

National Science Board 2020 Vision for the National Science Foundation



DRAFT FOR PUBLIC COMMENT

NATIONAL SCIENCE BOARD

Terms Expire May 10, 2006

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National Science Board

2020 Vision for the National Science Foundation

Preamble

“Given the constrained funding environment, it is even more critical that the National Science Board develop a long-term vision for NSF. In other words, we need a strategy that outlines how we can get the biggest bang for our buck through programs and activities supported by NSF. This does not mean how NSF will alter its grant size and duration. This means articulating a vision for the future of science and technology, including the next bold cutting-edge areas of research. We also need a plan on how NSF will lead the research community in meeting these new bold challenges. The Board is ideally suited for this responsibility and I believe strongly that it is a core activity of the Board’s mission. One of the specific areas that the Board should examine is the future of our Nation’s math and science education.” Chairman Kit Bond, Senate VA HUD Appropriations Hearing, February 17, 2005.

Mission

“To promote the progress of science; to advance national health, prosperity, and welfare; to secure the national defense; and for other purposes.” National Science Foundation Act of 1950.

2020 Vision

The National Science Foundation ensures that the Nation maintains a position of eminence in global science, technology and knowledge development, through leadership in transformational research and excellence in science education, thus driving economic vitality, an improved quality of life, and national security.

Strategic Priorities

To achieve this 2020 Vision, the Foundation will focus on three Strategic Priorities:

- **Strategic Priority 1** - Ensure the Nation maintains a position of eminence at the global frontier of basic and transformational research, emphasizing areas of greatest scientific opportunity and potential benefit to the Nation.
- **Strategic Priority 2** - Sustain a world-class science and engineering (S&E) workforce and develop a scientifically literate citizenry.
- **Strategic Priority 3** - Ensure the Nation’s basic research capacity in critical S&E infrastructure, facilities and tools.

History

The National Science Foundation (NSF, the Foundation) is one of our Nation's most vital institutions, playing a key role in placing the U.S. at the forefront of research and innovation globally. The Foundation's investments in research, technology, and education have produced a rich cascade of benefits to the Nation that include fundamental new ideas, vital new technologies, and a vibrant network of pioneering people and institutions. This has formed a strong basis upon which countless business innovations continue to flourish, contributing significantly to our knowledge base, to our economy, and to the standard of living Americans have enjoyed for decades.

The Foundation is a successful organization that many nations strive to emulate. Its effectiveness and efficiency are well known. No other institutional mechanism has proven so effective at producing knowledge, technology, and expanding human capacity in scientific and technical fields.

The context in which the Foundation operates has changed significantly in the past few years. Through the process of globalization, more nations are attaining technical and workforce capacities that can compete successfully with ours. At home, there are concerns that the U.S. is slipping in research, technology innovation, and education — three essential pillars of success in the 21st century. Last, but by no means least, the Federal Government faces much tighter constraints upon, and demands for, discretionary budget dollars. For any organization, public or private, such profound shifts in the operating framework compel leaders to do a comparably profound, incisive re-examination of the organization's vision, goals, and priorities.

“Americans believe that advances in S&T were the nation's and the government's greatest achievements during the 20th century.”
Pew Research Center for People and the Press, 1999.

According to the legislation that brought it into being, the Foundation consists of the National Science Board (NSB, the Board) and the NSF Director, who is also a member of the Board. This partnership, unique among Government agencies, has served the Foundation and the Nation exceptionally well. The National Science Board serves as the policymaking arm of NSF and approves its budgets and priorities. Through its ongoing reviews and its approval of major programs and awards, the Board provides continuous oversight of the Foundation's priorities and insures the excellence of its standards and processes. The Board also provides oversight of the implementation of its grant-making policies and of its financial and accounting practices. The National Science Board is uniquely positioned to provide, in consultation with the broader S&E community, a new 2020 Vision for NSF. This 2020 Vision for NSF provides the overarching framework for a new strategic planning process that will be led by NSF management and brought to the Board for final approval.

