regarding AC or COV ratings, an external firm, PricewaterhouseCoopers LLP (PwC), was engaged to review the COV and AC reports using the same criteria as NSF staff. PwC was asked to independently assess ratings and justifications contained within the COV and AC reports. NSF staff and PwC then met to compare and reconcile their conclusions. In almost all cases there was consensus. The differences were minor and had no impact on the final results.

Principal factors contributing to NSF's decision that the agency is successful for our outcome goals related to People, Ideas, and Tools include:

- the consistently high ratings for each of the eight directorates and offices, as contained in Advisory Committee reports – the external experts on the eight advisory committees judged all relevant outcome goals and indicators as successful.
- the lack of significant numbers of "not successful" assessments (in both COV and AC reports).
- the extensive number and quality of retrospective examples demonstrating significant achievement for the 11 indicators associated with the three outcome goals.

For agency GPRA reporting, we generally placed more emphasis on results contained in the AC reports because these reports are more complete and comprehensive compared to the COV reports, which cover only a third of our programs. The AC reports took into account all of the material provided by the COVs and Directorates/Office staff

VIII. VERIFICATION AND VALIDATION (V&V)

The Foundation has both qualitative and quantitative GPRA goals. Its qualitative goals include the three broad strategic outcome goals related to People, Ideas, and Tools and two investment process goals related to implementation of merit review criteria. 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 Advisory Committees) who assess the quality of program results based on their collective experience-based norms. Our 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, especially that related to facilities. 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.

In their January 2002 report PricewaterhouseCoopers LLP (PwC) addressed system aspects of NSF data quality for the Awards system, Enterprise Information System, Financial Accounting System, FastLane, Integrated Personnel System, and the Proposal, PI, and Reviewer System. PwC "*reviewed NSF's information systems to ensure that adequate internal controls are in place to produce reliable data. The techniques presented 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. One external report that we referenced was the House Subcommittee on Government Efficiency, Financial Management, and Intergovernmental Relations' computer security report card, which it released in October 2001. The report card rated NSF with the highest grade (B+) of 24 major federal agencies.*"

In FY 2002, NSF's data quality program has the following objectives:

- Complete the evaluation of data elements with primary focus on data supporting GPRA goals;
- Complete the population of validated data elements into the data dictionary for all GPRA data elements;
- Enhance the functionality of the data dictionary for all NSF-wide information systems to ensure that meta-data describing the data is identified and thoroughly documented;
- Continue to ascertain the causes of the data quality problems and develop systematic methods for correction; and
- Develop and promulgate data quality policies and procedures NSF-wide.

A COV data project initiated in FY 2001 will substantially improve the quality, consistency and availability of data, reports and charts that are used by external NSF committees. These committees, in addition to providing advice to the NSF organization, provide assessments used in NSF's annual GPRA reporting. Currently, each NSF organization produces its own reports and charts for each of its committees. As a result of this new project, the reports will be generated centrally to reduce costs and improve quality and consistency across NSF. The initial planning for the project begins in FY 2001 with the majority of the implementation to be completed in FY 2002. The project will be completed in FY 2003.

DATA V&V ACTIVITIES

We used a process similar to the one used in FY 2000 to verify and validate selected FY 2001 GPRA performance information. In FY 2000 and FY 2001, we engaged an external third party, PricewaterhouseCoopers LLP, to verify and validate selected GPRA performance results as well as the process through which supporting data was compiled. PwC documented the processes we follow to collect, process, maintain, and report selected performance data. They identified relevant controls and commented on their effectiveness. Based on 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 2001 goals. For the outcome goals, PwC confirmed the ratings and interpretations contained in the COV and AC reports. PwC also provided high-level review of NSF's information systems based on GAO standards for application controls. We expect to use a similar process in FY 2002.

In their report (January 2002), PwC concluded "From our review, we determined that NSF has reported on ten of the quantitative goals and all five qualitative goals in a manner such that any errors, should they exist, would not be significant enough to change the reader's interpretation of the Foundation's success in meeting the supporting performance goal. For these goals, 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. For the four goals related to facilities management, we identified significant data limitations, which impaired our ability to verify the processes. However, we believe that NSF's reported outcomes are consistent with the data they collected."

For reporting on goal achievement, all of our outcomes are compiled for programs and activities across the agency. To enable a uniform and systematic organization of reporting information for the strategic outcome goals, we have developed specially designed templates and reporting guidelines for use by committees of external experts (COVs and ACs). These templates and guidelines are reviewed and refined annually. Options for rating NSF are limited to either successful or not successful.

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 (compiled by our staff) 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 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 (HRM/OIRM) maintains information related to staff recruitment and staff training, under the guidance of the Chief Information Officer. OEOP databases are also available for reporting purposes.

The qualitative aspects associated with the goals on implementation of both merit review criteria are addressed in reports of external committees (COVs and ACs) and/or staff analyses.

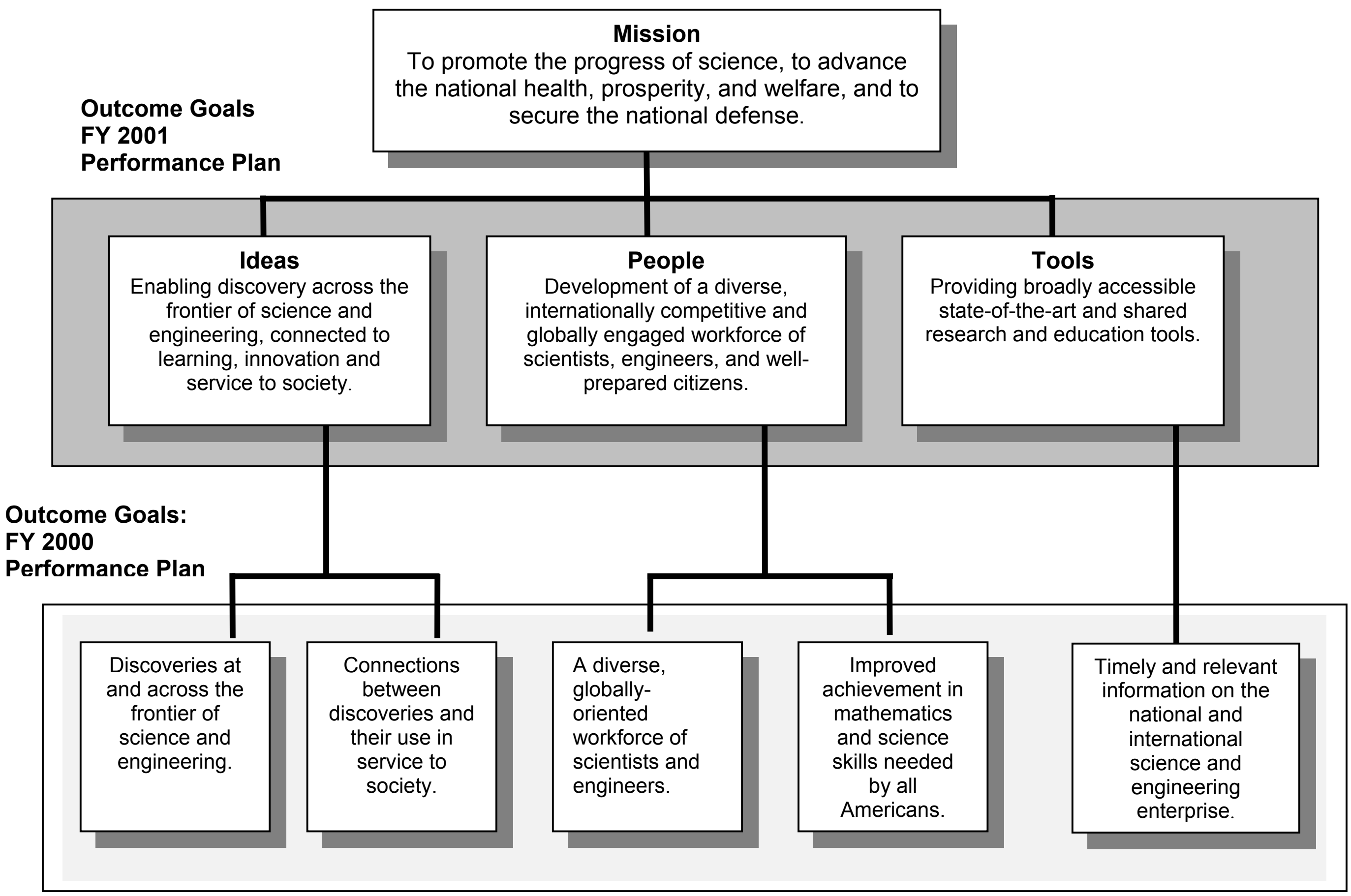
Data / Information Limitations

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 reports) may lack sufficient justification for ratings 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.

IX. TRANSITION FROM FY 2000 TO FY 2001

The NSF FY 2001 Performance Plan was based on our updated GPRA *Strategic Plan FY 2001 – 2006*, finalized in September 2000, and upon newly developed Strategic Outcomes included therein. The chart below clarifies the linkage between our new goals for FY 2001 and those described in earlier NSF GPRA documents. The new Strategic Outcome Goal areas of developing People, enabling Ideas, and providing Tools serve as the linkage between NSF's mission and annual performance goals. The goals in the FY 2001 Performance Plan took into account lessons learned in FY 1999 and FY 2000, recommendations from the NSF Strategic Planning Integration Group, and input from the research community, auditors, Congressional groups, and stakeholders. Additional discussion of annual performance goals and indicators pertaining to these Outcome areas may be found in the NSF FY 2001 Performance Plan.



ANNUAL PERFORMANCE GOALS FOR NSF STRATEGIC OUTCOMES

- FY 2000 Outcome Goal: A diverse, globally oriented workforce of scientists and engineers.
- FY 2000 Outcome Goal: Improved achievement in mathematics and science skills needed by all Americans.

These goals are incorporated under the FY 2001 Strategic Outcome: People-A diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens.

- FY 2000 Outcome Goal: Discoveries at and across the frontier of science and engineering.
- FY 2000 Outcome Goal: Connections between discoveries and their use in service to society.

These goals are incorporated under the FY 2001 Strategic Outcome: Ideas - Discovery across the frontier of science and engineering, connected to learning, innovation and service to society.

- FY 2000 Outcome Goal: Timely and relevant information on the national and international science and engineering enterprise.

This goal addresses the concerns of Science Resources Studies (SRS) customers regarding the accuracy of and the ability to obtain needed information on science and engineering personnel and resources. The goal was adjusted to determine what data are needed to better reflect the 21st century science and technology enterprise – to develop, assess, and begin implementation of design options for recasting SRS science and engineering resources data collections. This goal is incorporated under the FY 2001 Strategic Outcome: Tools - Broadly accessible state-of-the-art and shared research and education tools.

ANNUAL PERFORMANCE GOALS FOR NSF MANAGEMENT

- FY 2000 Performance Goal: By the end of FY 2000, all staff will receive an orientation to FastLane, and at least 80% of program and program support staff will receive practice in using its key modules.

NSF offers a comprehensive training program and strongly encourages all employees to keep current with technology improvements as well as government regulations. This goal was not continued in FY 2001.

- FY 2000 Performance Goal: NSF will complete all activities needed to address the Year 2000 problem for its information systems according to plan, on schedule and within budget.

OMB guidelines and milestones for assessment, renovation, validation and implementation were followed and achieved. External validation of NSF's systems compliance with Y2K guidance was accomplished. This goal is no longer relevant.

- FY 2000 Performance Goal: During FY 2000, at least 85% of all project reports will be submitted through the new electronic Project Reporting System.

Since the system was fully utilized the goal was not continued in FY 2001.

- FY 2000 Performance Goal: By the end of FY 2000, NSF will have the technological capability to take competitive proposals submitted electronically through the entire proposal and award/declination process without generating paper within NSF.

This goal has been modified to focus on the review process. NSF will conduct 10 pilot paperless projects that manage the competitive review process in an electronic environment.

CHANGES IN ANNUAL PERFORMANCE GOALS FOR NSF'S INVESTMENT PROCESS

- FY 2000 Performance Goal: At least 90% of NSF funds will be allocated to projects reviewed by appropriate peers external to NSF and selected through a merit-based competitive process.

  This performance goal was revised from that stated in FY 1999 and early 2000 in order to be consistent with the government-wide definition of merit-reviewed scientific research as specified by OMB in FY 2000:

  NSF exceeded the original goal of 90% for FY 1999 and FY 2000 by achieving results of 95% for both years. Nevertheless, NSF has calculated a new baseline, goals, and results based on OMB's revised merit review definition issued in FY 2000.

