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NATIONAL SCIENCE BOARD[1]
INTERIM REPORT

TOWARD A MORE EFFECTIVE NSF ROLE IN INTERNATIONAL SCIENCE AND ENGINEERING

Introduction

In the 21st century advances in science and engineering (S&E) will to a large measure determine economic growth, quality of life, and the health of our planet. The conduct of science, intrinsically global, has become increasingly important to addressing critical global issues. At the same time, awareness of the importance of investing in S&E has grown throughout the world. Our ability, as a Nation, to work effectively within the international framework is highly dependent on the contributions of S&E both to policy deliberations and to problem solving. Our participation in international S&E collaborations and partnerships is increasingly important as a means of keeping abreast of important new insights and discoveries in science and engineering.

In February 1999 the National Science Board (NSB) established a Task Force on International Issues in Science and Engineering.[2] The task force was charged with developing recommendations for strengthening the Federal institutional framework of policies and agency relations that support S&E in an international setting and with defining an effective leadership role for the National Science Foundation (NSF) in international science and engineering in the 21st century. It engaged in an extensive review of relevant policy documents and reports, including previous NSF and NSB reports dealing with NSF's role in international science and engineering and information provided by the NSF Director regarding NSF international activities. It also held

[1] The National Science Board serves as the governing board of the National Science Foundation (NSF) and provides advice to the President and the Congress on matters of national science and engineering policy.
[2] This paper was prepared for the National Science Board by the NSB Task Force on International Issues in Science and Engineering, chaired by Diana S. Natalicio, and including Board members John A. Armstrong, Pamela A. Ferguson, Mary K. Gaillard, Stanley V. Jaskolski, Jane Lubchenco, and Luis Sequeira, and NSF staff, Karl Erb and Eugene Wong.

hearings and consultations with experts and stakeholders, including with NSF management and staff.

Based on this input, the Board developed an interim report to the new Administration urging it to move expeditiously to ensure the development of a more effective, coordinated framework for its international S&E activities to maintain U.S. leadership and the long term vitality of the U.S. economy and its S&E enterprise. The report recommends a series of specific actions to: 1) strengthen coordination and management of U.S. international S&E research and education activities; 2) facilitate international collaboration in S&E research and education, particularly by younger scientists and engineers and with developing countries; and 3) improve the use of S&E information in foreign policy and in global problem solving.

The Board believes that, although the National Science Foundation (NSF) already plays a central role in international S&E research and education, NSF must significantly raise the visibility and pervasiveness of its international activities and assume a stronger leadership role within the Federal government. Increased international cooperation is necessary because it brings together a wide variety of ideas, information, talent, and resources to a problem, while fostering a diverse, internationally competitive and globally-engaged workforce of scientists and engineers. With its broad mandate to support fundamental research and education and its excellent reputation in the global arena, NSF is uniquely positioned to provide assistance and leadership on various aspects of the three areas mentioned above. This report recommends a series of actions to NSF to increase the effectiveness of its leadership in international science and engineering, acknowledging that they will have resource implications for the Foundation.

Keystone Recommendation: International science and engineering should become a high priority for NSF, with a much stronger focus and a much higher level of visibility. NSF should emphasize international considerations more explicitly in its research and education programs,

both in core disciplines and in NSF wide initiatives. NSF should also review its current resource allocation and organizational structure and determine any necessary changes and additional resources required to implement the recommendations of this report.

Changing Context and Framework

The NSF mission and its strategic objectives include both a broad and a specific mandate for international activities. The general tenor and the provisions of the NSF Act of 1950 (as amended) that relate to international science and engineering—sections 3(a-3), 3(b), 11(c), 13(a), and 13(b)—give the Foundation broad responsibility in the international science and engineering research and education arena.

The NSF Government Performance and Results Act (GPRA) Strategic Plan FY 2001 – 2006 states that "in pursuit of its mission, NSF invests in (1) PEOPLE to develop a diverse, internationally competitive and globally-engaged workforce of scientists, engineers and well-prepared citizens; (2) IDEAS to provide a deep and broad fundamental science and engineering knowledge base; and (3) TOOLS to provide widely accessible, state-of-the-art science and engineering infrastructure." The NSF Strategic Plan explicitly recognizes that "international partnerships are vital to achieving NSF's goals."