More than half a century ago, Vannevar Bush stated a set of principles concerning the national science enterprise that remain largely valid today. In *Science, the Endless Frontier* (1945), Dr. Bush affirmed the vital importance of new knowledge – obtained through basic scientific research – to ensuring the Nation’s health, prosperity, and security in the modern world. Bush also recognized the essential role of a well-trained technical workforce in creating this new knowledge; recognizing that the scientific frontier would advance slowly or rapidly, depending on the number of highly qualified and trained scientists exploring it. Further, Bush asserted that because the Nation’s health, prosperity, and security were all proper concerns of Government, scientific progress must be of vital interest to the Government. Bush went on to lay the groundwork for a National Research Foundation that would serve the national interest by promoting scientific research and education. Today, this institution is known as the National Science Foundation, and it is recognized worldwide as the gold standard for supporting basic research and education.

More than 50 years later, it is clear that NSF’s impact has been nothing short of monumental. Ideas first conceived in the laboratories of NSF-funded researchers have underpinned new technologies, led to multi-billion dollar industries, helped create new jobs, and benefited countless lives. Fiber optics, radar, wireless communication, magnetic resonance imaging, ultrasound, and even the Internet could not have occurred NSF-supported research in the basic S&E. An NSF-supported study found that 70 percent of the scientific papers cited in U.S. industry patents came from science supported by public funds and performed at universities, government labs, and other public agencies.¹ NSF research has also proven essential to address the security challenges facing the Nation. For example, the geographic information systems used to coordinate efforts at the World Trade Center were based on NSF-supported research.

“...new knowledge is perhaps the single most important driver of economic growth and the most precious and fully renewable resource available to individuals and societies to advance their material well-being. Economic advantage rests increasingly on the ability to exploit new scientific and technological advances. Robust support for basic research assures a deep reservoir of knowledge and provides flexibility and choices for addressing future needs.”

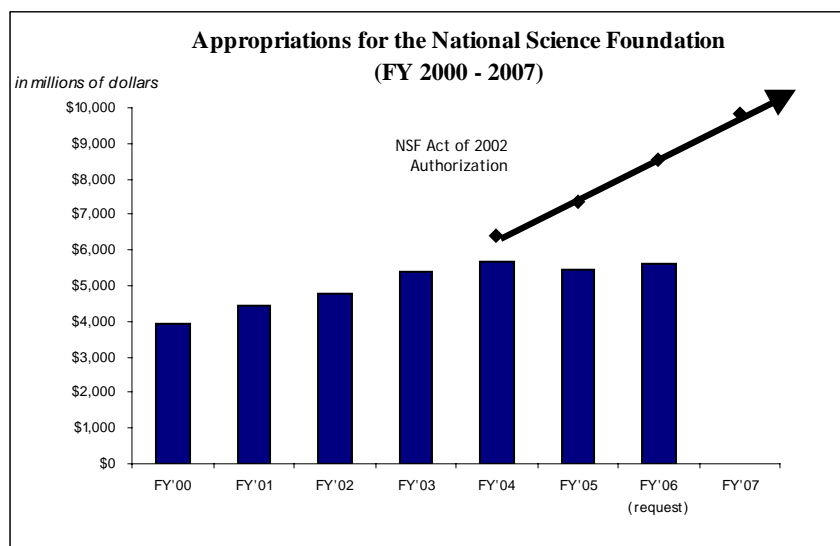
*National Science Board Strategic Plan
(NSB-98-215), 1998, page 2.*

NSF has played a vital role in developing a U.S. science and engineering workforce that is second to none. Each year, NSF supports more than 200,000 people – teachers, students, and researchers – many of whom go into industry and help create new technologies, products, jobs, and company start-ups. The Foundation has also filled a vital niche in advancing the American public’s understanding of science and its importance to our Nation’s economy and security.

¹ Francis Narin, Kimberly S. Hamilton, and Dominic Olivastro, “Increasing Linkage Between U.S. Technology and Public Science,” *Research Policy* 26, No 3 (December 1997): 317-30.

Federal Fiscal Realities for the Early 21st Century

In 2002 Congress recognized the vitally important role that S&E play in society by overwhelmingly approving the National Science Foundation Act of 2002 (P.L. 107-368). This Act authorized a doubling of NSF budget over 5 years, to a total of almost \$10 billion by FY 2007.