- FY 2000 Performance Goal: NSF's performance in implementation of the new merit review criteria is successful when reviewers address the elements of both generic review criteria appropriate to the proposal at hand and when program officers take the information provided into account in their decisions on awards, as judged by external independent experts.

  This goal was separated into its component parts and directed toward reviewers and program officers to better measure the performance of each.

- FY 2000 Performance Goal: Identify possible reasons for customer dissatisfaction with NSF's merit review system and with NSF's complaint system.

  The information is being utilized in staff training and in developing goals. This goal was not continued in FY 2001.

- FY 2000 Performance Goal: Identify best practices and training necessary for NSF staff to conduct merit review and answer questions about the review criteria and process. Identify best practices and training necessary for NSF staff to answer questions from the community and to deal with complaints in a forthright manner.

  Customer service continues to be of the highest priority for NSF. NSF continues to address these concerns, particularly those involving the merit review process and handling of customer complaints and will concentrate on improving its Merit Review Process (see FY 2001 performance goals V-4 and V-5.) This goal was not continued in FY 2001.

  - FY 2000 Performance Goal: Improve NSF's overall American Customer Satisfaction Index (ACSI) compared to the FY 1999 index of 57 (on a scale of 0 to 100.)

  Customer service continues to be a high priority for NSF. The results of these surveys were used to identify issues of importance to respondents, which enables NSF to design meaningful goals. This goal was not continued in FY 2001.

- FY 2000 Performance Goal: Develop a plan and system to request that Principal Investigators address the integration of research and education in their proposals, and develop a system to verify that PIs have done so.

  The goal is incorporated into the Implementation of Merit Review Criteria Goals for FY 2001 (see FY 2001 performance goals V-2 and V-3). Each program announcement, NSF's Guide to Programs and the Grant Proposal Guide explain the review criteria.

  The plan was developed and is being utilized. Issuance of Important Notice #125 reminded PIs of the importance of addressing this topic. This goal was not continued in FY 2001.

- FY 2000 Performance Goal: Develop and implement a system/mechanism to request and track reviewer comments tied to merit review criterion #2, "what are the broader impacts of the proposed activity?".

  The system was developed and is being utilized. The goal above is incorporated into the Implementation of Merit Review Criteria Goals for FY 2001 (see FY 2001 performance goals V-2 and V-3). Each program announcement, NSF's Guide to Programs and the Grant Proposal Guide explain the review criteria (see Implementation of Merit Review Criteria.) This goal was not continued in FY 2001.

- FY 2000 Performance Goal: In FY 2000, NSF will identify mechanisms to increase the number of women and underrepresented minorities in the proposal applicant pool, and will identify mechanisms to retain that pool.

  This goal is incorporated under the FY 2001 Strategic Outcome: People—A diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens, and also under the Implementation of Merit Review Criteria Goals (reviewer and Program Officer goals) for FY 2001.

  This goal was not continued as stated. In FY 2001, NSF focused its "broadening participation" performance area initially on diversification of the reviewer pool.

X. TRANSITION FROM FY 2001 TO FY 2002

The following goals, which were presented in the FY 2001 Performance Plan, have been modified or removed from the FY 2002 Revised Final Performance Plan. The significance and rationale for changes or exclusion are discussed below.

ANNUAL PERFORMANCE GOALS FOR NSF STRATEGIC OUTCOMES

FY 2001 Performance Goal III-1a: People Strategic Outcome -- Development of "a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens."

FY 2001 Performance Indicators:

NSF is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement in one or more of the following indicators:

- Improved mathematics, science, and technology skills for U.S. students at the K-12 level, and for citizens of all ages, so that they can be competitive in a technological society.
- A science and technology and instructional workforce that reflects America's diversity.
- Globally engaged science and engineering professionals who are among the best in the world.
- A public that is provided access to the benefits of science and engineering research and education.

FY 2002 Performance Indicators:

NSF's performance is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement in the majority (4 of 7) of the following indicators:

- Development of well-prepared scientists, engineers or educators whose participation in NSF activities provides them with the capability to explore frontiers and challenges of the future;
- Improved science and mathematics performance for U.S. K-12 students involved in NSF activities;
- Professional development of the SMET instructional workforce involved in NSF activities;
- Contributions to development of a diverse workforce through participation of underrepresented groups (women, underrepresented minorities, persons with disabilities) in NSF activities;
- Participation of NSF-supported scientists and engineers in international studies, collaborations, or partnerships;
- Enhancement of undergraduate curricular, laboratory or instructional infrastructure; and
- Awardee communication with the public in order to provide information about the process and benefits of NSF-supported science and engineering activities.

Explanation of change: The set of performance indicators related to the People Goal has been expanded and modified to appropriately reflect the breadth of NSF activities. The criterion for successful performance was raised from significant achievement in at least one indicator to successful achievement in a majority of indicators.

FY 2001 Performance Goal III-1b: After three years of support, over 80% of schools participating in systemic initiative programs will (1) implement a standards-based curriculum in science and mathematics; (2) further professional development of the instructional workforce; and (3) improve student achievement on a selected battery of tests.

FY 2002 Performance Goal III-1b: After three years of NSF support, over 80% of schools participating in systemic initiative programs will (1) implement a standards-based curriculum in science and mathematics with at least one-third of their teachers; (2) provide professional development for at least one-third of their teachers; and (3) improve student achievement on a selected battery of math and science tests at one or more of three educational levels (elementary, middle and high school).

Explanation of change: The revised wording of the goal clarifies the threshold for success.

FY 2001 Performance Goal III-1c: Through systemic initiatives and related teacher enhancement programs, NSF will provide intensive professional development experiences for at least 65,000 pre-college teachers.

FY 2002 Performance Goal: Not included.

Explanation of change: This performance goal is not part of our FY 2002 Performance Plan. For FY 2002 NSF has reapportioned a substantial amount of the funds for the Systemic Initiatives to support the new Presidential Math and Science Partnership (MSP) activity. No new competitions or awards are anticipated under the Systemic programs. A goal related to the MSP has been included in the FY 2003 GPRA Performance Plan.

FY 2001 Performance Goal III-2: Ideas Strategic Outcome -- Enabling discovery across the frontier of science and engineering, connected to learning, innovation and service to society.

FY 2001 Performance Indicators:

NSF is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement in one or more of the following indicators:

- A robust and growing fundamental knowledge base that enhances progress in all science and engineering areas including the science of learning;
- Discoveries that advance the frontiers of science, engineering, and technology;
- Partnerships connecting discovery to innovation, learning, and societal advancement;
- Research and education processes that are synergistic.

FY 2002 Performance Indicators:

NSF's performance is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement in the majority (4 of 6) of the following indicators:

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

Explanation of change: The set of performance indicators related to the Ideas Goal has been revised to better enable qualitative assessment and reflect the breadth of NSF activities. The criterion for successful performance was raised from significant achievement in at least one indicator to successful achievement in a majority of indicators.

FY 2001 Performance Goal III-3: Tools Strategic Outcome -- Providing "broadly accessible, state-of-the-art and shared research and education tools."

FY 2001 Performance Indicators:
NSF's performance is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement for one or more of the following indicators:

- Shared use platforms, facilities, instruments, and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce;
- Networking and connectivity that take full advantage of the Internet and make SMET information available to all citizens;
- Information and policy analyses that contribute to the effective use of science and engineering resources.

FY 2002 Performance Indicators:
NSF's performance is successful when, *in the aggregate*, results reported in the period demonstrate significant achievement in the majority (4 of 6) of the following indicators:

- Provision of facilities, databases or other infrastructure that enable discoveries or enhance productivity by NSF research or education communities;
- Provision of broadly accessible facilities, databases or other infrastructure that are widely shared by NSF research or education communities;
- Partnerships, e.g., with other federal agencies, national laboratories or other nations, to support and enable development of large facilities and infrastructure projects;
- Use of the Internet to make SMET information available to the NSF research or education communities;
- Development, management, or utilization of very large data sets and information-bases; and
- Development of information and policy analyses that contribute to the effective use of science and engineering resources.

Explanation of change: The set of performance indicators related to the Tools Goal has been expanded and modified to appropriately reflect the breadth of NSF activities. The criterion for successful performance was raised from significant achievement in at least one indicator to successful achievement in a majority of indicators.

ANNUAL PERFORMANCE GOALS FOR NSF MANAGEMENT

FY 2001 Performance Goal IV-1: Ninety-five percent of full proposals will be received electronically through FastLane.

FY 2002 Performance Goal: Not included.

Explanation of Change: This goal will not be continued in FY 2002. Electronic submission of proposals via FastLane is now standard operating procedure at NSF.

FY 2001 Performance Goal IV-3: By the end of FY 2001, NSF will increase usage of a broad-range of video-conferencing/long distance communications technology by 100% over the FY 1999 level.

FY 2002 Performance Goal: Not included.

Explanation of change: By the end of FY 2001, videoconferencing was viewed as a functioning, rather than experimental, technology. Because videoconferencing is an established practice for us, it will not be continued as a goal in the future. We will, however, continue to emphasize this technology for current and emerging business applications.

FY 2001 Performance Goal V-7: NSF will award 30% of its research grants to new investigators.

FY 2002 Performance Goal: Not included.

Explanation of change: This openness goal is not included in the FY 2002 performance plan because we wish to fully consider whether this particular goal provides a good measure of openness in the system.

FY 2001 Performance Goal V-8: NSF will begin to request voluntary demographic data electronically from all reviewers to determine participation levels of underrepresented groups in the NSF reviewer pool.

FY 2002 Performance Goal IV-6: Establish a baseline for participation of members of underrepresented groups in NSF proposal review activities.

Explanation of change: The FY 2002 goal is a continuation of the FY 2001 goal. To enable the development of robust baselines, we will continue to gather the appropriate voluntary data from reviewers.

FY 2001 Performance Goal V-9b: Ninety percent of facilities will meet all major annual schedule milestones by the end of the reporting period.

FY 2002 Performance Goal IV-9b: Ninety percent of facilities will meet all major annual schedule milestones.

Explanation of change: This goal was adjusted based on actual performance reporting experience in FY 2001 and feedback from facilities managers, NSF program officers and PricewaterhouseCoopers.

XI. 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.

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 (PricewaterhouseCoopers LLP) to conduct a review of data and information used in performance reporting. PwC reviewed NSF's performance data and information pertaining to selected outcome goals, management goals, and investment process 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.

BUDGET INFORMATION:

NSF obligated $4.5 billion in FY 2001. Administrative support for the Foundation was approximately 5% of the total NSF budget.

CLASSIFIED APPENDICES NOT AVAILABLE TO THE PUBLIC

None to report.

ANALYSIS OF TAX EXPENDITURES

None to report.

WAIVERS OF ADMINISTRATIVE REQUIREMENTS

None to report.

MANAGEMENT CHALLENGES

XII. - MANAGEMENT CHALLENGES AND REFORMS

Federal agency management challenges are discussed in the President's Management Agenda (PMA). For NSF, they are also identified internally by NSF staff and by OMB, GAO, and the NSF Office of the Inspector General (OIG).

The **President's Management Agenda** lists five government-wide initiatives. The first four of these initiatives (Strategic Management of Human Capital, Competitive Sourcing, Improved Financial Performance, and Expanded Electronic Government) are discussed in NSF's FY 2003 Performance Plan. NSF's implementation of the remaining initiative, Budget and Performance Integration, is currently under discussion within NSF and between NSF and OMB. We have contracted with PricewaterhouseCoopers (PwC) to provide formal recommendations to improve our approach on integrating the budget, performance and cost of performance, within the intent of the Government Performance and Results Act (GPRA), Statement of Federal Financial Accounting Standard (SFFAS) 4, and Managerial Cost Accounting Concepts and Standards for the Federal Government.

The **OIG** issues addressed below are those included in a November 2000 statement by the Inspector General on NSF's management and performance challenges. This statement was released on January 4, 2001 and is contained in the NSF FY 2000 Accountability Report. In many instances, the management and performance challenges contained in the PMA, OMB, GAO, and the OIG documents are very similar.