NSF estimates that it invested about $350 million in FY 1997 on activities with significant international dimensions. Of this total, $25 million was allocated for the Division of International Programs (INT) whose programs are explicitly dedicated to the support of international activities. These include support of overseas offices in Paris and Tokyo, research collaborations, conferences and workshops, information and data sharing, postdoctoral fellowships, and summer programs for graduate students. INT is responsible for supporting international relations at senior management levels and is the agency-wide point of contact on international matters for the Office of Science and

Technology Policy (OSTP), the Department of State (DOS) and other Federal technical agencies. INT staff also carry out a number of important service and brokering functions including provision of advice and expertise, internal knowledge and information transfer, communication with counterparts in other countries, linking of individuals and small research groups with similar interests, and provision of seed money for exploratory programs. Other NSF programs directed specifically towards the support of international activities are: the foreign data activities of the Division of Science Resources Studies; the NSF-NATO Postdoctoral Fellowships in Science and Advanced Study Institutes Travel Awards programs managed by the Directorate for Education and Human Resources (EHR); and the international networking program, managed by the Directorate for Computer and Information Science and Engineering (CISE).

The overwhelming share of NSF's international expenditures is not the direct result of a focus on international activities, but a natural and valuable byproduct of its general support for research and education. As part of its support of science and engineering, NSF funds a number of collaborations among individuals or groups of scientists and engineers that have a significant international dimension. The most internationally intensive sciences include all the geosciences, polar programs, major elements of the biological sciences (such as systematic and population biology and ecological studies) and the behavioral and social sciences (physical and cultural anthropology, linguistics, and geography).

Other disciplines in which the level of international activity is high are those that rely on major internationally-shared research or observational facilities located outside the United States or that draw on large-scale internationally coordinated projects. These disciplines are primarily in the physical sciences, although in some areas of engineering the use of important internationally shared facilities is not uncommon.

NSF also supports a number of international activities related to education, almost all of them focused on higher education and many of them directly tied to the Foundation's research support. Among these are programs that involve graduate students in field

research and data collection abroad and encourage the inclusion of foreign student counterparts in research training and educational development exercises. In many disciplinary areas, notably in the Directorates of Biological Sciences (BIO), Geosciences (GEO), and Social, Behavioral, and Economic Sciences (SBE), the subject matter requires that U.S. students journey to other countries to carry out their research or education. Undergraduates can gain exposure to foreign counterparts and facilities abroad through international components of the Research Experiences for Undergraduates (REU) program. A number of postdoctoral fellowships also emphasize international experiences.

Although the international dimension of science and engineering has always been an important part of NSF's portfolio and its mission, it is not as prominent and pervasive as it must be to meet future needs. The increasing globalization of S&E has heightened the awareness that excellent science and engineering will no longer be the domain of a select few countries. Other nations are making increasing investments in education and research and the balance of S&E expertise is shifting and new ideas and discoveries are emerging from all over the world. Foreign students educated in the United States are returning home in increasing numbers. Their return strengthens both their countries' education and research capabilities.

Opportunities for participation in international partnerships are increasing, as is the urgency of taking advantage of such opportunities. Scientific and engineering problems often involve instrumentation and facility costs that are affordable only through international partnerships. Many research problems, both disciplinary and multidisciplinary, require scientists and engineers in different countries to work together. Collaborative activities and international partnerships are an increasingly important means of keeping abreast of important new insights and discoveries critical to maintaining our leadership position in key fields, which contribute to our economic growth and quality of life as well.

To meet these new challenges, NSF must make international science and engineering a high priority, according international activities a much stronger focus and much higher level of visibility than they currently receive. NSF needs to emphasize the importance of international considerations and include them more explicitly in its programs, communicate the importance of international collaboration both to its external community and to its internal professional staff, institute better processes for tracking and monitoring its international activities, and strengthen its ties with other agencies and organizations to enhance international collaboration. Finally, NSF must make sure that an organizational structure exists that maintains an appropriate balance and facilitates effective communication between the activities and programs that are explicitly dedicated to support of international activities, particularly those located in INT, and those that evolve from its general support of science and engineering research and education.

Findings and Recommendations

1. *NSF contribution to planning, coordination and management of, and commitment to international S&E research and higher education activities*

Overall leadership for international science and engineering policy lies in the White House within OSTP. However, the focus of OSTP understandably is selective, with emphasis on the early stages of an issue, on critical day-to-day issues of diplomacy and security, and on general oversight. Implementation and follow-through on international S&E activities are often left to other agencies. NSF often provides leadership on such crosscutting matters as international scientific infrastructure, Antarctic and Arctic research, global change research, and the international mobility of human resources. The Foundation also implements a large number of formal, government-to-government bilateral science and engineering programs.