In response to a legislative directive and in order to plan for this budget expansion, the National Science Board prepared *Fulfilling the Promise: A Report to Congress on the Budgetary and Programmatic Expansion of the National Science Foundation* (NSB-03-151) that recommended focusing these new funds on six vital objectives:

- Improving the productivity of researchers and expanding opportunities for students.
- Opening new frontiers in research and education.
- Building a diverse, competitive and globally engaged U.S. S&E workforce.
- Increasing the number and diversity of institutions that participate in NSF-funded activities.
- Providing scientists and engineers with advanced tools, facilities, and cyber-infrastructure.
- Maintaining NSF's excellence in management.

This report set out specific plans for beneficial use of the authorized increases and showed in detail how an even larger increase could be deployed to benefit the Nation greatly. The National Science Board believes the increases reflected in the 2002 authorization and the additional amounts discussed in the Board's report would have had a significant beneficial impact on the long-term economic strength of our Nation.

Unfortunately, due to subsequent events constraining the Federal budget, these congressionally authorized increases have not occurred. Moreover, a constrained budgetary environment is likely to persist into the foreseeable future given the budgetary requirements of competing and urgent national priorities.

The challenges in today's landscapes are many. The leadership of NSF – the National Science Board and NSF Director – faces difficult decisions that require new solutions. These challenges will be addressed by enunciating a new 2020 Vision for NSF and developing a strategic plan that responds to the strategic priorities provided in this document.

Science and Engineering Research and Education Investment Principles

Given the difficult financial constraints controlling the annual appropriations for NSF, the National Science Board believes that NSF must creatively utilize its funds to address the challenges inherent in these four overarching investment principles in order to enable strategies for reaching near-term goals required to achieve the new 2020 Vision for NSF:

- **Investment Principle 1** - Focus on research at the frontiers of innovation, creativity, and transformation.
- **Investment Principle 2** - Achieve an increase in the number and diversity of individual researchers and students supported by NSF, recognizing the need for balance with average award size and duration.
- **Investment Principle 3** - Achieve an appropriate balance in the NSF research portfolio between the support of centers and individual principal investigator (PI) grants, with a focus on increasing the number and diversity of individual researchers and students supported by NSF.
- **Investment Principle 4** - Achieve an appropriate level of annual investment in NSF management excellence, including support for personnel and operational systems.

Near-Term Goals for Attaining 2020 Vision for NSF

The profound shifts in the Federal budgeting landscape that have taken place since the Congressionally authorized doubling of funding for NSF have required a re-examination of the means by which to maintain the vitality of the Nation in the S&E research and education enterprise. Within current budgetary constraints, utilization of the investment principles outlined in the previous section will be employed to achieve the following near-term goals necessary for advancing the strategic priorities and realizing the 2020 Vision for NSF:

- **Near-Term Goal 1 - NSF Leadership will develop a strategic plan consistent with the Strategic Priorities, Investment Principles, and Enabling Strategies set by the Board that emphasize appropriately the areas of greatest scientific opportunity and potential benefit to the Nation.**

The National Science Foundation is unique among other Federal agencies that support science: while other agencies have prescribed mandates among different fields of S&E research, NSF is charged with supporting a comprehensive research portfolio considering all fields and disciplines of S&E. In navigating today's constrained budget environment, NSF must remain science-driven and agile in order to respond quickly as new opportunities for S&E research and education emerge within the scientific community. This will demand difficult decisions, and draws into focus the need for state-of-the-art methodologies that can be used to inform priority-setting in, and among, scientific disciplines. NSF must develop a strategy for how it will more efficiently and effectively nurture and support areas of greatest scientific opportunity and potential benefit to the Nation.

- **Near-Term Goal 2 - NSF will strengthen opportunities for supporting transformative research.**

The National Science Foundation mission must be to support the most innovative and potentially transformative research – research that has the capacity to revolutionize existing fields, create-new subfields, or cause paradigm shifts in thought. Ongoing review and evaluation make clear to the Board that the Foundation's current solicitation, review and selection processes must evolve, in some respects substantially, in order to achieve the transformative potential the Board envisions. NSF must create an environment that welcomes and encourages such proposals from the research community.