For FY 2001, the NSF OIG identified 10 areas for NSF to monitor:

FY 2001 OIG Major Management Challenges

1. FastLane
2. GPRA Data Quality
3. Merit Review
4. Cost Sharing
5. Award Administration
6. Management of Large Infrastructure Projects
7. Management of U.S. Antarctic Program
8. Work Force Planning and Training
9. Fostering a Diverse Scientific Workforce
10. Data Security

1. FASTLANE

NSF OIG COMMENT: "In the FY 2001 budget, OMB identifies streamlining and simplifying grants management as one of the most important management challenges facing the federal government. At NSF, the development and implementation of FastLane, which began in 1994, has moved the agency closer to the goal of establishing a widely accessible paperless proposal and award process. In many respects the implementation has been successful and NSF serves as a leader within government in electronic innovation. The increase in the use of FastLane by those seeking grants each year has been encouraging and has undoubtedly helped contribute to the increase in productivity NSF has achieved in recent years. However, problems remain, as reflected by the inability of the help desk to cope with the high volume of incoming questions and problems. Because FastLane serves as the primary interface between NSF and its grantees and is critical to many of NSF's administrative plans and goals, we believe that management must continue to monitor its progress and assure that the system is as user-friendly and reliable as possible."

FROM THE PRESIDENT'S MANAGEMENT AGENDA: An expanded electronic-government is one of the government-wide initiatives presented in *the President's Management Agenda for 2002*. That document states that "the administration's goal is to champion citizen-centered electronic government."

FOCUSED NSF ACTIVITIES IN THIS AREA: NSF's FastLane system uses the Internet to allow its customers, the grantee community, to exchange information with NSF. It permits users to prepare and submit proposals, proposal reviews and project reports, determine the status of funding actions, submit post-award requests, interactively participate in panel evaluations of proposals, initiate cash requests, view reviews and award letters, and perform other basic interactions. Over 200,000 scientists, engineers, educators, technology experts and academic administrators use FastLane, with over 99 percent of proposals submitted electronically in FY 2001. In addition, the public can access titles, authors, funding amounts and abstracts of NSF awards.

A past challenge for FastLane was to make the system more user-friendly and reliable. In January 2001, FastLane implemented a conversion process to allow Word, WordPerfect, TeX and other documents to be uploaded and converted in real-time to PDF files. This significant, and technically challenging, change to the system was greeted by FastLane's user community with more positive responses than any other user-oriented change in the system. In March 2001, FastLane included a detailed manual, available through the web, for electronic preparation and submission of proposals.

The implementation in FY 2000 of a toll-free phone number to the FastLane Help Desk made it easier for NSF's user-community to obtain assistance – while at the same time increasing significantly the call volume. In June and July 2001, the FastLane Help Desk was able to handle peak loads without, for the first time, supplementing the Help Desk with staff from program offices. This improvement is attributed to better Help Desk practices, increase in the operating hours of the Fast Lane Help Desk and the number of trained Help Desk staff, improved on-line documentation, implementation of a word processor conversion tool, work on the web interface to make the system more user-friendly, and spreading out proposal deadlines.

2. GPRA DATA QUALITY

NSF OIG COMMENT: "GPRA seeks to improve the effectiveness, efficiency and accountability of federal programs by requiring agencies to set goals for performance and report on annual performance compared with the goals. In addition, it requires agencies to "describe the means to be used to verify and validate measured values" of performance in their performance plans. A recent GAO study, Managing for Results: Opportunities for Continued Improvements in Agencies Performance Plans (GAO/GGD/AIMD-99-215), said that a key weakness of NSF's FY 2000 Performance Plan is that it "provides limited confidence in the validation and verification of data." Meanwhile, the agency has contracted with several firms to assist in validating the performance data it reports. However, if uncertainty persists about data validity, decision-makers will be reluctant to rely on the information, and its usefulness will be diminished."

FOCUSED NSF ACTIVITIES IN THIS AREA: For FY 2000 and FY 2001 GPRA reporting, NSF engaged an external party, PricewaterhouseCoopers LLP (PwC), to provide an independent verification and validation (V&V) of selected GPRA goals. The V&V focused on reliability of data, on processes to collect, process, maintain, and report the data, and on program reports prepared by external experts. PwC mapped NSF procedures against GAO guidance for polices and procedures that underlie GPRA performance reporting.

For FY 2000 PwC reviewed a limited set of our goals and concluded that NSF "relies on sound business processes, system and application controls, and manual checks of system queries to confirm the accuracy of reported data. We believe that these processes are valid and verifiable."

For FY 2001 PwC reviewed the goals it had reviewed in FY 2000 and additional goals (see Appendix IV.). In their report they state: "We commend NSF for undertaking this second year effort to confirm the reliability of its data and the processes to collect, process, maintain, and report this data. From our FY 2001 review, we conclude that NSF has made a concerted effort to ensure that it reports accurately to the federal government and has effective systems, policies, and procedures to ensure data quality. We have noted some areas for improvement, particularly in the area of data collection for the goals related to facilities management. However, overall NSF relies on sound business practices, system and application controls, and manual checks of system queries to report performance. Further, our efforts to re-calculate the Foundation's results based on these systems, processes and data were successful."

FY 2001 progress on NSF's data quality program included completion of an extensive analysis of the existing data dictionary designed in Access and recommendations for improving the functionality of the data dictionary.

3. MERIT REVIEW

NSF OIG COMMENT: "Because of its importance to the success of NSF's mission, the merit review system remains on our list of management challenges. Operating a viable, credible, efficient merit review system is one of four critical factors identified by the agency in managing for excellence. NSF must continue to ensure that: reviewers correctly apply NSF's review criteria; due consideration is given to ideas, individuals and institutions that have not received past support; and that the process is fairly and effectively administered.

In particular, we believe that the agency has opportunities to improve in two areas. We believe that NSF should enhance its effort to expand the peer review community with regard to race, gender, geography, and type of school, providing the chance to participate to all who are qualified. In our view, the selection of peer reviewers is an opportunity for NSF to reach out to underrepresented segments of the scientific community and educate them about the process of obtaining federal support for their research. This will help to generate proposals from those who may have worthy research ideas but are unfamiliar with, or intimidated by, the system. Secondly, we are concerned about the agency's ability to maintain the confidentiality of proposals in an electronic environment. As more proposal review functions migrate to the internet, NSF must be able to ensure that the intellectual property contained in a proposal is secure."

FOCUSED NSF ACTIVITIES IN THIS AREA: NSF considers its merit review process the keystone for award selection. The agency evaluates proposals using two criteria – intellectual merit of the proposed activity and broader impacts of the proposed activity. NSF focuses its management activities on a wide variety of issues related to merit review – including use of both merit review criteria by reviewers and program officers, broadening participation, and enhancing customer service.

In FY 2001 NSF established an internal task force to examine strategies to improve both proposer and reviewer attention to the broader impacts criterion. The group assessed the characteristics and quality of reviewer responses to this criterion and found that, based on a sample of FY 2001 reviews, approximately 69% of reviews provided evaluative comments in response to the broader impacts criterion. The group also developed examples of broader impacts that may be useful to proposers in developing proposals and reviewers in evaluating proposals. In FY 2002, NSF will continue to develop and apply recommendations that focus on strategies that stress the importance of using both criteria. It will also make available examples of broader impacts.

With respect to increasing the diversity of the peer review pool, this was addressed as part of our Investment Process Goal V-8. FY 2001 marks the first time we have focused attention on reviewer pool data. To establish the baselines for this goal, we have begun to gather the appropriate voluntary data from the reviewers, which will be added to the reviewer pool database. A baseline for FY 2002 will be derived from this data.

We will address the challenge of proposal security below in our response to the challenge of data security.

4. COST SHARING

NSF OIG COMMENT: "In accordance with Congressional requirements, NSF requires that each grantee share in the cost of NSF research projects resulting from unsolicited proposals. In addition to this statutory requirement, NSF can require additional cost sharing when it believes there is tangible benefit to the award recipient, such as infrastructure development or the potential for program income. When cost sharing is provided for in the approved award budget, it is presumed that the funds are necessary to accomplish the objectives of the award. The commitment becomes a condition of the award and subject to audit to the same extent as the costs borne by NSF. Therefore, if promised cost sharing is not realized, then either the awardee has not met its programmatic objectives, or the project costs less than originally projected. In either case, NSF should have at least a portion of its funds returned to it.

We have been finding significant problems with awardees who are failing to meet their cost sharing requirements. In the past semi-annual period, we found several awardees with significant problems in this regard, discussed in more detail in our September 2000 Semiannual Report. We are continuing to focus our efforts in this area and are currently conducting a broad review of cost sharing at numerous institutions. Because of the importance of these research efforts to the scientific and engineering community, and the detrimental impact a shortfall can have on a project, we consider improvements in administering cost sharing to be among the most important priorities for NSF management."

FOCUSED NSF ACTIVITIES IN THIS AREA: In June 1999 an "Important Notice" was sent to Presidents of Universities and Colleges and Heads of National Science Foundation Grantee Organizations. This notice transmitted the "National Science Foundation Policy Statement on Cost Sharing" as approved by the National Science Board. In addition to providing a definition of cost sharing, the policy states that: (1) NSF-required cost sharing is considered an eligibility rather than review criterion; (2) NSF cost sharing requirements beyond the statutory requirement (1%) will be clearly stated in the program announcement, solicitation or other mechanism which generates proposals; (3) for unsolicited research and education projects, only statutory cost sharing will be required; and, (4) any negotiation regarding cost sharing will occur within NSF-stated parameters. NSF has a long-standing policy requiring cost- sharing certification when cost sharing exceeds $500,000.

This "Important Notice" was also distributed to NSF staff. During the past year, NSF has held several training sessions on cost-sharing for NSF staff and has also conducted sessions on cost-sharing for NSF customers at regional conferences, seminars and workshops.

The Foundation recently conducted an analysis of grantee audits that contain findings related to cost-sharing. It showed that while some grantees have often provided cost-sharing, they may not have had financial and accounting systems able to document their activities. NSF is now conducting more pre-award reviews of grantee financial and accounting systems to assess their capability to report on cost-sharing. Post-award reviews are also conducted to assure compliance with agreed upon cost-sharing requirements. In this analysis, over half of the audit activity (both in number of audit reports and dollar amount of findings cited) reported by the NSF OIG in its Semiannual Reports to Congress since 1997, when the NSF OIG first reported separate statistics on cost-sharing, was for grantee organizations that are "non-traditional" (e.g., public school systems). NSF is currently developing an appropriate strategy for reviewing cost-sharing by these types of grantee organizations and providing outreach and instruction as necessary.

5. AWARD ADMINISTRATION

NSF OIG COMMENT: “NSF's mission is to fund research and education in science and engineering by issuing different types of awards (primarily grants, contracts, and cooperative agreements) thereby strengthening U.S. science and engineering. Assessing scientific progress and ensuring effective financial/administrative management are critical elements in managing NSF's grant programs. Program officers in each of NSF's seven science Directorates are responsible for monitoring the scientific progress of NSF's grants while the Division of Grants and Agreements (DGA) and the Division of Contracts, Policy, and Oversight (CPO) oversee grantees' financial management of NSF awards.

At any one point in time NSF is administering as many as 30,000 ongoing awards. NSF relies on a total staff of 1,150 employees to carry out this oversight responsibility. This is in addition to their responsibility of soliciting and awarding approximately 10,000 grants and cooperative agreements annually amounting to over $3.5 billion. Given this sizeable workload, NSF is challenged to adequately monitor its awards for scientific accomplishments and compliance with the award agreement and federal regulations. For the most part, NSF relies on interim reports from grantees to monitor progress, but is unable to test the reliability of these reports. NSF also needs to establish a more coordinated oversight effort between its program officers and its grant and contract officers to ensure better sharing of information and more effective action to address compliance issues.”

FOCUSED NSF ACTIVITIES IN THIS AREA: NSF program portfolios have become more diverse and more complex; however, there has not been a concomitant increase in the staffing complement to provide additional program and administrative oversight functions. The Draft NSF Administrative and Management Strategic Plan currently under development presents a framework for Award Management and Oversight that focuses on a collaborative, multi-functional award management and oversight process that is informed by risk management strategies and verifies that projects are in compliance.

On-site post-award monitoring is one of the most effective methods of ensuring awardee compliance with award agreements and federal regulations. However, it is least often employed because of staff resource constraints, including the availability of travel funds. In order to leverage NSF administrative oversight capability, NSF will develop and initiate in FY 2002 a risk assessment/risk management plan for awards. A GPRA management goal covering these activities has been added to the FY 2002 Revised Final Performance Plan for NSF.