NSF is involved in major international projects with other Federal agencies and relies on a variety of ad hoc and more formal mechanisms for cooperation. The number of interagency projects that entail international collaboration has increased steadily over the

last decade. For example, in the International Continental Drilling Program (ICDP), the Division of Earth Sciences (EAR) in the GEO Directorate works directly with the United States Geological Survey (USGS) on a day-to-day and very informal basis. Other projects (i.e., the Large Hadron Collider and Global Change Research Program) are carried out under the framework of formal agreements. Overall responsibility for interagency coordination lies with the National Science and Technology Council's Committee on International Science, Engineering, and Technology (NSTC/CISET), co-chaired by OSTP and the State Department. NSF has an opportunity to raise the visibility of international issues and improve interagency coordination of international activities evolving in those committees in which it has a leadership role.

Many of the more formal agreements in which NSF participates are either managed or require review by the Department of State. A recent National Research Council (NRC) report[3] recommended that DOS transfer its responsibilities for management of bilateral and multilateral science and engineering agreements to other appropriate and willing Federal agencies when there is not a compelling reason for retaining responsibilities within the Department. The report also recommended that DOS streamline its review process for proposed international agreements and bilateral memoranda of understanding, indicating that "delays and inefficiencies in the process are a constant source of irritation among departments and agencies and sometimes create difficulties with foreign collaborators." NSF has an opportunity to work with DOS and other agencies in implementing these two recommendations and in identifying and correcting other unnecessary administrative barriers to international S&E collaboration.[4]

NSF frequently brings together disparate members of the international research community to facilitate their involvement in major planning efforts. Such efforts have been seminal in fostering international collaborations in a broad range of topics, ranging

[3] *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State*, Office of International Affairs, National Research Council, Washington, D.C. 1999

[4] Examples of other administrative barriers are foreign scientists' difficulties obtaining timely visas at U.S. Embassies, customs problems associated with moving scientific equipment needed for cooperative research into and out of countries, entry into territorial waters to do field research, and imposition of substantial research fees by local governments in some countries.

from biological informatics, to materials research, to global change. The Foundation, with its reputation for political neutrality, is seen as an innovative leader in promoting international cooperation and in sharing with other nations information about developing appropriate institutional frameworks to support science and engineering. As the number of global problems requiring S&E input increases, the need and opportunity for NSF involvement will continue to expand.

An important service function of NSF, authorized in the NSF Act (section 3(a-6)), is to provide a central clearinghouse for the collection of data on S&E resources and to provide a source of information for policy formulation by other agencies of the Federal Government. As part of this function, NSF follows and collects information about science and engineering activities in other countries that can be critical in effective coordination and management and in development of national and international policy. This information is not only used by many individuals and organizations in the United States, but is also relied upon by the science and engineering communities in other countries. Many countries have also patterned their own data collection and indicators development after NSF. The two NSF overseas offices in Paris and Tokyo provide current information about Europe and Asia and facilitate access of NSF staff to key scientific leaders in those regions. The Foundation produces special reports about S&E resources in other countries and regions and collects and disseminates a large quantity of international S&E data. NSF has also improved its own internal record-keeping by introducing a new system of collecting data on NSF international research activities in FY 2000 to provide more accurate information in the future.

The National Science Board, in its biennial publication, *Science and Engineering Indicators*, provides information about science and technology throughout the world, placing U.S. data on a number of topics in an international context. The Board's decision to expand and increase the visibility of its international coverage in *Indicators*, in keeping with the growing importance of science and engineering in the international arena, will significantly strengthen this base of valuable data.

With the growing importance of international S&E cooperation, there is both room for and need for improvement in all of the areas discussed above—planning, coordination, implementation, communication, and provision of information. Given appropriate resources, NSF can assist in these areas and assume a more forceful leadership role in areas consistent with its mission. However, effective coordination and management of the Nation's international S&E activities will require a government wide effort lead by OSTP, making more effective use of its NSTC structure.

Recommendation 1: NSF should identify and deploy mechanisms to foster more effective communication and coordination of its international S&E research and higher education activities with those of other Federal technical agencies and non-governmental scientific organizations. It should also work with those agencies and organizations and the Department of State to streamline formal processes and administrative requirements that create unnecessary obstacles to international S&E collaboration.