The Board has recently critically reviewed the NSF system of merit review and found the system to be sound.² The Board fully supports the current NSF system of merit review, which utilizes the peer review process as the principle driver in funding decisions.

² National Science Board. *Report of the National Science Board on the National Science Foundation's Merit Review System*, September 2005, (NSB-05-119)

Further, the Board believes that NSF program officers play a vital role in the success or failure of proposals for potentially transformative research. Therefore, it is essential that NSF ensure program officers have the necessary time, resources, and upper management support to exercise their scientific expertise and judgment in making funding recommendations. Empowering program officers not only allows the Foundation to fund the most promising and exciting science, but it also enables NSF to attract the most qualified and motivated individuals to serve as program officers.

- **Near-Term Goal 3 - NSF will increase the impact of its contribution to strengthening science, technology, engineering, and mathematics education.**

NSF is the principal Federal agency responsible for science, technology, engineering, and mathematics (STEM) education at all levels – K-12, collegiate, and centers of informal education in science and discovery. Education in S&E is a core mission for NSF, the importance of which has increased as the Nation confronts the growing needs for S&E talent in the workforce and for national science literacy in the interest of the Nation's long term prosperity, security, and quality of life. NSF must ensure a diverse and broadly trained S&E workforce, and assist in educating the public so that it understands the contributions of science and technology to the Nation's economy and to their everyday lives. To address the growing needs to improve U.S. STEM education, NSF must strengthen and deepen collaboration across the agency in research and education and ensure sustained excellence through rigorous evaluation. Proven practices that strengthen STEM education must be translated and transferred by NSF for implementation by our Nation's formal and informal education providers.

- **Near-Term Goal 4 - NSF will ensure that new and more diverse generations of faculty are given significant opportunities for research funding.**

The Nation's universities are vital institutions both for maintaining the strength of the U.S. basic research enterprise and for producing individuals with advanced S&E degrees to serve in the workforce. The Nation has done less well in encouraging and developing the mostly untapped potential of underrepresented minorities, women, and persons with disabilities. Developing this potential, especially to advance underrepresented minorities into the professoriate, will lead to expanded opportunities for individuals as well as improving national competitiveness and prosperity. NSF must encourage post-secondary institutions to achieve greater faculty diversity with thoughtfully conceived and executed programs for recruiting and retaining S&E faculty from underrepresented minority groups. NSF must ensure ample levels of funding for early career Ph.D.'s as they are the next generation of S&E faculty essential for the continued vitality of U.S. universities.

Enabling Strategies

The following enabling strategies serve as the primary vehicles for focusing on and achieving the near-term goals and strategic priorities established by the Board in this document. These enabling strategies are designed to build upon and reinforce NSF's strengths.

- **Enabling Strategy 1 - NSF must improve its impact in developing a scientifically literate citizenry and strengthening STEM education.**

There are three important venues of education: K-12, university, and informal institutions. Capitalizing on the Foundation's core mission and strengths by focusing on high leverage points in the formal and informal education systems, will maximize the impact of the Foundation's programs and funds on our Nation's critical needs. A priority for NSF education programs should be to enhance the integration of the research enterprise with education. In particular, NSF should strategically utilize the ability of informal science institutions to improve the teaching of S&E in schools, and to serve as natural bridges between academia, the general public, and our school communities. The Foundation must re-evaluate and re-focus its varied education programs to improve linkages with basic S&E research.

Discovery in S&E depends on an ample well-trained and highly qualified workforce, consisting of skilled practitioners with two- or four-year degrees and beyond, researchers and educators with advanced degrees, and pre-college science and mathematics teachers. Recent analyses suggests that two long-term trends threaten the strength of this workforce:³ increasing global competition for S&E talent; and a likely decline in the number of native-born STEM graduates entering the workforce. These trends will persist unless the Nation is able to more successfully train STEM students from all demographic groups. To improve its impact in this area, NSF must ensure the strongest and most effective link for university research outreach with K-12 and informal science educators.