6. MANAGEMENT OF LARGE INFRASTRUCTURE PROJECTS

NSF OIG COMMENT: "NSF is increasing its investments in large infrastructure projects such as astronomy centers, research equipment, supercomputing databases, and earthquake simulators. The agency spends approximately $1 billion a year on these research facilities and equipment projects, with each of these projects costing several hundred million dollars. Projects of this scale and complexity are becoming more common for NSF, which historically has administered awards averaging less than $100,000 each. Successful management of these projects and programs requires a more disciplined project management approach. Management of these projects is particularly challenging for NSF because of its limited number of staff. Although NSF recently issued guidelines for managing these larger projects, the guidelines are interim and have not been fully tested for adequacy."

FROM OMB: OMB has noted that NSF has several multi-year, large facility projects awaiting approval for funding. Although the agency has done well in keeping past projects on schedule and within budget, OMB believes that NSF's capability to manage proposed projects needs to be enhanced given the magnitude and costs of future projects. NSF was asked to develop and submit a plan to OMB that documents its costing, approval, and oversight of major facility projects.

FOCUSED NSF ACTIVITIES IN THIS AREA: In order to mitigate the risks attendant to large facilities management, and to comply with the President's mandate in *A Blueprint for New Beginnings: A Responsible Budget for America's Priorities* (February 2001), NSF developed a Large Facility Projects Management & Oversight Plan. The plan was submitted to OMB in September 2001.

This new facilities plan has four major foci:
- Enhance organizational and staff capabilities and improve coordination, collaboration, and shared learning among NSF 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.

Further development and implementation of the plan is continuing.

In FY 2002 the agency is also initiating development of a risk assessment protocol focused towards on-site monitoring activities.

7. MANAGEMENT OF U.S. ANTARCTIC PROGRAM

NSF OIG COMMENT: "NSF plays a leadership role among federal agencies involved in supporting research and logistics in the Antarctic through its Office of Polar Programs (OPP). Charged with managing all U.S. activities in the Antarctic as a single program, OPP not only funds research, but also is responsible for operating the infrastructure and logistics necessary to conduct scientific experiments in the harsh polar environment. In this role, it faces a number of unique challenges such as transporting and housing scientists and support staff, assuring their safety and health, protecting the near pristine polar surroundings, ensuring U.S. compliance with the international Antarctic Treaty, and promoting the national interest in maintaining an active and influential presence in Antarctica.

While OPP operates like other NSF directorates in making awards for polar research, its responsibilities do not end there. In providing science, operations, and logistics support to the research projects it funds, it is significantly different than other NSF units. OPP staff must not only know the science, but must also be able to manage contractors engaged in delivering a broad range of services to the American scientific community located in a difficult and dangerous environment. Our audit work has focused on reviewing these activities because of their many inherent risks. From our perspective, NSF's polar programs involve not only a large expenditure of money, but also the safety of scientists and workers, environmental concerns, and the prestige of the U.S. government. The successful operation of the United States Antarctic Program requires certain management and administrative skills that are responsive to the special needs of Antarctic scientific research."

FOCUSED NSF ACTIVITIES IN THIS AREA: Our staff provides special expertise in:

- Coordinating Department of Defense, NASA, USGS and DOE activities;
- Overseeing environmental, health, safety, and medical activities;
- Overseeing construction and maintenance of all infrastructure at three U.S. stations in Antarctica (roads, fire stations, clinics, power stations, heating, communications, ground stations, air traffic control, ground vehicles, food services, sewage treatment, water supplies, etc.);
- Coordinating support of scientists in Antarctica, construction of specialized science instrumentation, etc.;
- Budgeting for the above activities; and
- Selecting science projects for deployment on the basis of merit review and ability to meet logistics requirements.

8. WORK FORCE PLANNING AND TRAINING

NSF OIG COMMENT: "Although NSF has had healthy increases in its program responsibilities and budgets in recent years, salaries and expenses have remained relatively flat. NSF received an increase of 13.6 percent in its FY 2001 budget; however an increase of only 6 percent was obtained for salaries and expenses. While we commend the agency for successfully controlling its administrative overhead, the small increases allocated for administration and management over the past few years raise questions about whether NSF can successfully manage future growth without adding more staff. Concerns about the adequacy of staffing come at a time when the government as a whole is facing succession planning and recruiting problems. In addition, NSF's reliance on the Intergovernmental Personnel Act (IPA) personnel, who serve on a term basis, poses a challenge to the agency to make certain that personnel are adequately trained to administer grants. We are planning audit work in this area to ensure that the agency has a reasonable strategy for managing its human capital."

THE PRESIDENT'S MANAGEMENT AGENDA (2002) includes strategic management of human capital as a government-wide initiative.

GAO *(GAO-01-236, April 2001)* has identified shortcomings of many agencies involving key elements of modern strategic human capital management, including (1) strategic planning and organizational alignment; (2) leadership continuity and succession planning; and (3) acquiring and developing staff whose size, skills, and deployment meet agency needs.

FOCUSED NSF ACTIVITIES IN THIS AREA: NSF's flexible and motivated workforce currently includes approximately 600 permanent and visiting scientists and engineers (about 65% of whom are permanent government employees), 450 administrative personnel (who provide business operations support), and approximately 350 program support personnel.

NSF has a steadfast commitment to empower a workforce of teams and individuals who are continuously expanding their capabilities to shape the agency's future. To sustain its high-performing workforce, NSF is exploring ways to recruit and retain excellent employees. New initiatives include an updated telecommuting program, strategic recruiting techniques that also seek to increase representation of underrepresented groups in the NSF science and engineering workforce, a renewed focus on continuous learning and an increased emphasis on leadership and succession planning.

NSF's draft Administration and Management Strategic Plan (submitted to OMB in March 2002) will examine organizational alignment and the workforce size, skill mix, and deployment necessary to ensure mission accomplishment.

9. FOSTERING A DIVERSE SCIENTIFIC WORKFORCE

NSF OIG COMMENT: "NSF is committed to increasing the diversity of the nation's science and engineering workforce by embedding diversity concerns in all of its programs. In its strategic plan, NSF says it aims at new strategies for improving diversity and broadening participation in NSF-funded activities. NSF's most recent performance plan promises that the agency will begin implementing new strategies to increase diversity. NSF executives and managers frequently stress the importance of diversity in presentations to internal and external audiences. Because diversity programs are difficult to implement in a society challenged by economic, legal, and cultural constraints, NSF faces numerous challenges and should clearly define its diversity strategies and develop concrete steps (beyond giving general encouragement to its program managers) for attaining its goals in this area."

FOCUSED NSF ACTIVITIES IN THIS AREA: NSF recognizes that a diverse workforce – 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 its research and education communities and ultimately all citizens.

The FY 2003 NSF Performance Plan includes two goals related to the agency's science and engineering (S&E) staff. This S&E group includes program officers, division directors, the majority of staff assigned under the provisions of the Intergovernmental Personnel Act, limited term Visiting Scientists appointments, and others in management and scientific positions. In aggregate, this group is the one most intensively involved with the agency's external customers, the award community. It is also the group involved within the Foundation in development of new programs, in merit review and review analysis, and in making recommendations to fund or decline proposals. It is thus particularly important that these staff be diverse, with an ability "to identify best practices that are appropriate to a diverse [research and education] community" (Committee on Equal Opportunities in Science and Engineering, 2000[37]).

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[37] Enhancing the Diversity of the Science and Engineering Workforce to Sustain America's Leadership in the 21st Century, Committee on Equal Opportunities in Science and Engineering, 2000 Biennial Report to the United States Congress.

10. SECURITY AND CONTROLS

NSF OIG COMMENT: "Data Security: Electronic information and automated systems are essential to NSF's operations. Next year NSF will depend on its automated computer systems to manage over $4 billion in funds, receive and process over 35,000 grant proposals, handle over $3 billion in cash transactions to NSF awardees, generate its agency wide financial statements, and support a government wide website for federal financial management initiatives and activities. Therefore, it is imperative that NSF's systems are developed and operated with appropriate security controls to reduce the ever increasing risk of unauthorized access. NSF must be able to protect the availability, integrity, and confidentiality of its computer based information. Improvement is most needed in the areas of access controls and change controls. Access controls limit or detect inappropriate access to computer resources, while change controls prevent unauthorized modifications to programs from being implemented. The audit of NSF's financial statements has identified several internal control weaknesses related to security of NSF's automated systems, although none were material or rose to the level of a reportable condition."

GAO (01-758) noted that recent audits continue to show that federal computer systems are riddled with weaknesses that make them highly vulnerable to computer-based attacks and place a broad range of critical operations and assets at risk of fraud, misuse, and disruption.

FOCUSED NSF ACTIVITIES IN THIS AREA: The NSF Information Technology Security (ITS) Program is focused on assuring that NSF infrastructure and critical assets are appropriately protected while maintaining an open and collaborative environment for science and engineering research and education. NSF's approach is based on a fundamental philosophy of risk management where ITS risks are assessed, understood, and mitigated appropriately.

An agency-wide ITS program had been implemented that encompasses all aspects of information security, including policy and procedures, risk assessments and security plans, managed intrusion detection services, vulnerability assessments, and technical and management security controls. The NSF Chief Information Officer provides overall leadership for the ITS Program, and assures that policies, procedures, and activities are coordinated with NSF program management and research and education initiatives.

In FY 2001, NSF placed significant priority on ITS and initiatives to assure adequate protection of resources. In December 2000, NSF appointed an ADP Security Officer to coordinate ITS program plans and initiatives with the NSF Chief Information Officer. The majority of NSF's significant assets are managed within the Division of Information Systems in the Office of Information and Resource Management. This organization is responsible for managing the NSF Computer Center and providing telecommunications, e-mail, and agency-wide applications and services.

APPENDICES

APPENDIX I. - TABLE OF EXTERNAL EVALUATIONS

The Table below provides information on program assessments and evaluations other than Committee of Visitor and Advisory Committee assessments - with one exception – the CAREER program. The CAREER program is an agency-wide activity, and the assessment was contracted to an external private vendor.

The table lists other types of evaluations, not used in GPRA performance assessment, that were completed in FY 2001. These reports, studies, and evaluations are frequently used in setting new priorities in a field or in documenting progress in a particular area. The reader is encouraged to review the reports for additional information on findings and recommendations that are beyond the scope of this report.

Reports (other than COV and AC reports) produced by NSF are available online at http://www.nsf.gov/pubs/start.htm using the NSF's online document system and the publication number indicated.

Information on obtaining reports produced by the National Research Council or National Academy of Sciences can be found online by searching www.nap.edu or from the National Academy Press, 2101 Constitution Avenue, N.W., Lockbox 285, Washington, D.C. 20055 (1.800.642.6242).

Evaluations Completed in FY 2001	
BIO	
Evolution of Development and Tree of Life Workshop Report	**Findings:** Representatives from both the Evolution of Developmental Mechanisms (EvoDevo) and Tree of Life (ToL) communities agreed that research progress in these areas was constrained by the same major needs and that the elimination of these constraints would lead to remarkably fruitful and exciting interactions between evolutionary developmental biology and evolutionary systematics. Communities long separated technically and conceptually have now converged on a common set of evolutionary questions. The participants felt that after decades of separation they must exploit the powerful synergism presented by this convergence. **Recommendations:** 1) Hold a competition to create about 100 arrayed bacterial artificial chromosome (BAC) and cDNA libraries of representative organisms on the Tree of Life ("First 100"). 2) Provide grants for functional analysis tool development production of BAC or sequenced libraries of additional organisms that address fundamental evolution of development questions. 3) Provide support for sequencing about 24 major developmental gene families in the First 100 organisms. 4) Encourage collaboration among phylogeneticists and evolution of development researchers to develop a robust informatics infrastructure. **Availability:** NSF (http://www.nsf.gov/pubs/2001/bio012/)