Recommendation 2: Building on its natural leadership role, NSF should expand its efforts in disseminating information about U.S. international S&E research and higher education activities, taking advantage of the opportunities associated with the growth of the Internet. NSF can also provide leadership in working with OSTP and OMB to enable the development of cross agency mechanisms for collecting and disseminating data necessary for effective planning, coordination, and management of international S&E research and education activities.

2. *Encouragement and facilitation of expanded S&E research and higher education collaboration and partnerships with other nations.*

It is critical that NSF expands its participation in international research and higher education activities all over the world. International partnerships are necessary for the Foundation to position the United States to benefit from the global investment in science, engineering and technology.

In today's world good ideas are found in every country across the globe. U.S. scientists and engineers must be aware of discoveries occurring in other countries and open to adopting the best ideas wherever they are found. Many disciplines require access to sites outside the United States. There are also certain fields, such as environmental biology and atmospheric science, in which international cooperation and access are essential to the effective conduct of research because the questions being addressed are inherently global in nature. Increasingly, U.S. scientists and engineers must be able to operate in teams composed not only of people from many disciplines, but also from different national and cultural backgrounds. Large facilities and large distributed and networked databases will necessarily involve international partners. Also, many of the large projects that characterize big science can only be carried out through international collaborations and partnerships.

Recommendation 3: In conjunction with the science and engineering community, NSF should identify strategies to expand international collaborative activities and partnerships in S&E research and education in both core disciplines and in NSF wide initiatives.

Although the expansion of international cooperation should occur across the Foundation, three specific areas deserve special emphasis for the immediate and long-term future. One is increased participation in international S&E activities by younger U.S. scientists and engineers from diverse backgrounds, especially those in the early stage of their careers, in order to develop an internationally competitive and globally-engaged S&E workforce. A second is capacity building in developing countries through increased interaction of U.S. scientists and engineers with those from developing countries. The third is an increased focus on international collaborations in the social, behavioral, and economic sciences.

A. Increased participation in international S&E activities by younger U.S. scientists and engineers

NSF's investment in people is aimed at creating globally-engaged S&E professionals who are among the best in the world and an S&E workforce that draws on the strengths of America's diversity and has global career perspectives and opportunities. U.S. leadership in the discovery-led global economy of the next century will depend on NSF's success in achieving these two objectives. NSF supports a number of programs designed to encourage and provide international research experiences for U.S. scientists and engineers, especially at the early stages of their careers. However, the opportunities and incentives to pursue such experiences are not identical across all fields of science and engineering. Appropriate encouragement is lacking in some fields and there is a widespread perception that time spent abroad may be detrimental to one's career. Re-entry after a sojourn abroad may put the student outside the normal cycle of academic life. Students may also need assistance re-connecting with networks, assessing opportunities that would make best use of their new skills, and in dealing with an atypical career path with respect to their U.S. colleagues.

Recommendation 4: NSF should identify and build on opportunities within its current programs to encourage science and engineering students and researchers, especially those in the early stages of their careers, to participate in an international research or education experience. NSF should also explore new programmatic approaches to broaden both opportunities and incentives for participation, recognizing that different approaches are likely to be needed for different fields.

B. S&E capacity building in developing countries

The United States has traditionally interacted with developing countries by providing foreign aid. Particularly in the S&E realm, there is a new emphasis on sustainable development through creation of the necessary infrastructure, including human resources, for participation in the S&E arena. Increasingly it is recognized that interaction through

collaboration and partnerships is not only more likely to promote sustainable development in today's world but also to make developing countries more effective partners in global problem solving. Assistance to developing countries was regarded historically as part of US AID's mission. In the context of changing country relations and the stronger emphasis on partnerships, NSF can contribute significantly to the improvement and expansion of scientific capabilities in a number of developing countries through its support of global- and regional– scale research, and by promoting increased interaction among U.S. scientists and engineers and those in developing countries.

Recommendation 5: NSF should take a more active role in facilitating cooperation in international S&E research and higher education with developing countries. It should work closely with other Federal technical agencies and multilateral scientific organizations that have S&E interests in the developing countries, and with domestic and international development assistance organizations in seeking out opportunities, identifying goals and targets, and developing cooperative projects and partnerships.