- **Enabling Strategy 2 - NSF must provide the advanced tools, facilities, and cyberinfrastructure in order for researchers to do transformational research.**

NSF will provide researchers and educators with access to the most advanced tools, facilities, and cyber-infrastructure. The development and availability of new tools has opened vast research frontiers and fueled technological innovations in fields as broad as biotechnology, imaging for health and medicine, nanotechnology and communications. In the recent decade, funding for academic research infrastructure has not kept pace with rapidly changing technology, expanding research opportunities, and the increasing

³ National Science Board. *The Science and Engineering Workforce: Realizing America's Potential*, August 2003, (NSB-03-69).

number of users. Moreover, many research questions can only be addressed with the use of new generations of powerful technological tools. These new tools will make scientists and engineers more productive, and enable them to undertake more complex tasks and research problems. Investments in infrastructure are needed to be focused on: information technology research, midsize infrastructure, large facilities projects, cyberinfrastructure, and educational and training opportunities.

- **Enabling Strategy 3 - NSF must strengthen the communication within, and modes for supporting, international and interagency partnerships, and must explore the potential value-added of new and innovative partnerships models.**

By its very nature, S&E is global, and recently, the significance of science and technology in the global context has grown dramatically. The global economy that emerged in the second half of the 20th century, resting on highly articulated communication and information infrastructure, increasingly relies on knowledge and innovation for its growth and core processes. The worldwide exchange of ideas will continue to fuel economic growth in advanced economies at the same time that it enables less developed nations to catch up and potentially to skip time-draining and ecologically destructive intermediate steps. Science and technology not only can, but must contribute both to the generation of new opportunities and benefits and to the solution of problems.

Given the extraordinary – and growing – importance of science and technology as we move into the next century, there is a need for a fresh look to ensure, on both Federal and NSF levels, a coherent strategy that supports a productive relationship between scientific and foreign policy objectives. The benefits of scientific knowledge and communication have broad societal significance; in a contentious world, bilateral and multilateral cooperation in science and technology help build stable relations on the basis of mutual benefits. International collaborative activities, particularly those that involving younger scientists and engineers are increasingly necessary for training a globally engaged STEM workforce. NSF should be a forward thinking leader in developing new models for international cooperation in S&E research and education.

- **Enabling Strategy 4 - The Foundation must maintain the excellence of NSF staff and management.**

The rapidly quickening pace of discovery, character of research, and demands for quality science education have placed a substantial new workload on NSF staff and management. NSF's excellence depends on maintaining a diverse, agile, results-oriented NSF workforce that operates in a continuous learning environment. The NSF workforce and management infrastructure must have access to new technologies and leading-edge management approaches to maintain efficiency, effectiveness, and properly serve the Nation's research and education communities.

Conclusions

Our Nation depends on the creation and use of new knowledge to generate jobs, ensure a high quality of life for its citizens, and maintain global pre-eminence in discovery and innovation throughout the 21st century. The National Science Foundation is internationally respected for its effectiveness in identifying and supporting people and ideas that advance critical scientific understanding, help create useful technologies, and expand human capacity. Other nations are emulating NSF's model and are investing heavily in their scientific enterprises. Through the process of globalization, technical expertise and S&E workforce capabilities are being cultivated and employed outside American borders. America's long-standing competitive advantage is slipping.

Compounding these trends, increasing demands and tightening constraints on Federal discretionary budget dollars have substantially reduced the required growth of NSF investments in fundamental research that can ensure the development of the next generation of scientists, engineers, and STEM educators. The tragic consequence of the confluence of these factors will result in significant lost opportunities, a slower pace of our Nation's science and technology advancement, and diminished position in the global marketplace for innovation.

The Board has prepared this report, *National Science Board 2020 Vision for the National Science Foundation* ([NSB-05-142](#)), to address these constraints. The Board's overarching vision statement, in conjunction with strategic priorities, critical investment principles, near-term goals, and enabling strategies, will guide the Foundation as it addresses new challenges in a complex fiscal and operational environment. Successful implementation of this vision will serve the best interests of our Nation by significantly enhancing the vitality, creativity, and productivity of the U.S. science and engineering enterprise.