Research Needs in Phyloinformatics" and "Developing the Technology and Infrastructure Needed for Assembly of the Tree of Life	**Findings:** A major new coordinated research effort is necessary. The integration of expertise and of data from a variety of sources will be essential for resolving the most vexing phylogenetic problems, and coordinated research groups will be the most efficient means to achieve this objective. Specifically, the workshop participants envision the funding of Tree of Life "networks" and "hubs," and of a "phyloinformatics" facility focused on synthesis and outreach. **Recommendations:** The NSF should establish, as soon as possible, a new program focused on "Assembling the Tree of Life" (ATOL). The concrete benefits to science and society stemming from ATOL, and the feasibility of accomplishing its major mission, justifies the development of a major new initiative and the investment necessary to build and maintain such a program. Specifically, the ATOL program should support the development of the following new structures: - Tree of Life Networks. TOLNets are the essential mechanisms for coordinating individual investigators from diverse fields of knowledge who are working on reconstructing the phylogeny of Life - Tree of Life Hubs. TOLHubs, with a concentration of expertise and specialized facilities, would serve the ATOL effort as focal points for obtaining and synthesizing phylogenetic data. They would facilitate interactions among TOLNets and function as ATOL training centers. - Phyloinformatics and Coordination Infrastructure (PICI). Centralization of the informatics program would avoid duplication of effort and facilitate integration among databases. Intellectual synergy would be promoted by co-locating research scientists, visiting scholars, and support staff in one place. Investment in such a center would establish a global resource and encourage cooperation with ongoing biodiversity and bioinformatics initiatives. Throughout the development of this program it will be critical to support training relevant to all aspects of ATOL, and the development of new methods for gathering, analyzing, and synthesizing phylogenetic data. Furthermore, every effort must be made to foster cross-disciplinary efforts, international collaboration, and linkage to other relevant programs. **Availability:** http://www.research.amnh.org/biodiversity

The Microbe Project: A Report from the Interagency Working Group on Microbial Genomics.	**Findings:** There are major areas of research as yet untouched that would increase our understanding of the broader microbial world, its diversity, and its potential applications. A coordinated interagency and international effort is needed to seize the opportunities offered by genome-enabled microbial science. In recognition of this need, the Microbe Project Interagency Working Group was convened in August 2000, and charged with developing a coordinated interagency action plan or microbial genomics activities. The Microbe Project has three broad goals: to build needed infrastructure, promote research and develop human resources and an informed public. **Recommendations:** - Microbial genome sequencing should be expanded to include scientifically important but as yet understudied microbes. - Individual agencies should continue, or as necessary, increase support for research on technique and tool development. - The Federal government should initiate a deliberate planning effort to address the issue of providing sustained support for and access to microbial genomic resources. - Develop standardized bioinformatics tools for the analysis of microbial genomes. - Database issues (including standardized annotation, interoperability and long term support) must be resolved through an interagency effort with planning activities to begin immediately. - Each agency, as its mission directs, should encourage and support genome–enabled microbial research objectives, as described in this report. - Individual and interagency activities initiated as part of the Microbe Project should contain elements that encourage training and /or educational activities, and include efforts to enhance the diversity of participants in all aspects of each activity. - Interagency coordination of the development and distribution of training materials should be encouraged. - Continue coordination cross agencies of all Microbe Project activities, in part through the development of an interagency Microbe Project web site. Availability**:** www.ostp.gov/html/microbial/start.htm

CISE	
White Paper on an NSF ANIR Middleware Initiative	**Scope:** Program Analysis. **Findings:** This group was commissioned to make recommendations for an NSF middleware program. Recommended that NSF support middleware research and a complementary middleware infrastructure program. **Availability:** Division Director, ANIR/NSF.
Report of Review Committee of NSF's High Performance International Internet Services (HPIIS) Project	**Scope:** Assessed the value to the research community of 3 HPIIS awards (Transpac – Asia-Pacific; Euro-Link; and Mirnet – Russia) that connect US researchers to researchers in other countries. Determine continuing need for HPIIS program. **Findings:** Transpac and Euro-Link are well run and effective. Mirnet is making an excellent start. The report recommended a classification of usage types and metrics for usage. Continued support and recognition of needs at application level (as illustrated by the ITR GryPhyN project) were recommended. **Availability:** Division Director, ANIR/NSF.

Report of the National Workshop on Internet Voting: Issues and Research Agenda	**Scope:** Studied the feasibility of online voting at the request of the White House (memorandum, December 17, 1999). **Findings:** Poll Site Internet voting offers benefits and could be fielded within the next several election cycles. Remote voting and Internet voting registration pose significant integrity issues. It is appropriate for the NSF to address technical and social science research in this area. **Availability:** Internet Policy Institute (http://www.internetpolicy.org/).
Making IT Better: Expanding Information Technology Research to Meet Society's Needs	**Scope:** Identifies research areas that need increased effort for the Nation to enjoy full benefits of the Information Technology (IT) systems. **Findings:** Report recommends that NSF and DARPA establish programs for research on large scale IT systems; boosted funding for basic IT research commensurate with growth of research challenges; increased support for interdisciplinary research on social applications of IT. **Availability:** Computer Science and Telecommunications Board, National Research Council National Academy Press. (http://www.nap.edu/)
The Internet's Coming of Age	**Scope:** A study of the Internet and key challenges that shape its maturation. **Findings:** Recommended continued support for research on scaling challenges; partnerships for research to be conducted in realistic operational settings, and research on the economics of interconnection. **Availability**: Computer Science and Telecommunications Board, National Research Council, National Academy Press. www.nap.edu
Report to the President, Digital Libraries: Universal Access to Human Knowledge	**Scope:** Examined state of research on digital libraries (DL). **Findings:** Recommendations to NSF and other agencies. Expand research in DL including organizing content, scalability of systems, archival storage, intellectual property, privacy and security, and human use. Create several large-scale DL testbeds. Make Federal content persistently available on the Internet. Play a leadership role in policy for intellectual property rights. **Availability:** President's Information Technology Advisory Committee, Panel on Digital Libraries National Coordinating Office, Arlington VA. (www.ccic.gov)
Report to the President, Transforming Health Care Through Information Technology	**Scope:** Examined the use of IT in the health care sector. **Findings:** Recommendations were made in several areas focused on NIH and DHHS. Relevant to NSF were recommendations to work with NIH, DARPA and DOE to design and deploy a scalable computing and information infrastructure supporting biomedical research. Several IT research areas were identified. **Availability:** President's Information Technology Advisory Committee, Panel on Transforming Health Care National Coordinating Office, Arlington VA. (www.ccic.gov)

Report to the President, Developing Open Source Software to Advance High End Computing	**Scope:** Computing based on growing vulnerability in the development of software for high end computing. Group assessed the open source model to address this need. **Findings:** The Federal government should encourage open source software with efforts on technical assessment, management plans, policy studies, etc. These recommendations are particularly pertinent to NSF's PACI and Terascale Facilities. **Availability:** President's Information Technology Advisory Committee, Panel on Open Source Software for High End Computing National Coordinating Office, Arlington VA. (www.ccic.gov)

EHR	
The Graduate Research Fellowships (GRF) Program	**Scope:** To assess the impact of Fellowships on successful applicants. *The Graduate Research Fellowships (GRF) Program*-Abt/WestEd (REC9912174). **Findings:** Findings indicated an overall positive effect of the fellowships. Fellows complete the Ph.D. at a higher rate than non-Fellows, and the percentage of female Fellows completing the Ph.D. has become essentially the same as for men. Findings from the evaluation that relate to policy considerations include: • Highly qualified students are funded and the award is highly prestigious. • Fellows consider the major advantages of the fellowship to be its prestige and the flexibility it allows in choosing a research area, structuring a graduate program, and selecting the educational institution and mentor. • About two thirds of the NSF fellows complete their degrees within nine years, with comparable completion rates for female and male fellows. Minority Graduate Fellowship recipients take longer, but the gap is narrowing. Recipients of the add-on Women in Engineering awards tend to complete their doctorates at a faster but lower rate than their male GRF counterparts in engineering. • A large fraction of NSF fellows earn their baccalaureates from a small number of prestigious institutions (40% from 18 institutions in 2001). This year's applicants, on the other hand, came from 699 domestic and 69 foreign institutions. • NSF fellows tend to enroll and complete doctorates in a small number of highly ranked institutions, more so in some disciplines than others. Minority-serving institutions (MSIs) were the baccalaureate origins of a large fraction of applicants and awardees for the (discontinued in 1998) Minority Graduate Fellowship Program. The elimination of the separate minority competition has resulted in a dramatic decrease in applications, awards, and success rates of applicants from MSIs. **Availability:** Available from EHR Directorate, NSF

Academic Excellence for Urban Students - Their Accomplishments in Science and Mathematics	**Scope:** An evaluative study of 22 of the USI districts funded between 1994-1999. **Findings:** NSF's investments in urban education have led to dramatic improvements in student achievement in science and mathematics in most of these funded sites. ESR's urban program has been a catalyst for large-scale systemic change directed towards improving the science and mathematics achievement of all students. Greatest gains were in districts that had participated in the USI program for the longest period of time. USI students made gains in science and mathematics achievement, while reducing achievement gaps among racial/ethnic groups. Students substantially improved their enrollment rates in advanced science and mathematics courses. Underrepresented minority students made even greater gains than their peers during the same period, resulting in reduced enrollment disparities. Implementation of a standards-based curriculum and instruction, aligned assessment practices, and appropriate professional development are key to an increase in student achievement. The convergence of resources, a strong leadership structure, and effective partners were also critical to the improvement in student performance. The study concluded that the infrastructure developed by these districts would likely sustain the achievement gains. The study also concluded that it takes 7-10 years to bring about substantial improvement in systemic reform that may lead to the gains cited in the report (Kim, 2001). **Availability:** The executive summary and full report can be downloaded at www.systemic.com/usi and www.siurbanstudy.org/newspublication
Institution-wide Reform Initiative (IR)	**Scope:** The evaluators examined the differences between institutions receiving awards and institutions that had received high ratings in the IR competition, but were declined. **Findings:** The purpose of this three-year initiative was to encourage broader reform in undergraduate institutions by providing further support for reform-related activities already underway. The study showed that IR support had a substantial effect on students, faculty, and curriculum, with 58,000 students and nearly 1700 faculty participating, and more than 1200 courses developed or revised. Results indicate that the IR awards brought about change in some institutions, particularly 2-year colleges, but differences were small when participants were compared to a similarly motivated set of institutions. **Availability:** Available from EHR Directorate, NSF

Undergraduate Faculty Enhancement (UFE) Program	**Scope:** To determine the effectiveness of faculty training on classroom practices. Undergraduate Faculty Enhancement (UFE) Program-SRI (9412964). **Findings:** The UFE Program provided opportunities for the education of undergraduate faculty through workshops and other activities. Evaluators examined the impact of these. They found that the UFE program had led to 5,000 new courses, 7,300 major course revisions, and 8,600 moderate course revisions. Approximately 1,200 programs of study were developed or redesigned. In addition at least 2,700 other faculty had developed a new course or lab as a result of contact with colleagues who were colleagues who were UFE participants. The evaluators also estimated that, by 1999, more that 1,850,000 students (one in 22 students nationally) had completed courses that were developed or had major revisions as a result of UFE. "Faculty reported that students in their revised or modified courses performed better along a number of dimensions than comparable students in traditional courses. Faculty also cited improvements in students' abilities to solve problems, think critically, communicate, collaborate, use technology, and understand the scientific method." **Availability:** SRI. Available from EHR Directorate, NSF

ENG	
Environmentally Benign Manufacturing	**Scope:** The report includes global benchmarking of the current technologies, systems, and policies in manufacturing, with suggested recommendations for future research needs. Use of metals and polymers in the automotive and the electronics sectors were the primary topical areas. **Findings:** The study found that better tools, data, metrics, and technologies were needed on specific materials and industrial sectors. It called for development of high-performance business practices such as supply chain management, goals alignment, and assessment tracking. **Availability:** World Technology Evaluation Center (WTEC) of the International Technology Research Institute at Loyola College of Maryland. http://itri.loyola.edu/ebm/ebm.pdf
Outcomes and Impacts of the State/Industry-University Cooperative Research Centers (S/IUCRC) Program	**Scope:** Focused on research cooperation between industries and universities. **Findings:** Found that the program has been a modest success as measured against its goals and objectives and compared with the outcomes and impacts of the I/UCRC program that served as its model. **Availability:** Available from NSF (NSF 01-110)

Trends in Industrial Support of University-Based Cooperative Research	**Scope:** Focused on research cooperation between industries and universities **Findings:** The ongoing study found that Engineering Research Centers (ERCs) working to extend an established area of interest in industry are attractive to large, research-intensive firms that have a long-term interest in the results of the center's work. In contrast, centers working in areas that are out in front of existing product lines or corporate interests are much more likely be of interest to small firms and firms that do little or no research and have few or no financial resources to support center work. **Availability:** Available from Engineering Directorate, NSF
Impact of Interaction with Engineering Research Centers on Industry: Repeat Study	**Scope:** Examines the outcomes and impacts of ERC membership on firms that are members of mature second-generation ERCs (centers in the classes of 1994–96) and identifies changes in firms' interactions with ERCs due to changes in the program and in industry compared with first-generation ERCs (classes of 1985–90).