Recommendation 6: In the context of its international cooperative activities and, where appropriate, in association with other agencies, NSF should take the lead in enabling the development of new international networks and virtual organizations that take advantage of information technology, high-speed research and education networks, and other tools to facilitate fuller participation of researchers in developing countries in the global research enterprise.

C. Increased focus on international collaborations in the social, behavioral, and economic sciences

This is a critical period for the social, behavioral, and economic sciences. Advances in science and engineering are increasingly important, but often unpredictable, determinants of our future. Many of these advances result from international collaboration. The social, behavioral, and economic sciences are key to understanding both the impact of

science and engineering and the factors influencing the degree, types, and outcomes of international collaboration. Progress in these fields is also important for international relations and international problem solving, two areas that both influence and are influenced by international S&E collaboration. These sciences are an increasingly important component of a number of important global science and engineering issues. The knowledge derived from research and education in these fields helps us better understand the influence of science and engineering on individuals, groups, and society. It also improves our understanding of the impact of society on the state of the science and engineering enterprise and helps us identify key determinants of the future success of the enterprise.

Recommendation 7: NSF should identify and build on opportunities within its research and education programs in the social, behavioral, and economic sciences to expand international collaborative activities and partnerships. The Foundation should also explore new programmatic approaches and work more closely with other Federal agencies and professional societies that have interest in these fields in seeking out opportunities, identifying goals and targets, and developing cooperative projects and partnerships.

3. *S&E information for foreign policy and global problem solving*

NSF does not currently specifically target resources to strengthen science for policy. The Foundation's fundamental approach has been to seek out cooperative opportunities that benefit U.S. science and engineering and generate collateral U.S. foreign policy and national security benefit in the process. However, the research NSF sponsors often has important bearing on many public policy issues. The Foundation fosters connections between discoveries and their use in the service to society. In that respect, NSF is a major supporter of research related to a number of "global" policy issues. In the environmental area, for example, those global issues include: securing a sustainable global environment, sustaining biodiversity, managing toxic waste, reducing the threat of emerging infectious diseases, and managing the effects of invasive species. Other global

issues include nuclear non-proliferation, disaster management, reducing the threat of bioterrorism, arms-control treaty verification, nuclear reactor safety, and protecting intellectual property. NSF funded research, especially if it is conducted with international partners, can help contribute vital scientific perspective for dealing with these issues. However, since the connection of NSF supported research to global policy issues is often neither direct nor explicit, awareness of its broader societal implications is frequently limited. In addition, adequate mechanisms for disseminating the results of research related to global issues to decision-makers are not always available.

NSF has a long history of supporting the larger policy goals of the U.S. Government, particularly in the national security, international economic, and foreign policy arenas. NSF personnel have worked closely with OSTP and the Department of State and provided input to the recent NRC study of the contributions that science and technology can make to foreign policy. NSF has participated in a number of programs of bilateral science and engineering cooperation with Japan, China, the Soviet Union, and Eastern Bloc countries that have served as a foundation for improving relationships between the United States and these countries. NSF has also made special efforts in recent years to promote scientific cooperation with other countries of special foreign policy and international economic policy importance, including South Africa, Mexico, Vietnam, and Mongolia.

Although NSF has ably assisted the Department of State, it will need to strengthen and expand these activities. For several years there has been growing concern that the attention given to science and technology in foreign policy deliberations is inadequate. The number of State Department science counselors at U.S. embassies abroad has decreased markedly at a time when science and engineering have become increasingly important in addressing critical global issues. Additional Federal investment in NSF's financial and human resources is needed for staff exchanges and rotations, workshops and seminars, and better mechanisms for disseminating research results.

Recommendation 8: NSF should strengthen its efforts to work closely with OSTP, the Department of State, other Federal agencies, and international organizations to generate increased support for bilateral, multilateral, and regional scientific and engineering research and education cooperative activities that will expand the knowledge base and contribute to the solution of global problems.

Recommendation 9: NSF should continue its interactions with the Department of State, further encourage the Department to integrate science and engineering considerations into its conduct of foreign policy, and explore mechanisms for facilitating increased knowledge flow and interchange between NSF and DOS personnel.

Conclusion

If NSF is to have an effective leadership role in international science and engineering in the 21st century, international activities should become a high priority, with a much stronger focus and higher level of visibility, and the Foundation should also assume a more prominent role in this arena within the Federal Government. The findings and recommendations presented in this paper identify key areas for attention and action.