GEO	
Ocean Sciences at the New Millennium.	**Scope:** The Decadal Committee was charged to consider existing reports, additional sources of information, and community input in developing a report summarizing the directions for ocean science over the next decade. **Findings:** Numerous findings were made relating to the scientific opportunities in ocean sciences in the coming decade. The committee recommended: the development of a multi-agency fleet replacement plan; a vigorous effort in technology development, implementation and support in all areas of ocean science; improvement of databases and ready access to these databases by the scientific community; continued emphasis on the development of models that link different parts of the ocean system; and a vigorous exploration of a new class of controlled perturbation experiments. **Availability:** National Academy of Sciences www.nas.edu
Initial Science Plan (ISP) for the Integrated Ocean Drilling Program	**Scope:** To examine the scientific significance, technical feasibility, and potential societal benefits of the ISP. **Findings:** The Committee reaffirmed that the scientific significance, technical feasibility, and potential societal benefits of the ISP make it of exceptional importance and timeliness. The Committee concluded that the benefits of the program described in the ISP far outweigh the costs and the technical uncertainties. The Committee gave its unreserved support to the priorities of the program as described in the ISP. A number of specific recommendations on scientific and technological objectives, facilities, organizational and implementation options, and resource requirements were included. **Availability:** National Academy of Sciences, www.nas.edu

Basic Research Opportunities in Earth Science	**Scope:** To undertake a major study of research in the Earth Sciences. **Findings:** The Board found that the Division of Earth Sciences (EAR) has done an excellent job in maintaining the balance among core programs supporting investigator-driven disciplinary research, problem-focused programs of multidisciplinary research, and equipment-oriented programs for new instrumentation and facilities. The committee offers recommendations that address the evolving science requirements in all three of these programmatic areas and primarily pertain to new mechanisms that will allow EAR to exploit research opportunities identified by the committee. The Board also strongly endorsed the four observational components of the *EarthScope* Initiative. **Availability:** National Research Council/National Academy Press, 2000, www.nas.edu

MPS	
Physics in a New Era	**Scope:** The report surveys the field of physics broadly, identifies priorities, and formulates recommendations. The overview assesses the state of physics in four broad categories – quantum manipulation and new materials, complex systems, structure and evolution of the universe, and fundamental laws and symmetries – emphasizing the unity of the field and the strong commonality that links the different areas, while highlighting new and emerging ones. **Findings:** Six high-priority opportunities identified, nine recommendations are made: support of physics by the federal government; physics education; role of basic physics research in national security; increasingly important role of partnerships among universities, industry, and national labs; the stewardship of federal science agencies; and the rapidly changing role of information technology in physics research and education. **Availability:** National Research Council, http://www.nap.edu/catalog/10118.html
An Assessment of the Department of Energy's Office of Fusion Energy Sciences Program.	**Scope:** An assessment of the scientific quality of the Department of Energy (DOE) Office o Fusion Energy Sciences Program. **Findings:** Although this report was generated at the request of the DOE's Office of Science, NSF is often referred to within the document. In particular, the report recommends that NSF play a greater role in extending the reach of fusion science and in sponsoring general plasma science. **Availability:** National Research Council, http://books.nap.edu/catalog/9986.html

Committee on Organization and Management of Research in Astronomy and Astrophysics	**Scope:** To assess the organizational effectiveness of Federal support of astronomical sciences and, specifically, the pros and cons of transferring NSF's astronomy responsibilities to NASA. **Findings:** NSF's astronomy and astrophysics responsibilities should not be transferred to NASA. The Federal government should develop a single integrated strategy for astronomy and astrophysics research that includes supporting facilities both on the ground and in space. An interagency planning board for astronomy and astrophysics should be formed that would receive input from the community through a joint advisory committee of outside experts. Additional recommendations address ways to improve the present overall management structure and strengthen NSF's ability to support astronomy. **Availability:** National Research Council (http://www.nas.edu/) with the prepublication copy available at http://books.nap.edu/html/integrated_program/comraa.pdf
Proceedings of the Workshop on the Present Status and Future Developments of Solid State Chemistry and Materials	**Scope:** Define research opportunities in the field of solid-state chemistry and materials; identify the most important multidisciplinary areas for involvement by the solid-state chemistry and materials community; determine novel roles for the Solid State Chemistry and Materials community that will advance educational and training opportunities for future scientists, engineers, and technicians; develop new approaches that allow for the more effective and efficient conduct of research and educational activities. **Findings:** Numerous recommendations are listed for various sub-fields in this discipline. **Availability:** NSF web site http://www.nsf.gov/mps/dmr/ssc.pdf
US-Africa Materials Workshop	**Scope:** The workshop explored research opportunities directed towards expanding materials research and education for the purpose of contributing to the development of new technologies as well as promoting collaboration among U.S. and African universities and industries. **Findings:** Need to establish one or more organizations to ensure the continuation of conversations that began at the workshop. Technical recommendations from a number of working groups are included in the report. **Availability:** http://iumrs.org/docs/africa.pdf
National Science Foundation Force Transduction in Biology Workshop	**Scope:** The goal of this workshop was to explore recent advances in research on force transduction in biology at all length scales, and to seek possible overlap or synergies between these different areas. An additional goal was to explore the potential interdisciplinary interactions that will lead to significant advances in this area. Also, the workshop was to identify important new directions for research and to make recommendations about potential funding opportunities. **Findings:** Perhaps the most important conclusion of the workshop was that research in force transduction in biology has important problems that span many length scales and many disciplines. However, the interdisciplinary nature of the research, the quantitative nature of the important problems and the key relationship between the materials properties and the important issues all make this an area that the NSF can play a significant role in fostering progress. **Availability:** http://hurkle.deas.harvard.edu/nsf/workshop.html

SBE	
The Societal Implications of Nanoscience and Nanotechnology	**Focus:** The aim was to: (1) survey current studies on the societal implications of nanotechnology (educational, technological, economic, medical, environmental, ethical, legal, etc.); (2) identify investigative and assessment methods for future studies of societal implications; (3) propose a vision for accomplishing nanotechnology's promise while minimizing undesirable consequences. **Availability:** The report has been published both on the web and in book form (http://itri.loyola.edu/nano/NSET.Societal.Implications/).

APPENDIX II. – SCHEDULE OF PROGRAM EVALUATIONS

The following table provides information on the scheduling of meetings for Committees of Visitors (COVs) for our programs. The table lists the fiscal year of the most recent COV meeting for the program and the fiscal year for the next COV review of the program. We have highlighted the COV meetings that were held in FY 2001 in bold font.

Committee of Visitors Meetings By Directorate

(COV meetings held during FY 2001 are highlighted in bold font)

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
BIOLOGICAL SCIENCES		
Biological Infrastructure		
Instrument Related Activities	2000	2002
Research Resources	2000	2003
Training	2000	
Plant Genome	**2001**	
Environmental Biology		
Ecological Studies	1999	2002
Long Term Research	**2001**	
Systematic and Population Biology	2000	2004
Integrative Biology and Neuroscience	**2001**	2005
Neuroscience	1999	2003
Developmental Mechanisms	2000	2004
Physiology and Ethnology	1997	2002
Molecular and Cellular Biosciences		2002
Biomolecular Structure and Function	2000	
Biomolecular Processes	2000	
Cell Biology	**2001**	
Genetics	1999	

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
COMPUTER AND INFORMATION SCIENCE AND ENGINEERING		
Advanced Computational Infrastructure and Research		
Advanced Computational Research	**2001**	2004
PACI	1999	2002
Computer-Communications Research		
Communications	2000	2003
Computer Systems Architecture	2000	2003
Design Automation	2000	2003
Hybrid and Embedded Systems (new in '02)	N/A	2003
Numeric, Symbolic and Geometric Computation	2000	2003
Operating Systems and Compilers	2000	2003
Signal Processing Systems	2000	2003
Software Engineering and Languages	2000	2003
Theory of Computing	2000	2003
Trusted Computing (new in '02)	N/A	2003
Information and Intelligent Systems		
Computation and Social Systems	1999	2002
Human Computer Interaction	1999	2002
Knowledge and Cognitive Systems	1999	2002
Robotics and Human Augmentation	1999	2002
Information and Data Management	1999	2002
Advanced Networking Infrastructure and Research		
Networking Research	2000	2003
Special Projects in Networking Research	2000	2003
Advanced Networking Infrastructure	2000	2003
Information Technology Research (ITR) (new in '00)	N/A	2003
Experimental and Integrative Activities	**2001**	
-Instrumentation Infrastructure Cluster		
Research Infrastructure	**2001**	2004
Research Resources (new in '02)	N/A	2004
-Multidisciplinary Research Cluster		
Biological Information Technology and Systems (new in '02)	N/A	2004
Quantum and Biologically Inspired Computing (new in '02)	N/A	2004
Digital Government	**2001**	2004
Next Generation Software	**2001**	2004
-Education Workforce Cluster		
Information Technology Workforce (new in '02)	N/A	2004
Minority Institutions Infrastructure	**2001**	2004
CISE Educational Innovation	**2001**	2004
****CISE Postdoctoral Research Associates**	**2001**	

-EIA Special Projects Cluster		
Special Projects (new in '02)	N/A	2004
****NSF-CONACyT Collaborative Research**	**2001**	
****NSF-CNPq Collaborative Research**	**2001**	
**EIA monitored, managed/reviewed by Division in Partnership with Engineering		

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
EDUCATION AND HUMAN RESOURCES		
Educational Systemic Reform		
Statewide Systemic Initiatives	**2001**	2004
Urban Systemic Initiatives	**2001**	2004
Rural Systemic Initiatives	**2001**	2004
Office of Innovation Partnerships		
Innovation Partnership Activities (new in '01)	N/A	2004
EPSCoR	2000	2003
Elementary, Secondary and Informal Education		
Informal Science Education	**2001**	2004
Teacher Enhancement	2000	2003
Instructional Materials Development	1997	2002
Centers for Learning and Teaching (new in '01)	N/A	2004
Undergraduate Education		
Teacher Preparation	2000	2003
Advanced Technological Education	2000	2003
NSF Computer, Science, Engineering and Mathematics Scholarships (new in '01)	N/A	2002
Distinguished Teaching Scholars (new in '02)	N/A	2004
Scholarship for Service (new in '01)	N/A	2004
National SMETE Digital Library (new in '01)	N/A	2002
Course, Curriculum, and Laboratory Improvement	2000	2003
Undergraduate Assessment (new in '02)	N/A	2004
Graduate Education		
Graduate Research Fellowships	1999	2003
NATO Postdoctorate Fellowships	**2001**	2005
IGERT (new in '97)		2002
GK-12 Fellows (new in '99)	N/A	2002
Human Resource Development		
The Louis Stokes Alliances for Minority Participation	**2001**	2004
Centers for Research Excellence In Science and Technology (CREST)	**2001**	2004
Programs for Gender Equity (PGE)	2000	2003
Programs for Persons with Disabilities (PPD)	2000	2003
Alliances for Graduate Education and the Professoriate (AGEP)	**2001**	2004
Tribal Colleges Program (TCP) (new in '01)	N/A	2004
Historically Black Colleges and Universities (HBCU)	**2001**	2004

Research, Evaluation & Communications		
REPP/ROLE (new in '96)		2002
Evaluation	2000	2003
Education Research Initiative (ERI) (new in '01)	N/A	2002
Other		
H-IB VISA K-12		2004
Math and Science Partnership (MSP) (new in '02)	N/A	2005

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
ENGINEERING		
Bioengineering and Environmental Systems		2002
Biochemical Engineering	1999	2002
Biotechnology	1999	2002
Biomedical Engineering	1999	2002
Research to Aid the Disabled	1999	2002
Environmental Engineering	1999	2002
Environmental Technology	1999	2002
Civil and Mechanical Systems	**2001**	2004
Dynamic System Modeling, Sensing and Control	**2001**	2004
Geotechnical and GeoHazard Systems	**2001**	2004
Infrastructure and Information Systems	**2001**	2004
Solid Mechanics and Materials Engineering	**2001**	2004
Structural Systems and Engineering	**2001**	2004
Network for Earthquake Engineering Simulation	**2001**	2004
Chemical and Transport Systems		2003
Chemical Reaction Processes	2000	2003
Interfacial, Transport and Separation Processes	2000	2003
Fluid and Particle Processes	2000	2003
Thermal Systems	2000	2003
Design, Manufacture and Industrial Innovation		
-Engineering Decision Systems Programs (new in '02)	N/A	2003
Engineering Design	2000	2003
Manufacturing Enterprise Systems (new in '02)	N/A	2003
Service Enterprise Systems (new in '02)	N/A	2003
Operations Research	2000	2003
-Manufacturing Processes and Equipment Systems	2000	2003
Materials Processing and Manufacturing	2000	2003
Manufacturing Machines and Equipment	2000	2003
Nanomanufacturing (new in '02)	N/A	2003
-Industrial Innovation Programs Cluster		

Small Business Innovation Research (SBIR)	**2001**	2004
Innovation and Organizational Change	2000	
Grant Opportunities for Academic Liaison with Industry	2000	2003
Small Business Technology Transfer	**2001**	2004
Electrical and Communications Systems		
Electronics, Photonics and Device Technologies	2000	2002
Control, Networks, and Computational Intelligence	2000	2002
Integrative Systems (new in '02)	N/A	2002
Engineering, Education and Centers	**2001**	2004
Engineering Education	**2001**	2004
Engineering Research Centers	**2001**	2004
Earthquake Engineering Research Centers	**2001**	2004
Human Resource Development	**2001**	2004
State/Industry/University Cooperative Research Centers	**2001**	2004
Industry/Univ. Cooperative Research Centers	**2001**	2004

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
GEOSCIENCES		
Atmospheric Sciences		
-Lower Atmospheric Research Cluster		
Atmospheric Chemistry	**2001**	2004
Climate Dynamics	**2001**	2004
Meoscale Dynamic Meteorology	**2001**	2004
Large-scale Dynamic Meteorology	**2001**	2004
Physical Meteorology	**2001**	2004
Paleoclimate	**2001**	2004
-Upper Atmospheric Research Cluster		
Magnetospheric Physics	1999	2002
Aeronomy	1999	2002
Upper Atmospheric Research Facilities	1999	2002
Solar Terrestrial Research	1999	2002
-Centers and Facilities Cluster		
Lower Atmospheric Observing Facilities	2000	2003
UNIDATA	2000	2003
NCAR/UCAR	2000	2003
Earth Sciences		
Instrumentation and Facilities	1997	2004
-Research Support Cluster	1998	
Tectonics	1998	2002
Geology and Paleontology	1998	2002
Hydrological Sciences	1998	2002
Petrology and Geochemistry	1998	2002
Geophysics	1998	2002
Continental Dynamics	1998	2002

Ocean Sciences		
-Integrative Programs Cluster	1997	2002
Oceanographic Technical Services	1994	2002
Ship Operations	1994	2002
Oceanographic Instrumentation	1994	2002
Ship Acquisitions and Upgrades (new in '02)	N/A	2002
Shipboard Scientific Support Equipment (new in '02)	N/A	2002
Oceanographic Tech and Interdisciplinary Coordination	1998	2002
-Marine Geosciences Cluster		
Marine Geology and Geophysics	1998	2003
Ocean Drilling	1994	2003
-Ocean Cluster		
Chemical Oceanography	1998	2003
Physical Oceanography	1998	2003
Biological Oceanography	1998	2003

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
MATHEMATICAL AND PHYSICAL SCIENCES		
Astronomical Sciences	1999	2002
Planetary Astronomy	1999	2002
Stellar Astronomy and Astrophysics	1999	2002
Galactic Astronomy	1999	2002
Education, Human Resources and Special Programs	1999	2002
Advanced Technologies and Instrumentation	1999	2002
Electromagnetic Spectrum Management	1999	2002
Extragalactic Astronomy and Cosmology	1999	2002
-Facilities Cluster		
Gemini 8-Meter Telescopes	1999	2002
National Radio Astronomy Observatory (NRAO)	1999	2002
National Optical Astronomy Observatories (NOAO)	1999	2002
National Astronomy and Ionosphere Center (NAIC)	1999	2002
Chemistry	**2001**	2004
Office of Special Projects	**2001**	2004
Chemistry Research Instrumentation and Facilities (CRIF)	**2001**	2004
Organic Chemical Dynamics	**2001**	2004
Organic Synthesis	**2001**	2004
Chemistry of Materials	**2001**	2004
Theoretical and Computational Chemistry	**2001**	2004
Experimental Physical Chemistry	**2001**	2004
Inorganic, Bioinorganic and Organometallic Chemistry	**2001**	2004
Analytical and Surface Chemistry	**2001**	2004

Materials Research	1999	2002
-Base Science Cluster		
Condensed Matter Physics	1999	2002
Solid-State Chemistry	1999	2002
Polymers	1999	2002
-Advanced Materials and Processing Cluster		
Metals	1999	2002
Ceramics	1999	2002
Electronic Materials	1999	2002
-Materials Research and Technology Enabling Cluster		
Materials Theory	1999	2002
Instrumentation for Materials Research	1999	2002
National Facilities	1999	2002
Materials Research Science and Engineering Centers	1999	2002
Mathematical Sciences	**2001**	2004
Applied Mathematics	**2001**	2004
Topology and Foundations	**2001**	2004
Computational Mathematics	**2001**	2004
Infrastructure	**2001**	2004
Geometric Analysis	**2001**	2004
Analysis	**2001**	2004
Algebra, Number Theory, and Combinatories	**2001**	2004
Statistics and Probability	**2001**	2004
Physics	2000	
Atomic, Molecular, Optical and Plasma Physics	2000	2003
Elementary Particle Physics	2000	2003
Theoretical Physics	2000	2003
Particle and Nuclear Astrophysics (new in ’00)	N/A	2003
Nuclear Physics	2000	2003
Education and Interdisciplinary Research (new in ’00)	N/A	2003
Gravitational Physics	2000	2003

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
SOCIAL, BEHAVIORAL, AND ECONOMIC SCIENCES		
Office of International Science and Engineering (INT)	1999	2002
Science Resource Statistics (SRS) (new in ‘99)		2004
-NSF-wide Programs Cluster		
CAREER	**2001**	
ADVANCE (new in ‘01)		
Behavioral and Cognitive Sciences (BCS)		2004
Archeology and Archaeometry	1999	2004
Child Learning and Development	1997	2004

Cultural Anthropology	1999	2004
Linguistics	1999	2004
Human Cognition and Perception	1999	2004
Social Psychology	1999	2004
Physical Anthropology	1999	2004
Geography and Regional Sciences	1999	2004
Social and Economic Sciences (SES)		2003
Decision, Risk, and Management Sciences	2000	2003
Political Science	2000	2003
Law and Social Science	2000	2003
Innovation and Organizational Change	2000	2003
Methodology, Measurement and Statistics	2000	2003
Science and Technology Studies	2000	2003
Societal Dimensions of Engineering, Science, and Technology	2000	2003
Economics	2000	2003
Sociology	2000	2003

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
OFFICE OF POLAR PROGRAMS		
Polar Research Support	**2001**	2004
Antarctic Sciences		2003
Antarctic Aeronomy and Astrophysics	2000	2003
Antarctic Biology and Medicine	2000	2003
Antarctic Geology and Geophysics	2000	2003
Antarctic Glaciology	2000	2003
Antarctic Ocean and Climate Systems	2000	2003
Arctic Sciences		2003
Arctic Research Opportunities	2000	2003
Arctic Research and Policy	2000	2003
Arctic System Sciences	2000	2003
Arctic Natural Sciences	2000	2003
Arctic Social Sciences	2000	2003

DIRECTORATE *Division* Program	Fiscal Year of Most Recent COV	Fiscal Year of Next COV
OFFICE OF INTEGRATIVE ACTIVITIES		
Major Research Instrumentation (MRI)	2000*	
Science and Technology Centers (STC)	1996*	2007
*External evaluations		

APPENDIX III. – TABLE OF ACRONYMS

AC	Advisory Committee
ACR	Advanced Computational Research
ACSI	American Customer Satisfaction Index
ADP	Automated Data Processing
AGEP	Alliances for Graduate Education and the Professoriate
AKRSI	Alaska Rural Systemic Initiative
ALMA	Atacama Large Millimeter Array
AMANDA	Antarctic Muon and Neutrino Detection Array
AMRC	Antarctic Meteorological Research Center
AMS	American Mathematical Society
AO	Arctic Oscillation
ARSI	Appalachia Rural Systemic Initiative
AST	Astronomical Sciences Division
ATE	Advanced Technological Education
ATLAS	A Toroidal LHC Apparatus
BAC	Bacterial Artificial Chromosome
BBC	British Broadcasting Corporation
BCS	Division of Behavioral and Cognitive Sciences
BE	Biocomplexity in the Environment
BIO	Directorate for Biological Sciences
CAREER	Faculty Early Career Development Program
CASES	Cooperative Atmosphere-Surface Exchange Study
CAVE	Cave Automatic Virtual Environment
CDA	Cross-Directorate Activities Program
CDRC	Child Development Research Collaborative
CERN	European Organization for Nuclear Research
CHE	Chemistry Division
CHESS	Cornell High Energy Synchrotron Source
CHRNS	Center for High Resolution Neutron Scattering
CIRE	Collaboratives to Integrate Research and Education
CIS	Center for Integrated Studies
CISE	Directorate for Computer and Information Science and Engineering
CLAWPACK	Conservation Law Package
CLT	Centers for Learning and Teaching
CMS	Compact Muon Spectrometer
CNRS/INRA	Centre National de Recherche Scientifique/Institut National de la Recherche Agronomique
CompTIA	Computing Technology Industry Association
COV	Committee of Visitors
CPMSA	Comprehensive Partnerships for Mathematics and Science Achievement
CPO	Division of Contracts, Policy and Oversight
CREST	Centers for Research Excellence In Science and Technology
CRI	Children’s Research Initiative
CRIF	Chemistry Research Instrumentation and Facilities
DARPA	Defense Advanced Research Projects Agency
DDI	Data Documentation Initiative
DGA	Division of Grants and Agreements
DHHS	Department of Health and Human Services
DL	Digital Libraries
DMR	Division of Materials Research
DMS	Division of Mathematical Sciences
DNA	Deoxyribonucleic Acid
DOD	Department of Defense
DOE	Department of Energy
DRSI	Delta Rural Systemic Initiative
DYCOMS	Dynamics and Chemistry of Marine Stratocumulus
EAR	Division of Earth Sciences
EHR	Directorate for Education and Human Resources
EIA	Division of Experimental and Integrative Activities
EIS	Enterprise Information System
ENG	Directorate for Engineering
EPSCoR	Experimental Program to Stimulate Competitive Research
ERC	Engineering Research Center
ERI	Education Research Initiative
ESR	Educational System Reform
EST	Expressed Sequence Tag
FAA	Federal Aviation Administration
FACA	Federal Advisory Committee Act

FAS	Financial Accounting System
FEMA	Federal Emergency Management Agency
FT-ICR	Fourier-Transform-Ion Cyclotron Resonance
GABA	Gamma Aminobutyric Acid
GAO	General Accounting Office
GEO	Directorate for Geosciences
GK-12	Graduate Teaching Fellows in K-12 Education
GPA	Grade Point Average
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GRF	Graduate Research Fellowship
GSN	Global Seismographic Network
GSS	General Social Survey
GW	Ground water
HBCU	Historically Black Colleges and Universities
HDGC	Human Dimensions of Global Change
HPIIS	High Performance International Internet Services
HPNC	High Performance Network Connections
HRM	Division of Human Resources Management
IBN	Division of Integrative Biology and Neuroscience
ICPSR	Inter-University Consortium for Political and Social Research
IGERT	Integrative Graduate Education and Research Traineeship
INT	Office of International Science and Engineering
IP	Internet Protocol
IPA	Intergovernmental Personnel Act (appointee)
IPCC	Intergovernmental Panel on Climate Change
IRIS	Incorporated Research Institutions for Seismology
IRIS	Industrial Research & Development Information System
ISE	Informal Science Education
IT	Information Technology
ITR	Information Technology Research
ITS	Information Technology Security
IUCRC	Industry University Cooperative Research Center
KeLP	Kernel Lattice Parallelism (KeLP)
KHEP	K-12 Higher Education Partnerships
LAPACK	Linear Algebra Package
LASER	Leadership and Assistance for Science Education Reform Center
LHC	Large Hadron Collider
LIGO	Laser Interferometer Gravitational-wave Observatory
LSAMP	Louis Stokes Alliances for Minority Participation
MEMS	Microelectromechanical Systems
MPS	Directorate for Mathematical and Physical Sciences
MRE	Major Research Equipment (account)
MRI	Major Research Instrumentation (program)
MRSEC	Materials Research Science and Engineering Center
MS	Master of Science or Mass Spectrometry
MSP	Math and Science Partnerships
NAIC	National Astronomy and Ionosphere Center
NAPA	National Academy of Public Administration
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCAR	National Center for Atmospheric Research
NCTM	National Council of Teachers of Mathematics
NEES	Network for Earthquake Engineering Simulation
NHGIS	National Historical Geographic Information System
NHMFL	National High Magnetic Field Laboratory
NIH	National Institutes of Health
NNI	National Nanotechnology Initiative
NNUN	National Nanofabrication Users Network
NOAA	National Oceanic and Atmospheric Administration
NOAO	National Optical Astronomy Observatory
NRAO	National Radio Astronomy Observatory
NRC	National Research Council
NRL	Naval Research Laboratory
NSB	National Science Board

NSE	Nanoscale Science and Engineering
NSEC	Nanoscale Science and Engineering Centers
NVO	National Virtual Observatory
ODS	Online Document System
OEOP	Office of Equal Opportunity Programs
OIG	Office of Inspector General
OIRM	Office of Information and Resource Management
OMB	Office of Management and Budget
OPM	Office of Personnel Management
OPP	Office of Polar Programs
ORISE	Oak Ridge Institute for Science and Education
OTS	Organization for Tropical Studies
OWC	Oklahoma Weather Center
PACI	Partnerships for Advanced Computational Infrastructure
PARS	Proposal, PI and Reviewer System
PDF	Program Document Format
PFI	Partnerships for Innovation
PGE	Programs for Gender Equity
PHY	Division of Physics
PI	Principal Investigator
PICI	Phyloinformatics and Coordination Infrastructure
PIMS	Program Information Management System
PMA	President's Management Agenda
PMET	Physical Meteorology
PPD	Programs for Persons with Disabilities
PSID	Panel Study of Income Dynamics
PwC LLP	PricewaterhouseCoopers LLP
REPP	Research in Education Policy and Practice
RET	Research Experiences for Teachers
REU	Research Experiences for Undergraduates
ROLE	Research on Learning and Education
RSI	Rural Systemic Initiative
SAR	Synthetic Aperture Radar
SBE	Directorate for Social, Behavioral and Economic Sciences
SBIR	Small Business Innovation Research
ScaLAPACK	Scalable Linear Algebra Package
SES	Division of Social and Economic Sciences
SFFAS	Statement of Federal Financial Accounting Standard
SGER	Small Grant for Exploratory Research
SMET	Science, Mathematics, Engineering and Technology
SMETE	Science, Mathematics, Engineering and Technology Education
SOARS	Significant Opportunities in Atmospheric Research and Science
SPSM	South Pole Station Modernization
SRC	Synchrotron Radiation Center
SRI	SRI International
SRS	Division of Science Resources Statistics
SSI	Statewide Systemic Initiative
STC	Science and Technology Center
STEM	Science, Technology, Engineering and Mathematics
TCS	Terascale Computing System
TEA	Teachers Experiencing Antarctica and the Arctic
UCAN	Utah, Colorado, Arizona, New Mexico
UCAR	University Corporation for Atmospheric Research
UFE	Undergraduate Faculty Enhancement
UML	Unified Modeling Language
UPR	University of Puerto Rico
URM	Underrepresented Minorities
USGS	United States Geological Survey
USI	Urban Systemic Initiative
USP	Urban Systemic Program
VORTEX	Verification of Origins of Rotation in Tornadoes Experiment
VR	Virtual Reality
WAIS	West Antarctic Ice Sheet
WDCP	World Data Center for Paleoclimatology
WTC	World Trade Center
WTEC	World Technology Evaluation Center

APPENDIX IV. PwC EXECUTIVE SUMMARY

EXCERPT FROM THE PRICEWATERHOUSECOOPERS LLP REPORT *"NATIONAL SCIENCE FOUNDATION FY 2001 GPRA PERFORMANCE MEASUREMENT VALIDATION AND VERIFICATION FINAL REPORT JANUARY 2002"*

1 Executive Summary

The National Science Foundation ("NSF" or "the Foundation"), 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 measures to help the agency meet its mission, goals, and objectives. The Foundation asked PricewaterhouseCoopers (PwC) to assess whether the methods that NSF uses to compile and report selected FY 2001 performance measures are verifiable and produce valid results. This is the second consecutive year that PwC has performed this function.

We commend NSF for undertaking this second year effort to confirm the reliability of its data and the processes to collect, process, maintain, and report this data. From our FY 2001 review, we conclude that NSF has made a concerted effort to ensure that it reports accurately to the federal government and has effective systems, policies, and procedures to ensure data quality. We have noted some areas for improvement, particularly in the area of data collection for the goals related to facilities management. However, overall NSF relies on sound business practices, system and application controls, and manual checks of system queries to report performance. Further, our efforts to re-calculate the Foundation's results based on these systems, processes and data were successful.

The General Accounting Office (GAO) has directed federal agencies to provide confidence that the policies and procedures that underlie GPRA performance reporting are complete, accurate and consistent. To address GAO's mandate and past concerns, NSF asked us to conduct an independent verification and validation review of eighteen FY 2001 quantitative and qualitative goals contained in the FY 2001 NSF GPRA Performance Plan. 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. Significant error, including bias, would affect conclusions about the extent to which NSF has achieved its performance goals. These definitions and the GAO-specified criteria were the guiding principles of our assessment.

Thirteen of the goals we assessed are undergoing review for the first time, while the remaining six are being reviewed a second time. As part of our review of the processes and results for these selected performance goals, we:

- Assessed the accuracy of NSF's performance measures
- 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
- Identified changes to processes and data for those goals undergoing review for the second time

This assessment is not an audit and, as such, was not conducted in accordance with generally accepted government auditing standards. Rather, we followed GAO's *Guide to Assessing Agency Annual Performance Plans* (GAO/GCD-10.1.20) to guide our review. Our assessment was intended neither to determine whether NSF's goals are appropriate nor to conclude whether these goals are the appropriate way to gauge agency success. Based on GAO guidance, we assessed whether NSF's processes to collect, process, maintain, and report data for its goals 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 their 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?

For goals undergoing review for the first time, we documented the processes NSF follows to collect, process, maintain, and report performance data. We also identified relevant controls and commented on their effectiveness.

1.1 Results

From our review, we determined that NSF has reported on ten of the quantitative goals and all five of the qualitative goals in a manner such that any errors, should they exist, would not be significant enough to change the reader's interpretation of the Foundation's success in meeting the supporting performance goal. For these goals, 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. For the four goals related to facilities management, we identified significant data limitations, which impaired our ability to verify the processes. However, we believe that NSF's reported outcomes are consistent with the data they collected. We summarize our results in the following table:

FY 2001 Performance Goal	**Are processes verifiable and are results valid?**		
Quantitative goals reviewed for the first time in FY 2001	**Yes**	**Partially**	**No**
IV-2: In FY 2001, NSF will conduct ten pilot paperless projects that manage the competitive review process in an electronic environment.	✔		
IV-3: By the end of FY 2001, NSF will increase usage of a broad-range of video-conferencing/long-distance communications technology by 100% over the FY 1999 level.	✔		
V-1: At least 85% of basic and applied research funds will be allocated to projects, which undergo merit review.	✔		
V-6a: NSF will increase the average annualized award size for research grants to $110,000.	✔		
V-6b: NSF will increase the average duration of awards of research grants to at least three years.	✔		
V-9a: For 90 percent of facilities, keep construction and upgrades within annual expenditure plan, not to exceed 110 percent of estimates.		✔	
V-9b: Ninety percent of facilities will meet all major annual schedule milestones by the end of the reporting period.		✔	
V-9c: For all construction and upgrade projects initiated after 1996, when current planning processes were put in place, keep total cost within 110 percent of estimates made at the initiation of construction.		✔	
V-10: For 90 percent of facilities, keep operating time lost due to unscheduled downtime to less than 10 percent of the total scheduled operating time.		✔	
III-1b: Over 80% of schools participating in systematic initiative programs will 1) implement a standards-based curriculum in science and mathematics, 2) further professional development of the instructional workforce, and 3) improve student achievement on a selected battery of tests, after three years of NSF support.	✔		
III-1c: Through systematic initiatives and related teacher enhancement programs, NSF will provide intensive professional development experiences for at least 65,000 pre-college teachers.	✔		
Update Reviews (Goals initially reviewed in FY 2000)			
IV-1: Ninety-five percent of full proposals will be received electronically through FastLane.	✔		

FY 2001 Performance Goal	Are processes verifiable and are results valid?		
Quantitative goals reviewed for the first time in FY 2001	**Yes**	**Partially**	**No**
IV-4: NSF will show an increase over 1997 in the total number of hires to S&E positions from underrepresented groups.	✔		
V-5: For 70 percent of proposals, be able to tell applicants whether their proposals have been declined or recommended for funding within six months of receipt.	✔		
Qualitative Goals			
III-1: Development of "a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens."	✔		
III-2: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."	✔		
III-3: Providing "broadly accessible, state-of-the-art and shared research and education tools."	✔		
V-2: NSF performance in implementation of the merit review criteria is successful when reviewers address the elements of both generic review criteria.	✔		
V-3: NSF performance in implementation of the merit review criteria is successful when program officers address the elements of both generic review criteria when making their award decisions.	✔		

Our conclusions that the qualitative goals are valid and verifiable are based on our ability to confirm the ratings and interpretations contained in the Advisory Committee (AC) and Committee of Visitors (COV) reports. At the date of this report, we have been unable to review the final language that NSF will use in presenting the Foundation-wide results due to varying external reporting due dates for performance measurement information. However, we expect that the results that will be reported in upcoming months will coincide with the comments and conclusions reported in the AC and COV reports.

In addition, we concluded that there was insufficient information in many of the COV reports on which to base an unequivocal determination of success in achieving certain indicators. We recommend that NSF balance their final performance report language reflecting the neutrality of these reports and the inability to support the AC and COV report text with clearly identifiable examples and awards.

Recommendations

For each goal under review, we provide recommendations for how NSF can strengthen the processes it uses to collect, process, maintain, and report GPRA information. Details for our recommendations can be found in the report. We highlight our overarching recommendations below:

- **For goals that compare actual performance to estimates, ensure that estimates are unchangeable.** For the goals related to facilities management, NSF designed the data collection system to allow principal investigators (PIs) to change the estimates, which are used to calculate the results. NSF allows these changes to account for management problems beyond the facilities control. However, the ability to change estimates and the fact that the system does not track these changes hinders the ability to compare actual costs, milestones and completion dates to original estimates. By making estimates unchangeable, NSF could create true project-specific baselines for these goals, which will provide NSF an accurate picture of project performance, compared to estimates. Should NSF choose to continue to allow estimates to be changed, we recommend that the system be enhanced to track estimate changes, as a management and monitoring tool for NSF and Program Officers (POs).

- **Simplify the GPRA reporting process for facilities goals.** NSF should consider allowing POs, rather than PIs, to report on the progress of facilities projects. By allowing POs to report on project performance, NSF can simplify the reporting process, improve internal accountability, and lessen the reporting burden on PIs. POs could use annual project reports, schedule. or other reports already developed by the PI, to report progress on facilities projects for GPRA. This would eliminate the need for PIs to provide duplicative information and create budgets and schedules based on the federal fiscal year yet have little value for program management.

- **Clarify language for goals to better reflect NSF's objectives and thresholds for success.** For some of the goals we reviewed, we believe that NSF can revise the language to be more specific and indicative of what NSF is trying to achieve. For example, NSF could clarify the language for goal III-1b to indicate that the goal only measures schools participating for three years or more in the systemic initiative program. Also, for construction and upgrade goals, NSF could revise the language to mention that it only measures construction and upgrade projects that have a total cost of at least $5 million or funded out of the Major Research and Equipment Account. Clarifying the language of these goals will help NSF staff and external reviewers understand NSF's objectives and facilitate the process to collect, process, maintain, and report data.

- **Further refine reporting templates and instructions for the qualitative measures.** NSF has made great strides to develop and improve the templates that are provided to the committees. However, we believe that this improvement can continue to evolve. A well-designed template will save committees valuable time, provide more verifiable support, reduce ambiguity, and provide more comprehensive evaluations. Committees could be encouraged to provide more than one example, if desired. A sample template for the "People" goals at a Division level is provided below.

- (Sample not included in this excerpt).

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